UDC 521–525

YU ISSN 0373–3734

BULLETIN

DE

L'OBSERVATOIRE ASTRONOMIQUE DE BELGRADE

N⁰ 142

BEOGRAD

1990

Bull. Obs. Astron. Belgrade N⁰ 142 pp. 1–97 Belgrade Décembre 1990

BULLETIN

DE

L'OBSERVATOIRE ASTRONOMIQUE DE BELGRADE

FOUNDED IN 1936

Published by Astronomical Observatory, Volgina 7,
11050 Belgrade, Yugoslavia

Director of the Astronomical Observatory: I. Vince

The publication of this issue is financially supported by the Republic Found for Sciences of Serbia

Printed by / štampa:

MULTIEKSPERT, Beograd, Ruzveltova 42. tel. 455–282
Tiraž:500 primeraka

Bull. Obs. Astron. Belgrade, N° 142 (1990), 1–15

UDC 523.83
Original scientific paper

A SEARCH AND CLASSIFICATION OF MULTIPLE SYSTEMS IN THE GENERAL FIELD

J. P. Anosova

Leningrad University Observatory, USSR

(Received: October 12, 1989)

SUMMARY: The subject of the present paper is a study of multiple stellar and galaxy systems aimed at a classification of their dynamical states and finding a statistical criterion for recognition of chance and non-chance groups of objects. The proposed statistical criterion is applied to some multiple systems of stars and galaxies. A corresponding algorithm is extended and finally the dynamical states of triple system ADS 9909 (φ Sco) are studied taking into account the uncertainty of the observational data.

1. INTRODUCTION

The study of surface and space distributions of stars and galaxies in the general Galactic and Metagalactic field shows a marked tendency to the clustering for these objects. It is joining of stars and galaxies in the multiples with a different number from the smallest systems (double and triple stars and galaxies) to the clusters of these objects with a large number.

The investigations of star multiplicity distributions in the solar neighbourhood (see e.g. Agekyan at al. 1962, Brosche 1964, Abt and Levi 1976, Dommanget 1977, Worley 1977, Poveda et al. 1982) have shown that a mean multiplicity ratio is equal approximately to 0.45 : 0.35 : 0.10 : 0.10 for the single, double, triple, and more multiple stars correspondingly. Dommanget (1977) made a statistical comparison between the multiple stars and the open star clusters and found that a significant distinction is observed in the characteristic distributions between the multiple systems with $n \leqslant 10$–20 and ones with $n > 20$. Therefore, one can consider the stellar systems with a number $n \leqslant 10$–20 as multiple stars, and ones with a larger n as star clusters.

The galaxies also have a strong tendency to the clustering, their multiplicity distribution is similar to the analogous one for the stars of our Galaxy. There have been also observed galaxies with multiple nuclei.

The study of multiple systems has interest for many problems in stellar and extragalactic astronomy because of widespreading of multiple stars and galaxies in the Galactic and Metagalactic fields and in the star and galaxy clusters, as well as some cosmogonic conclusion which one may draw from the investigation of statistics and dynamics of multiple systems (the age estimations for clusters, Galaxy and Metagalaxy including the multiples; a presentation of their qualitative evolution scenario etc.).

The general problems in the study of multiple systems of objects (stars, galaxies etc.) are the following ones:

1) a discovery of multiple systems in the general Galactic or Metagalactic field or in the star or galaxy clusters;

2) a separation of the discovered multiples to the chance (optical) groups of objects and the non-chance ones;

3) an eduction of the systems with components connected physically;

4) a division of such multiple systems into the ones with components connected dynamically (i. e. with relatively strong dynamical connections) and the ones without such connections;

5) a division of the systems with connected components into the stable and unstable ones;

6) a numerical study of dynamical evolution for nstable systems: the estimations of their life-time; alysis of processes of formation, evolution, and tion for the subsystems of a smaller multiplicity; g of the trajectories of the component's relative ns etc.

One must solve the problems formulated obove ding to the indicated sequence. The necessary tion for solving these problems is the availability three-dimensional coordinates and velocities and elative masses for all components in a multiple n, i.e. the availability of data obtained by the com- of astrometrical and astrophysical observations hese objects. The problems enumerated require iverse accuracy levels in the data used for their on, in addition to that the requirements to accura- el grow as the number of problems increases. The lete solution of all problems enumerated above ultiple stars is possible only at the highest accuracy attainable at present for the observational data ob- d from the ground observations as well as by the observatories.

The problem to obtain the complex of obser- al data for star and galaxy systems is a compli- task in connection with some natural physical es of their components. It requires significant s of specialists in different astronomical speciali- s. The majority of multiple stars and galaxies ins the components of different brightnesses. ently the components have so significant diversi- the apparent magnitudes and in the spectral types minosity classes (for stars) or in the morphological (for galaxies) that it strongly troubles obtaining homogeneous high-precise data for all components the astrometrical observations as well as the hysical ones. Moreover, a large part of the obser- ultiple stars and galaxies have no known distances d for systems with the values $r > 100$ pc it is ssible to solve correctly the problems formulated at present. For the multiple galaxies, one may obtain the relative positions and radial velocities mponents.

In connection with these difficulties, the prob- o obtain the complex of astrometrical and astro- cal data for the multiple stars has not been prac- formulated before. For the most part, the obser- s of components in multiple stars (until an assu- limited apparent magnitude) have been carried out ssing with the observations of double stars. More- the programs of astrometrical and astrophysical vations include for the most part different objec- the photographic astrometrical observations are ally carried out for stars with $m = 9^m - 11^m$; the physical ones – for stars brighter than $7^m - 8^m$; program of meridian astrometrical observations de only the primary components (brighter than 4^m) of a few multiple stars. For the multiple galaxies, as also a significant deficit of observational data.

2. THE CONSTRUCTION OF HIERARCHICAL STRUCTURE FOR THE FIELD OF OBJECTS

The first problem in the study of multiple stars and galaxies is the discovery of such systems in the general Galactic or Metagalactic field or in the clusters of objects under consideration.

In the majority of works, some subjective methods have been used for a recognition of multiple systems (see e.g. Holmberg 1940, Karachentsev 1970, Turner and Gott 1977). Materne (1978) was the first to develop a strict algorithm to construct a hierarchical structure in the Metagalactic field on the base of the well-known mathematical method of cluster-analysis (see e.g. Aivasian et al.). Then Tully (1980), Huchra and Geller (1982), and Vennik (1984) used this method in order to compile the more complete and homogeneous lists of galaxy groups in the Metagalaxy.

This method consists of the following operations: 1) at first, one searches from a totality of N objects of the field two objects i and j ($i,j = 1,2,...,N$) with an extreme value of a selection parameter chosen (Materne (1978), Huchra and Geller (1982, 1983) have chosen it as a minimum theree-dimensional distance R_{ij} between objects, Tully (1980) and Vennik (1984) have taken it as a maximum parameter of the gravitating force $F_{ij} = M_{max} R_{ij}^{-2}$, where $M_{max} = \max(M_i, M_j)$, M_i and M_j are the masses of objects i and j); 2) secondly, one considers such two objects as a single unit with a mass equal to the summary one of this binary and with an inertia centre at its baricentre; 3) furthermore, one uses this algorithm for N–1 objects etc., until all the members within the considered totality are joined in a unified hierarchical structure according to a chain defined by the condition for the maximum of values R_{ij}^{-1} or F_{ij}.

In order to separate the members of multiple systems from the background objects, one must use some isolating criteria, however there is no objective criterion of such type at present. Therefore, some empirical dependences between the characteristics of multiple system components and background objects have been generally used. Such dependences reflect an isolation of the members of systems from the background objects in a phase space of coordinates and velocities. The diverse authors used the unlike selection parameters and various (sometimes strongly distinguishing from each other) decisive values of these parameters when they compiled the lists or catalogues of multiple stars and galaxies.

3. CLASSIFICATION OF MULTIPLE SYSTEMS

The multiple systems of objects (stars, galaxies, their groups or clusters etc.) with any number of compo-

nents
the d

comp
space
be iso
space;
groups

groups
in the
mon fe
compo
regular
be isola
nate spa
-chance
systems
I
city spac
II

A classifi

III–la
passa

nents might be divided into three basic types from the dynamical point of view:

I - such multiple systems in which all or a few components are by chance within a region of the phase space covered by the system: these systems cannot be isolated from the background objects in the phase space; one may qualify suchlike systems as the *chance* groups of objects or *optical* systems;

II – such multiple systems which are no chance groups; they are isolated from the background objects in the phase space; their components have some common features; however, the gravitating forces between components are small or approximately equal to the regular forces of the environment; these systems, cannot be isolated from the background objects in the coordinate space; one may qualify suchlike systems as the *non-chance* groups of objects. One might divide these systems into two classes:

II a – systems completely isolated in the velocity space (e. g. the moving star clusters);

II b – systems only partially isolated in the velocity space (e. g. in one or two of velocity components, like some of well-known Eggen's kinematical groups);

III – multiple systems which can be isolated from the background objects in the coordinate space; in these systems the irregular gravitating forces between their components essentially exceed the regular forces of the environment; one may qualify such systems as the multiples *with a physical connection* between their components.

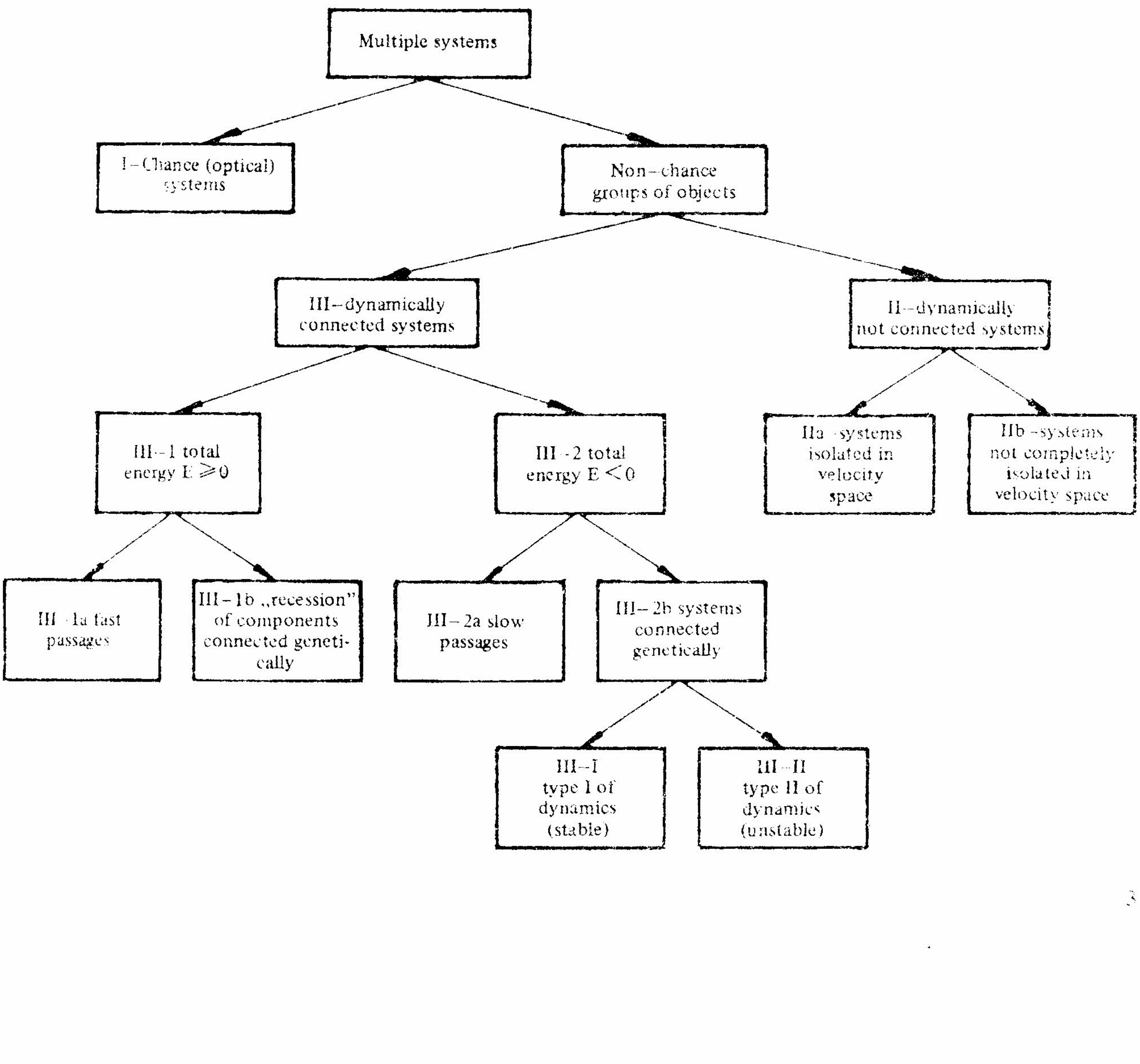
One might divide the systems of the latter type into two classes:

III – 1 – multiple systems in which *there is no dynamical connection* among all or a part of components so that the total energy is *non-negative* $E \geq 0$. One might also divide such systems into two subclasses:

III – 1a – the multiple systems in which *there is no genetic connection* among all or a part of components: all n single objects in a system *rapidly* pass by each other or a number s ($s < n$) of single components and subsystems inside this system *rapidly* pass by each other,

Table 1

A classification of the states of multiple systems



III – 1b – the multiple systems in which *there is a genetic community* of components but also there is a „recession" of components ($E \geqslant 0$) – e.g. according to the well-known conception of V.A. Ambartsumian;

III – 2 – the multiples in which *there is a dynamical connection* of the components so that the total energy is *negative* $E < 0$; one might also divide such systems into two subclasses:

III – 2a – the multiple systems in which *there is no genetic community* among a part of components: a number s ($s < n$) of single components and subsystems with a smaller multiplicity than n inside a system pass slow ($E < 0$) by each other;

III – 2b – the multiples in which *there is a genetic community among all components* (a co-formation); such systems may have one of two dynamical types:

III – I – *dynamically stable* multiples;

III – II – *dynamically unstable* ones.

The proposed classification of multiple systems (stars, galaxies etc.) might clearly be shown by a block-scheme (see Table 1).

4. STATISTICAL CRITERIA FOR RECOGNITION OF CHANCE AND NON–CHANCE GROUPS OF OBJECTS.

Deutsch (1961) was the first to develop a statistical criterion in order to recognize the chance star groups in the galactic field; this criterion uses only the astrometric data for stars – the relative positions of components on the celestial sphere and their proper motions.

This criterion estimates the expectation EX of a number of chance realizations that n single stars will be found within a circle of radius ρ and area σ on the celestial sphere of total area Σ, on condition that the proper motions μ of these stars are in agreement in limits of their uncertainties $\delta\mu$

$$EX = C_N{}^n \left(\frac{\sigma}{\Sigma}\right)^{n-1} \left(\frac{s}{S}\right)^{n-1}, \qquad (1)$$

where $C_N{}^n$ is a number of combinations from N by n; N is the total number of stars; the star proper motions are represented as the vectors radiating from one point and reaching their ends to some region of area S, s is an area of circle of radius $\epsilon\sqrt{n}$ where ϵ is a probable error of a single measurement of the star proper motion.

Deutsch's criterion is feasible only to the multiple stars. Moreover, it does not take into consideration a likeness or difference in the space characteristics of stars – their parallaxes and radial velocities.

In the present work, a statistical criterion is proposed in order to recognize the chance and non-chance star and galaxy groups with any multiplicity n which takes into consideration a likeness or difference of the individual configurational and kinematical data for all components within a system

$$r, \mu, v_A; \quad \rho, r, \mu, v_i; \quad i=1,2,\dots,n-1 \qquad (2)$$

where A is the primary component of a system with multiplicity n, i is the number of its i–th companion; ρ is the relative angular separation of the i–th object from the component A; r, μ, and v are the distance on the line–of–sight, the modulus of a relative proper motion and the relative radial velocity accordingly. The effects of uncertainties in the values

$$\delta r, \delta\mu, \delta v_A \quad \delta\rho, \delta r, \delta\mu, \delta v_i \qquad (3)$$

are also taken into account.

The necessary condition in order to establish the chance or nonchance for a multiple system is shown to be an availability of the total complex of observed data (2) and (3) for all components, unless the relative orbits of all components are obtained. For every multiple system with a total complex of observed data, one could estimate:

1) the probability P that all n components have by chance been found in the region σ of phase space occupied by the multiple system,

2) the expectation EX of a number of the systems with parameters corresponding to the observed data (2) taking into account (3).

This probability P and expectation EX in the case of a sphere Σ with a radius R are estimated by the following formulae by assuming a random distribution of the objects within the sphere

$$P = C_{N-1}^{n-1} B^{n-1} (1 - B)^{N-n} \qquad (4)$$

$$EX = C_N^n B^{n-1} (1 - B)^{N-n}$$

where B is the ratio of the volume of the region σ to the volume of the sphere Σ given as (Anosova 1990)

$$B = 1.55\ 10^{-3} (\mathrm{tg}\, \rho_{n/2})^2 \left(\frac{\mathrm{tg}\, \Delta\mu_{/2}}{\mathrm{tg}\, \mu}\right)^2 \left(\frac{r_A}{R}\right)^5$$

$$\frac{|v_a|}{U} \cdot\cdot \qquad (5)$$

$$\left[1 - \left(\frac{r_n}{r_A}\right)^3\right]\left[1 - \left(\frac{r_n}{r_A}\right)^2 \frac{v_n}{v_A}\right].$$

where $r_A > r_n$; the number n corresponds to a component that is the most distant one from the primary component A of the system; when $r_A < r_n$ the indexes n and A in the quantities r and v are changed: the quantity U is the maxumum possible total velocity of objects in the field under consideration, μ is the proper motion of an object located at the distance R from observer which corresponds to the value U.

Comparing the expectations EX obtained with an observed number of multiple systems with data close to (2) in the uncertainty limits (3), one could conclude that the multiple system under consideration is a chance group of objects or a non-chance one by the following conditions:

I – the multiple system is certainly a non-chance group if the expectation is submitted to the inequality

$$EX \leqslant 1 ; \qquad (6)$$

II – the multiple system is certainly a chance (optical) group if the equality takes place

$$EX \approx N/n, \qquad (7)$$

where N/n is the maximum possible number of systems with multiplicity n in the general field of objects;

III – one cannot make any certain conclusion for the multiple system if the relation is realized

$$1 < EX < N/n \qquad (8)$$

perhaps, the lack of confidence for such multiples is due to large errors (3) of the values (2).

The statistical criterion proposed might be used for solving of a number of problems: 1) a recognition of multiple systems – chance and non-chance groups of objects in stellar and extragalactic fields; 2) a sampling of the probable members in the moving star clusters and streams; 3) an elimination of the background objects in the star and galaxy groups and clusters; 4) a recognition inside the star and galaxy clusters of the subgroups of objects connected physically.

In the coordinate space, formula (5) becomes

$$B = 0.25\,(\mathrm{tg}\,\rho_n/2)^2\,(r_A/R)^3\,[1-(r_n/r_A)^3] \quad (9)$$

where $r_n < r_A$. This formula with (4) is a statistical criterion isolating multiple systems in the coordinate space. It could be used in order to recognize multiple systems with components connected physically. By analogy, one can easily obtain a statistical criterion isolating multiples in the velocity space.

5. CRITICAL PARAMETER VALUES ISOLATING THE CERTAINLY PHYSICAL MULTIPLE STARS AND GALAXIES

One might use the criterion proposed above in order to recognize chance and non-chance groups of objects and physical multiples in order to obtain some objective critical values of parameters isolating the certainly physical systems from the probably background objects considering some different selection parameters – the relative angular separations ρ within pairs of objects, the corresponding three-dimensional distances R or the parameter F of the gravitating force.

The condition (6) must be fulfilled for the certainly physical system with n components, and the condition (7) must be satisfied for the probably chance system with multiplicity n + 1, in this case the (n + 1)-th probably background object is the most nearby one to the system of multiplicity n in the coordinate space.

Transposing the expressions (4) and (9) in order to estimate the expectations EX_n and EX_{n+1} for the systems with multiplicities n and n+1, one can obtain the ratios of the parameters

$$\rho_{n+1}/\rho_n,\ R_{n+1}/R_n,\ F_{n+1}/F_n\,. \qquad (10)$$

Substituting in the expressions obtained the quantities of the expectations (6) and (7), one obtains some objective extreme quantities (10) corresponding to a maximum possible isolation of a system with multiplicity n from the background objects of the field

$$(\rho_{n+1}/\rho_n)_{max} = \sqrt{N/n+1},\ (R_{n+1}/R_n)_{max} = \sqrt{N/n+1},$$
$$(F_{n+1}/F_n) = (n+1/N)\,\frac{\max(M_{n+1},\ \Sigma_{i=1}^{n} M_i)}{\max(M_n\ ,\ \Sigma_{i=1}^{n-1} M_i)} \qquad (11)$$

Let us consider for example the triple stars in the solar neighbourhood within the radius R = 20 pc (Gliese, 1969). For the certainly chance triple stars with components A, B, C in this case, one has the following limited estimations for the ratios of the selection parameters

$$(\rho_{n+1}/\rho_n)_{max} \cong 30,\ (R_{n+1}/R_n)_{max} \cong 30,$$
$$(F_{n+1}/F_n)_{max} \cong 10^{-3}. \qquad (12)$$

The proposed statistical criterion recognizing the chance and nonchance multiple systems gives some possibility to estimate a critical quantity Δv_{cr} for the tolerant differences of the radial velocities of components in the certainly physical multiple galaxies for the different separation between their components on the celestial sphere and along the line of sight. The results of calculations carried out for the double Markarian galaxies from a paper of Dahari (1985) are shown in Table 2 in which the quantity Δv_{cr} is expressed in km/s, z is the redshift of the primary component within a binary, D is the linear distance between the components in kpc. The estimations obtained show that the quantity Δv_{cr} strongly varies depending on the values of z and D; if their values, are small the quantity Δv_{cr} may reach the largest values of $\Delta v_{cr} \approx 1\,000$ km/s. As the values z and D incerease the quantity Δv_{cr} rapidly decreases and falls to the values compared with the uncertainties of modern observations of radial velocities of galaxies.

Table 2

The quantities Δv_{c1} (km/s) for multiple galaxies with components connected physically (EX≤ 1)

z \ d(kpc)	10	30	50	70
10^{-2}	1000	150	60	30
$2 \cdot 10^{-2}$	200	20	10	5
$3 \cdot 10^{-2}$	50	5	2	1
$4 \cdot 10^{-2}$	25	1	1	0.5

6. APPLICATION OF THE STATISTICAL CRITERION TO MULTIPLE STARS ANG GALAXIES

a) some wide triple stars in the solar neighbourhood

In the Index catalogue of double and multiple stars (Jeffers et al. 1963), there are a few wide multiple systems which have large angular separations between their components. A distribution N (ρ) for the binaries and multiples from this Catalogue, where ρ is the maximum separation between two components, is presented in Table 3. The data for triple stars are separately shown in the third column of this Table.

Among these triple stars, one selects seven systems located at the distances from the Sun shorter than 20 pc and having the total complex of observed data (2) and (3) for all components. The most distant components have the characteristics (2) similar to the ones of other components in five wide multiple stars presented. For two systems ADS 10058 and ADS 11853, the distances from the Sun and the radial velocities of the distant components are in disagreement with the corresponding values of other components.

Using the proposed statistical criterion, one estimates for the multiple stars under consideration the probability P that component C, that is the most distant one from the primary component A, by chance in its environment, and the expectation EX of a member of suchlike optical systems inside the sphere of radius R = max (r_A, r_C) on the following parameters of the stellar field (see e.g. Wielen 1974): a radius of the neighbourhood R = 20 pc, a mean local star number density ν = 0.12 stars in 1 pc^3, a velocity $|v|$ = 20 km/s, and a peculiar velocity standard σ_v = 20 km/s. The results of calculations are in Table 4.

Table 3

Distribution N (ρ) of multiple stars in IDS

ρ	0–2	2–5	3–5	5–10	10–30	30–100	100
N	$5.4 \cdot 10^4$	$1.6 \cdot 10^4$	$2.6 \cdot 10^2$	$7.2 \cdot 10$	$2.5 \cdot 10$	2	2
N(n=3)	$3.9 \cdot 10^3$	$1.7 \cdot 10^2$	$3.3 \cdot 10$	9	2	1	1

Table 4

The probabilities P and expectations EX of a number of optical stars (chance groups)

ADS	7114+ (9+10)UMa	α Cen	20390 S3142	10058	11853	48	6175 (Castor)
ρ'	$3.8 \cdot 10^2$	$1.3 \cdot 10^2$	$7.7 \cdot 10$	9.4	6.9	5.5	1.2
			The probabilities P				
1)	$5.0 \cdot 10^{-3}$	$7.6 \cdot 10^{-5}$	$2.6 \cdot 10^{-5}$	0.30	$2.6 \cdot 10^{-5}$	$1.4 \cdot 10^{-7}$	$7.2 \cdot 10^{-8}$
2)	$1.1 \cdot 10^{-4}$	$5.3 \cdot 10^{-7}$	$4.2 \cdot 10^{-7}$	0.60	$2.5 \cdot 10^{-5}$	$5.2 \cdot 10^{-5}$	$1.2 \cdot 10^{-8}$
3)	$7.3 \cdot 10^{-5}$	$2.8 \cdot 10^{-7}$	$2.5 \cdot 10^{-7}$	0.60	$3.0 \cdot 10^{-9}$	$3.0 \cdot 10^{-9}$	$5.9 \cdot 10^{-9}$
4)	$2.8 \cdot 10^{-5}$	$7.0 \cdot 10^{-8}$	$7.6 \cdot 10^{-8}$	0.30	$2.6 \cdot 10^{-5}$	$4.0 \cdot 10^{-10}$	$8.0 \cdot 10^{-10}$
R_{pc}	20	20	20	200	50	20	20
			The expectations EX				
1)	8.5	$0 \cdot 10$	$4.5 \cdot 10^{-2}$	$5.3 \cdot 10^5$	0.68	$2.4 \cdot 10^{-3}$	$1.2 \cdot 10^{-4}$
2)	0.18	$8.9 \cdot 10^{-4}$	$7.2 \cdot 10^{-4}$	$0.3 \cdot 10^6$	0.59	$3.4 \cdot 10^{-4}$	$1.9 \cdot 10^{-5}$
3)	0.12	$3.5 \cdot 10^{-4}$	$4.5 \cdot 10^{-4}$	$0.3 \cdot 10^6$	0.58	$2.0 \cdot 10^{-6}$	$9.1 \cdot 10^{-6}$
4)	$0.47 \cdot 10^{-1}$	$1.1 \cdot 10^{-4}$	$1.3 \cdot 10^{-4}$	$5.6 \cdot 10^5$	0.68	$2.6 \cdot 10^{-7}$	$1.3 \cdot 10^{-6}$

Explanations: 1) only ρ values used; 2) only ρ and μ used; 3) ρ, μ, r used; 4) used values of all quantities ρ, μ, r, v.

It appears that the first five multiple stars are certainly physical systems; ADS 10058 is probably an optical one; the quadruple star ADS 11853 is a projection of two physical binaries.

b) the multiple galaxies in the metagalactic field

Let us calculate the values P and EX for the galaxy triplets from a list of Karachentseva et al. (1979). The following characteristics of the metagalactic field were used for the estimations of the quantities sought: a mean galaxy number density of ν = 0.05 galaxies in 1 Mpc^3 (see Agekyan et al. 1962), the Hubble constant is H_0 = 75 km s^{-1} Mpc^{-1}, the radius of the sphere is $R = \max(r_A, r_C)$.

The results of calculations are in Table 5, the triplets classified by the authors of the list as the probably physical systems on a critical quantity Δv_{cr} = 500 km/s are marked by asterisks. In Table 6 (the second line), there is a distribution N (EX) of the galaxy triplets in the values EX. This Table shows that the galaxy triplets are clearly separated into two groups according to the quantities EX: 44 triplets have EX < 300, and 33 ones have EX > 1 000, there are only 6 triple galaxies in the intermediate interval. If one considers EX = 300 as a critical value of EX (an increasing of EX may be caused by an internal velocity dispersion as well as by the uncertainties in the values v of components) then for the most part (70 triplets out of 83 ones) the results by I.D. Karachentsev and V.E. Karachentseva on the selection of the physical galaxy triplets are confirmed. Only in three cases (N 33, 50, and 68 from the list by Karachentseva et al. 1979), the nearby triplets with close components have a difference Δ v of the radial velocities more than 500 km/s, however the values EX for them are small and these triplets might be qualified as probable physical systems. Ten distant and wide systems (N 31, 34, 46, 48, 60, 73–77) with Δ v < 500 km/s have EX > 300 and therefore they might be qualified as possible chance (optical) systems. Use of the criteria (6) and (7) enables to recognize 11 certainly physical systems (N 1, 22, 24, 25, 28, 33, 36, 39, 41, 44, 54) with EX < 1 and 33 probably optical systems with EX > 10^3 (their numbers are underlined in Table 6) among the triple galaxies under consideration. In Table 7 there are the distributions of the ratios of three-dimensional distances for the galaxy triplets with the quantities EX inside the intervals indicated. In the last line of this Table a number of triplets with corresponding values EX is given, in Table 7a there are the

Table 5

Triplets of galaxies

N^o	EX	N^o	EX	N^o	EX	N^o	EX	N^o	EX	N^o	EX
1*	$3.4 \cdot 10^{-13}$	15*	$2.7 \cdot 10^2$	29	$8.2 \cdot 10^2$	43*	$6.8 \cdot 10$	57	$7.1 \cdot 10^3$	71*	$2.1 \cdot 10^2$
2*	$2.2 \cdot 10^2$	16*	$2.9 \cdot 10^2$	30	$1.5 \cdot 10^5$	44*	$4.3 \cdot 10^{-3}$	58	$2.9 \cdot 10^4$	72*	$2.4 \cdot 10^2$
3*	$3.0 \cdot 10$	17	$8.8 \cdot 10^3$	31*	$6.9 \cdot 10^2$	45*	$2.2 \cdot 10$	59*	$2.1 \cdot 10^2$	73*	$3.5 \cdot 10^3$
4*	$8.5 \cdot 10$	18	$5.9 \cdot 10^4$	32	$5.2 \cdot 10^3$	46*	$1.3 \cdot 10^3$	60*	$0.8 \cdot 10^4$	74*	$7.1 \cdot 10^3$
5	$1.1 \cdot 10^4$	19	$9.1 \cdot 10^4$	33	$2.4 \cdot 10^{-1}$	47*	$1.4 \cdot 10^2$	61*	$5.8 \cdot 10$	75*	$5.5 \cdot 10^2$
6	$2.9 \cdot 10^5$	20	$4.7 \cdot 10^3$	34*	$4.1 \cdot 10^3$	48*	$3.3 \cdot 10^2$	62*	9.0	76*	$1.6 \cdot 10^3$
7	$7.2 \cdot 10^4$	21*	8.9	35	$1.9 \cdot 10^4$	49*	$2.3 \cdot 10^2$	63	$3.7 \cdot 10^3$	77*	$2.8 \cdot 10^3$
8	$2.3 \cdot 10^3$	22*	$5.5 \cdot 10^{-1}$	36*	$9.3 \cdot 10^{-2}$	50	$2.0 \cdot 10$	64*	$7.9 \cdot 10$	78*	$6.7 \cdot 10$
9	$2.2 \cdot 10^4$	23*	$1.7 \cdot 10^{-5}$	37	$0.5 \cdot 10^7$	51*	$1.2 \cdot 10^2$	65	$2.8 \cdot 10^5$	79*	$1.4 \cdot 10^2$
10	$1.8 \cdot 10^3$	24	$9.0 \cdot 10^4$	38*	$1.0 \cdot 10^2$	52*	$1.4 \cdot 10$	66	$1.8 \cdot 10^5$	80*	2.2
11*	$6.0 \cdot 10$	25*	$8.8 \cdot 10^{-1}$	39*	$2.2 \cdot 10^{-1}$	53	$1.6 \cdot 10^4$	67*	$1.6 \cdot 10^2$	81*	$9.3 \cdot 10$
12*	$9.5 \cdot 10$	26*	$6.3 \cdot 10$	40	$9.1 \cdot 10^4$	54*	$4.8 \cdot 10^{-1}$	68	$2.3 \cdot 10^2$	82*	$1.7 \cdot 10$
13	$5.8 \cdot 10^5$	27	$5.7 \cdot 10^4$	41*	$3.8 \cdot 10^{-3}$	55*	1.7	69	–	83	$8.6 \cdot 10^2$
14*	$3.0 \cdot 10$	28*	$2.1 \cdot 10^{-2}$	42*	3.6	56	$1.6 \cdot 10^5$	70*	$3.5 \cdot 10$	84	$1.6 \cdot 10^5$

Table 6

A distribution of expectations EX for the multiple galaxies from the lits of Karachentseva et al. and Dahari

EX	⩽1	1–10	10–100	100–300	300–500	500–1000	> 1000
n = 3	10	5	16	13	3	3	33
n = 2	17	11	7	6	3	3	2

mean values and rms deviations for the parameters EX, R_C/R_B, and ρ_C/ρ_B. The data show (Table 7) that a strong prevalence of small ratios R_C/R_B (an isolation of the distant component from the close pair is not large) takes place for the probably physical galaxy systems with EX < 300. At the same time, the distribution of values R_C/R_B for the probably optical systems is practically random within the interval (1, 100). Table 7a shows also the absence of correlation between the quantities (EX, ρ_C/ρ_B) and (R_C/R_B, ρ_C/ρ_B). According to this Table, the certainly physical systems have $R_C/R_B \leqslant 5$, the probably physical ones have $5 < R_C/R_B \leqslant 15$, the possible chance ones have $15 < R_C/R_B \leqslant 30$, and the certainly optical (chance) systems have $R_C/R_B > 30$.

Now, let us apply the statistical criterion of recognizing optical and physical multiple systems to the close double galaxies from the list of Dahari (1985) in which the primary components are Seyfert galaxies. The results of calculation of P and EX for these objects are in Table 8, the distribution N (EX) for them is given in the third line of Table 6. These data show that the condition EX ⩽ 1 is satisfied for 17 nearby and close double galaxies and they may be qualified as certain physical systems; the inequality 1 < EX ⩽ 300 takes place for 24 binaries and they might be qualified as

Table 7

The distributions of the hierarchy coefficients of galaxy triplets

Rc/Rb \ EX	⩽ 1	1–100	100–300	300–1000	10^3–10^5
1 – 5	4	12	6	2	7
5 – 10	6	7	2	2	6
10 – 20	1	2	3	0	4
20 – 50	0	1	1	2	5
50 – 100	0	0	0	0	6
> 100	0	0	1	0	5
N	17	22	13	6	32

Table 7a

The means of hierarchy coefficients for the galaxy triplets

EX	0.1 ± 0.2	47 ± 36	210 ± 54	540 ± 200	(30 ± 14) · 10^3
(R_c/R_b)	4.3 ± 2.3	8.0 ± 7.3	16 ± 25	18 ± 21	45 ± 65
(ρ_c/ρ_b)	3.0 ± 1.8	2.9 ± 1.8	3.0 ± 2.2	2.9 ± 1.2	3.5 ± 4.1
N	11	22	13	6	32

Table 8

Seyfert double galaxies

N°	EX	N°	EX	N°	EX	N°	EX	N°	EX
10	6.0 · 10^2	463	1.3	915	1.3 · 10^2	3227	7.0 · 10^{-3}	5506	1.0 · 10
40	2.5 · 10^{-4}	474	7.4 · 10^3	926	8.1 · 10^2	3516	2.0 · 10^2	5929	1.2 · 10^{-2}
141	1.1 · 10^2	506	1.2 · 10	975	6.1	3998	3.5 · 10^{-2}	5953	7.6 · 10^{-1}
176	4.0	530	2.9 · 10^3	1040	2.4 · 10^{-1}	4117	3.6 · 10^{-2}	6251	3.9 · 10^2
266	7.2 · 10^{-2}	533	1.3 · 10	1073	4.1 · 10^2	4151	1.3 · 10^2	7212	4.4 · 10^{-6}
268	9.6 · 10^2	595	1.3 · 10^2	1218	5.9	4258	5.1 · 10^{-3}	7319	1.8
279	5.2 · 10	612	9.5	1239	3.1	4593	1.6	7469	1.9
349	9.7 · 10^{-1}	716	2.7 · 10	1144	7.4	4922	3.9 · 10^{-2}	4329	1.3 · 10
374	4.4 · 10^2	739	1.0 · 10^{-1}	2992	5.3 · 10^{-1}	5273	2.2 · 10	700	2.5
423	1.2	744	2.0 · 10	3031	5.1 · 10	5427	6.2 · 10		

probable physical systems; six doubles (MrK 10, 268, 374, 926, 1073, and 6251) might be qualified as probable optical systems and two double galaxies (MrK 474 and 550) with $EX > 10^3$ are certainly optical systems.

7. ALGORITHM FOR RECOGNITION, ESTABLISHMENT OF A NUMBER AND MULTIPLICITY FOR SYSTEMS', AND THEIR CLASSIFICATION IN THE GENERAL FIELD

After constructing a hierarchical structure for a field of objects, using the statistical criterion one can recognize the groups of objects in the field, establish the number and multiplicity of them, and make their classification – in order to separate the chance and physical systems among them.

A proposed algorithm consists of the following operations:

1) one takes any object A_j from the general totality of N objects in the field;

2) for this object A_j, one constructs a sequence of $N - 1$ objects arranged according to decreasing of the selection parameter used in the construction of the hierarchical structure of the field;

3) for this sequence of $N-1$ objects, one obtains a sequence of the expectations $EX_1, EX_2, ..., EX_{N-1}$ according to the formulae (4) and (5) justified for the phase space;
every time, one considers as a primary object of a multiple system the inertia centre of a subsystem consisting of $i-1$ objects for which the calculatins have already been executed, and the observational data (2) and (3) for this subsystem are obtained as the means for $i-1$ and A_j objects;

4) one verifies the inequality (6) $EX \leqslant 1$ for every element of the sequence EX_i ($i=1, 2, ..., N-1$). Note that the sequence EX_i determined for $N-1$ objects considered in the phase space is no monotonously increasing sequence in spite of decreasing of the selection parameter with rise of the number i;

5) a number K of elements from the totality EX_i satisfiing the condition (6) then determines the multiplicity of this system $n = K + 1$; if neither of the elements EX_i satisfies the condition (6) then the object A_j is qualified as a single object of the field; if the criterion of isolation in the phase space is not satisfied for any object i then the observed data for this object i are excluded from the calculation of EX_{i+1}, i.e. the position of object $i + 1$ in the phase space is considered in regard to the inertia centre of $i - 1$ objects etc.;

6) an examination of elements A_j from the general totality of N objects excluding from it the objects included in the multiple systems found earlier allows to define a number n^* and a composition of the non-chance groups of objects with a various multiplicity in the general field;

7) by repeating the operations 1) and 2) and by using the statistical criterion of isolating in the coordinate space – one determines for every object A_j ($j = 1,2,..., N$) a sequence of the expectations EX^*_{ij} for the number of the corresponding chance groups in the coordinate space by using formulae (4) and (9) with the observational parameters of their members. The obtained sequences EX^*_{ij} are the monotonous inceasing sequences in accordance with the algorithm used for adding of objects to an object A_j;

8) one finds objects for which the inequality (6) ceases to be fulfilled for the increasing sequence EX^*_{ij};

9) the number $i + 1$ determines a multiplicity $n_1 = i + 1$ of a system (an object A_j and i of its companions) for which the condition of isolation is fulfilled in the coordinate space, and this system might be qualified as the certainly physical system in the field of objects under study;

10) a repetition of the operations 6) gives a number n^{**} of systems with a physical connection of their components isolated in the coordinate space. Using the statistical criterion of isolation in the velocity space, one may recognize the multiples – the certainly non-chance groups in this space – by repetition of operations 7) – 10).

8. CRITERIA FOR CLASSIFICATION OF DYNAMMICAL STATES IN CERTAINLY PHYSICAL MULTIPLE SYSTEMS

The main characteristics of dynamical states within multiples which are certainly physical (the type III of the classification of multiple systems – see item III) are the values of their total energies E and the relative energy E_{ij} ($i, j = 1,2,...,n, i \neq j$) of every possible combinations of components – the subsystems of a smaller multiplicity. The signs of the energies E and E_{ij} determine the existence or absence of dynamical connection between the components and correspondingly the classes of multiples.

Class III – 1 – multiple systems in which *there is no dynamical connection* of the components, they have *non-negative* total *energies* $E \geqslant O$. The following cases are possible:

a – 1) $E \geqslant O, E_{ij} \geqslant O; i,j = 1,2,...,n; i \neq j$
for all possible combinations of components in a system – *the dynamical connection is absent for all components;*
a – 2) $E \geqslant O, E_{ij} < O; i,j = 1,...,s; i \neq j; s < n$
(for some subsystems of a lower multiplicity) – in a multiple system there are s components connected dynamically, the rest of $n-s$ components are not dynamically connected with them and with each other;
b) the subclass – „recession" of components *connected genetically* (a *co-formation*) in a system shows a special case when two or a few components have a positive

relative energy and move in the opposite directions with a large relative velocity.

Class III–2 – multiple systems in which *there is a dynamical connection* between all components, they have a *negative* total *energy* $E < O$.

In order to relate two types of dynamics in multiple systems (stable or unstable systems) with the components connected dynamically and physically (class III – 2b) one should use the criteria developed in celestial mechanics (see e.g. Timoshkova and Kholshevnikov 1982, Anosova 1985) for stability of the systems consisting of N gravitating bodies.

III – I – *dynamically hierarchical stable* multiple systems with Keplerian character of motions of the bodies – the stability criteria (the conditions of isolation of the distant bodies from the subsystems of other bodies) are fulfilled during all the time of dynamical evolution of a multiple system.

III – II – *dynamically non-hierarchical unstable* multiple systems are separated by two forms:

a) the conditions of an escape (a hyperbolity of mainly radial motion of a distant component regarding to a subsystem of other bodies) are fulfilled from the very beginning of a study of the dynamical evolution

b) the escape conditions in a system will be fulfilled after a certain lapse of time T from the beginning of tracking of its evolution.

9. TAKING INTO ACCOUNT THE UNCERTAINTIES IN THE OBSERVED DATA ON CLASSIFICATION OF MULTIPLE SYSTEMS

In order to estimate the dynamical state of an observed star or galaxy system one must take into account some uncertainties in the observational data i.e. take into account the errors in the intial state of this system.

In the present work, in order to take into consideration this effect one proposes to use a method of statistical tests – a method of variation of observational data in the limits of their uncertainties for the components of multiple systems.

Let us describe this method for the triple stellar systems; it could be easily generalized for a system with any multiplicity.

One has for the components within a triple star system a vector of observational parameters

$$\vec{X} = (x_1, x_2, ..., x_{19}) = (\rho, \theta)_{AB,AC}; (\mu_\alpha, \mu_\delta, v, \pi, M)_{A,B,C} \quad (15)$$

and a vector of their errors

$$\vec{\delta x} = (\delta x_1, \delta x_2, ..., \delta x_{19}). \quad (16)$$

The dynamical state of a triple system is determined by the following energetic characteristics: the total energy

$$E = E(\vec{X}), \sigma_E = \sigma_E(\vec{X}, \vec{\delta x}) \quad (17)$$

and the relative energies of pairs of components

$$E_{ij} = E_{ij}(\vec{X}), \ \sigma E_{ij} = \sigma E_{ij}(\vec{X}, \vec{\delta x}) \quad (18)$$

Let us use the Monte Carlo method of the variations of values x_l within the confidence intervals

$$x_{lj} \in [x_l - \kappa\,\delta_{xl}, x_l + \kappa\,\delta_{xl}] \quad (19)$$

where $l = 1, 2, ..., 19$ is the number of the observational parameters, xl are their observed quantities, $j = 1, 2, ..., N$ is the number of the test. Proposing the Gaussian distribution for the uncertainties δ_x truncated at the confidence probability $P = 0.95$ one has a quantity $\kappa = 2$.

For every multiple system, one can make N tests varying all (of by turns) in order to obtain every time new quantities for these parameters and to calculate by them the energetic characteristics E and E_{ij} which determine every time the class of the dynamical state of this multiple system. For a large number of tests ($N \cong 10^3 - 10^4$), the frequency of realization of the classes of dynamical states determines the probabilities of these states for a multiple system under consideration.

10. DYNAMICAL STATES FOR SELECTED TRIPLE STARS

An analysis of data from nearly 60 Catalogues received from the Centre de Donnees Stelaires in Strasbourgh by the Centre of Astronomical Data of the Astronomical Council of the Academy of Sciences of the U.S.S.R. has shown that at present the total complex of observational data necessary for solution of the problems formulated above (see section II) concerning the study of multiple systems exists for 16 nearby and bright triple stars including such well-known systems such as α Cen, α Gem (Castor), γ And etc. However even for these systems, the estimations of uncertainties in the observational data are not present in the Catalogues for all components. In the present paper 8 triple stars are investigated: ADS 1630, 2926, 6175 (Castor), 6650, 6811, 7114, 9626, and 9909.

The results of application of the method of simulteneous variations of all observational parameters within the limits of their errors are given in Table 9 for these triple stars. In Table 9 there are the probabilities of dynamical states of these systems, the mean quantities of their energetic characteristics – the total energy E and energy E_b of a close pair and the mean quantities σE and σE_b for the boundaries of confidence intervals at the level 1σ for these values.

Table 9

The probabilities of dynamical states and means of energetic parameters of the triple stellar systems

Name	ADS	r (pc)	Probabilities P of states I (E ≥ 0)	III–I	(E > 0)	III–II	$E \pm \sigma_E$	$E_b \pm \sigma E_b$
γ And	1630	80	0.00	0.53		0.47	−117 ± 25	− 104 ± 19
Castor	6175	14	0.02	0.12		0.86	− 18 ± 10	− 17 ± 10
γ Sco	9909	22	0.00	0.20		0.80	− 531 ± 8.6	−44.3 ± 7.5
ζ Cnc	6650	19	0.29		0.71		− 12 ± 25	− 31 ± 17
μ Boo	9626	29	0.11		0.89		−10.0 ± 8.4	−19.6 ± 6.4
21 Cnc	6811	50	0.30		0.70		− 50 ± 140	− 80 ± 110
ι UMa	7114	16	0.20		0.80		− 4.6 ± 4.5	− 2.5 ± 2.6
	2926	170	0.97		0.03		+ 23 ± 23	+ 15 ± 23

One may formulate the results obtained as the following ones:

1) the triple stars ADS 1630, 6175, and 9909 located at the distances from the Sun of 80, 14, and 22 pc, respectively, are certainly dynamically connected systems with a probability $P \geqslant 0.98$ (the variations of energies are $\delta E = |\frac{\sigma E}{E}|$, $\delta E_b = |\frac{\sigma E_b}{E_b}| \leqslant 0.2, 0.6$);.

2) the triples ADS 2926, 6650, 6811, 7114, and 9626 have large variations of the total energy $\delta E \cong 1-3$. Therefore, for them one cannot certainly obtain the values of the total energies. However, the probabilities of dynamical connections in these systems, except in ADS 2926, are large $P(E < O) > 0.7$. The triple star ADS 2926 has a positive energy $P(E > O) = 0.97$ according to the observed data existing at present. Moreover, the maximum contribution in the positive energy E appeas to make a positive energy E_b of the close pair AB with an angular separation $\rho = 7.''6$ between the components $P(E_b > O) = 0.77$. It should be noted that the kinematical parameters of an inertia centre of the pair AB and a distant component C are in good agreement, but the uncertainties of space velocities of A and B are significantly large. Therefore, the problem of physical connections of the components of ADS 2926 may be solved only after a closer definition of the kinematical characteristics of the close pair;

3) the triple systems ADS 6650 and ADS 9626 have small variations of the energies of the close pairs $\delta E_b \cong 0.2, 0.5$ and these pairs are dynamically connected binaries with a probability $P = 0.96$; in order to establish some dynamical connection between these binaries and the third distant component one must verify the kinematical parameters for the latter one.

4) in the triple stars ADS 6811 and ADS 7114, one cannot certainly estimate the total energy E_b of a close pair (the variations $\delta E_b \cong 1$), although marked orbital motions of the components are observed in them and the probability of its dynamical connection is $P > 0.85$. One must verify the space velocities of the close stars in these systems;

5) the certainly physical triple stars ADS 6175 ($r = 14$ pc) and ADS 9909 ($r = 22$ pc) are dynamically non-hierarchical unstable triple systems with a probability $P > 0.80$ in spite of an apparent high hierarchy of their configurations: ADS 6175 – $\beta = \rho_{AC}/\rho_{AB} \cong 12$, ADS 9909 – $\beta \cong 6$. In the triple star ADS 1630 ($r = 80$ pc) one can make no certain conclusion on a type of dynamics because of the large uncertainties in the space velocity of the distant component A with respect to the close pair BC.

11. A STUDY OF DYNAMICAL EVOLUTION OF TRIPLE STAR ADS 9909 (ζ Sco)

The data from Table 9 show that the study of dynamical states of triple star systems has given the certain results at least for two triple stars ADS 6175 and ADS 9909.

A study of dynamical evolution for the second system was carried out in detail.

The triple star ADS 9909 has the following observational parameters: the precise coordinates for the epoch 1950.0 – $\alpha = 16^h01^m36^s.889$, $\delta = -11°14'12''.27$; the primary component A with an apparent magnitude $m_A = 4^m.16$ has a close companion B with $m_B = 5^m.2$ at the angular separation $\rho_{AB} = 1''.30$ and also a more distant companiom C with $m_C = 7^m.36$ at the angular separation $\rho_{AC} = 7''.43$; the spectral type of the pair AB is F 5–8 IV–V and the one of C is G 7–8 V.

One has a vector of observational data at the epoch $T_o = 1920.5$ for this system

$$\vec{X} = \rho_{AB}; \rho_{AC}; \theta_{AB}; \theta_{AC}; (\Delta\mu_\alpha)_{AB}; (\Delta\mu_\delta)_{AB}; (\Delta\mu_\alpha)_{AC}; (\Delta\mu_\delta)_{AC}; V_{A,B,C}; \pi_{A,B,C}; \qquad (20)$$

$M_{A,B,C}$ = 1".30, 7".43, 9°.0, 60°.2,
(0.044, 0.035, 0.009, – 0.009)" per year;
(–33.6, –33.6, –33.8) km/s; 0".044; (1.60, 1.20, 0.80) $M_{\odot}$

and a vector of the uncertainties for these data

$$\vec{\delta x} = \delta\rho_{AB}; \delta\rho_{AC}; \delta\theta_{AB}; \delta\theta_{AC}; (\delta\Delta\mu_\alpha)_{AB}; (\delta\Delta\mu_\alpha)_{AB}; (\delta\Delta\mu_\alpha)_{AC}; (\delta\Delta\mu_\delta)_{AC}; \delta(v)_{A,B,C}; \delta(\pi)_{A,B,C}; \quad (21)$$

$\delta(M)_{A,B,C}$ = 0".04, 0".01, 0°.7, 0°.2;
(0.005, 0.001, 0.003, 0.003)" per year; (0.2, 0.2, 0.2) km/s, 0.002; (0.10, 0.10, 0.10) $M_{\odot}$

The configuration of triple star system ADS 9909 as well as the vectors of relative proper motions of components are in Figure 1.

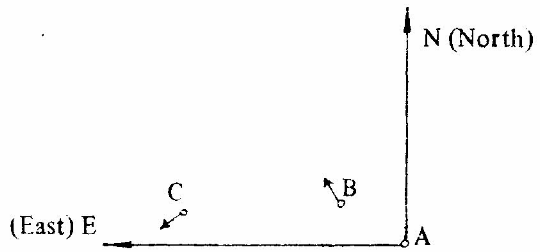


Fig. 1

The masses M of stars are calculated by the following formulae

$$\lg M = \frac{6.76 - M_{bol}}{3.85} \quad \text{for } M_{bol} > 7^m.5$$

$$(22)$$

and $$\lg M = \frac{4.62 - M_{bol}}{10.03} \quad \text{for } M_{bol} < 7^m.5$$

the quantities M are expressed in the solar masses; M_{bol} is the bolometric absolute magnitude of stars to be obtained by their spectral types and luminosity classes.

The following system of units is assumed (see Anosova 1985)

unit of distance $[r] = 0.01\ l_* \text{ pc} = 2062.65\ l_* \text{a.u.}$
unit of mass $[M] = 2 \cdot 10^{33}\ \mu_*\ \text{g},$ (23)
unit of time $[t] = 10^4\ k_*$ years,

One may assume $l_* = \mu_* = k_* = 1$ for the multiple systems with components – the solar type stars. The unit star velocity is $[v] = 0.9778$ km/s, $G = 0.4474$.

In Table 9 (the third line) there are given the results of determining the dynamical state of the triple star ADS 9909 – the probabilities of dynamical connection between components and the quantities of energetic parameters. These data show that this triple star is a certainly physically connected system with the probability $P \cong 1$; its energies E and E_b are reliably obtained with the variations $\delta E = |\frac{\sigma E}{E}| \leqslant 0.2$, $\delta E_b = |\frac{\sigma E_b}{E_b}| \leqslant 0.2$. Therefore, one can solve the problem of determining its dynamics type stable or unstable (see item IX and Anosova 1985, Anosova and Orlov 1985, Anosova 1986).

In order to solve this problem one may again use the method of statistical tests proposed above for 50 runs varying the observational data (20) of their doubled errors assuming the Gaussian distribution of these uncertainities. One calculates the means, and rms deviations of the basic dynamical parameters (see Anosova 1985, Anosova and Orlov 1985, Anosova 1986) at an initial time moment T_0.

The following initial data have been obtained as a result of the tests carried out – the coordinates and velocities of the components are in the baricentric coordinate system the masses of the bodies are relative

$x_1 = -0.0162, \pm 0.0007$	$x_2 = -0.0017, \pm 0.0014$	$x_3 = 0.0356 \pm 0.0021$
$y_1 = 0.0139, \pm 0.0016$	$y_2 = -0.0139, \pm 0.0016$	$y_3^3 = -0.0501 \pm 0.0033$
$z_1 = 0$,	$z_2 = 0$,	$z_3 = 0$
$\dot{x}_1 = -1.37 \pm 0.19$,	$\dot{x}_2 = 3.20 \pm 0.21$,	$\dot{x}_3 = -2.15 \pm 0.31$
$\dot{y}_1 = 1.64 \pm 0.24$,	$\dot{y}_2 = -2.47 \pm 0.45$,	$\dot{y}_3 = 0.47 \pm 0.30$
$\dot{z}_1 = 0.02 \pm 1.32$,	$\dot{z}_2 = -0.02 \pm 1.66$,	$\dot{z}_3 = 0.09 \pm 1.38$
$M_1 = 1.0$,	$M_2 = 0.76 \pm 0.08$,	$M_3 = 0.49 \pm 0.07$

where the indexes 1,2,3 correspond to the components A,B,C, respectively.

The main dynamical parameters of the triple star ADS 9909 have the following values at an initial time moment $T_0 = 1920.5$:

mean dimension $d = (32 \pm 2)$ a.u.,
mean crossing time $\tau = (2.7 \pm 3)$ years,
total energy $E = (-53.2 \pm 8.6)$ – energy units in the system of units (23);
total energy of the close binary $E_b = (-44.3 \pm 7.5)$ energy units;
virial coefficient $k_0 = \frac{T_0^*}{U_0} = (0.28 \pm 0.01)$ where T_0^* and U_0 are the kinetic and potential energies of the system at $t = T_0$; an angular momentum $L = (0.11 \pm 0.02)$ units of angular momentum; the dynamical elements of the inner pair (AB) orbit: major semi-axis $a_{in} = (19.5 \pm 0.4)$ a.u., eccentricity $e = (0.78 \pm 0.02)$, period

P_{in} = (54 ± 1) years; the dynamical elements for the external pair AB–C: a_{ex} = (170 ± 50) a.u., e_{ex} = (0.71 ± 0.21), P_{ex} = (1.2 ± 0.2) · 10^3 years; coefficient of stability $s = \frac{a_{ex}(1 - e_{ex})}{a_{in}}$ = (2.3 ± 0.9), its critical quantity s* = 3.5 (if s > s* a triple system must be stable – according to Hairingtons 1972) criterion.

The probability that the triple system ADS 9909 is stable is equal P_s = 0.05, the probability of instability is P_{is} = 0.95.

In connection with the conclusion that ADS 9909 has the unstable type II of dynamics one may study the dynamical evolution of this system by computer simulations (see Anosova 1985, 1986, Anosova and Orlov 1985). A corresponding study carried out from T_0 = = 1920.5 has given the following results: a lower limit of escape time is t_e = (1.2 ± 0.3) · 10^3 years (in 38% of the cases under consideration, the system did not disrupt during a time t = 100 τ = 3 · 10^3 years); one has observed during the evolution n = 4.3 ± 2.6 of triple approaches of bodies which have a perimeter $p = \sum_{i \neq j} r_{ij} \leqslant 100$ a.u. where r_{ij} is the distances between two components; a triple approach causing an escape has the perimeter p = = (56 ± 18) a.u.; a final binary AB (after the escape of component C) has a semiaxis major a_f = (5.1 ± 1.6) a.u., an eccentricity e_f = 0.70 ± 0.27, and a period P_f = (23 ± 7) years; a value of cos χ = 0.95 ± 0.05 where χ is an inclination of the orbit of the escaper C to the orbit of the final binary AB – both orbits are approximately co-planar (as at the initial time moment T); the inclination of the velocity vector of the escaper C to the angular momentum vector of the triple system is given by cos γ = 0.017 ± 0.011; the final value of the virial coefficient is k = 0.43 ± 0.16 at the end of evolution (after escape of component C γ – the system is near an equilibrium state; an excess of the energy taken away by the component C is equal to DE = 0.14 ± 0.80 – an excess of the kinetic energy of escaper over the one necessary for an escape of triple system according to the criterion of G.A. Tevzadze (see 1962).

Thus, the study of the dynamical state and dynamical evolution of the triple star ADS 9909 (γ Sco) carried out here has shown that this system is certainly a physical one and it has probably the unstable type II dynamics. The quantitative results obtained on the basis

Table 10

Individual contribution of uncertainties of the observational data

Parameter x_1	Uncertainty δx_1	π = 0".070 x_1	δE	π = 0".010 x_1	δE
π"	±0.005	0.070	0.05	0.010	0.45
	0.002		0.04		0.20
(μ_{AB})"/y	±0.005	– 0.026, + 0.006	0.02	–0.0022,0.003	0.25
	0.0005		0.00		0.03
μ_{AB} (μ_0)	±0.5	0.6	0.25	0.4	0.10
	0.2		0.10		0.04
μ_c "/s	±0.005	0.048, – 0.037	0.05	0.002,0.002	0.08
	0.0005		0.01		0.01
V_{AB} km/s	±1.0	– 7.2	0.03	3.4	0.08
	0.3		0.01		0.02
V_c km/s	±1.0	3.2	0.02	1.6	0.06
	0.3		0.01		0.02
ρ"$_{AB}$	±0.1	6.25	0.02	7.58	0.02
	0.005		0.00		0.00
M_c (M_0)	±0.5	2.2	0.02	2.1	0.01
	0.2		0.01		0.00
ρ"$_{AC}$	±0.1	73.41	0.1 · 10^{-3}	57,64	0.3 · 10^{-2}
	0.005		0.5 · 10^{-5}		0.2 · 10^{-5}
Integral contribution	$(\delta x_1)_{obs}$		0.27		0.50
	$(\delta x_1)_{min}$		0.10		0.25

of observational data have given a large dispersion in values of the evolutional parameters; in order to obtain more certain results one should improve the accuracy of the observational data.

12. THE NECESSARY ACCURACY LEVEL OF THE OBSERVATIONAL DATA

The method proposed in order to take into account the uncertainties in the observational data for the multiple star components allows to estimate the individual contributions from the uncertainties of every characteristics observed and to evaluate the accuracy level necessary for solving the problem produced – revealing the dynamical states of objects under study.

In the present work, such a study has been carried out for two triple stars α Gem (Castor) – ADS 6175 and ADS 2926 whose parallaxes are equal to 0".070 and 0".010 respectively.

The results are given in Table 10. In the first column of this Table there are the observed data x_1; in the second column there are their uncertainties δx_1 obtained from the observations (the upper lines and the values $(\delta x_1)_{min}$ corresponding to the maximum accuracy level reached at present by the systematically planned observations (the lower lines) – see Kiselev and Kiyaeva 1980, Anosova 1984, Anosova and Orlov 1985, Dommanget 1985, Anosova 1986, Anosova and Sudakov 1987, Anosova et al. 1987.

The conditions of reaching such an accuracy level in the observational data for the components of triple stars will be given below. In the following columns of Table 10 there are the values of the observed characteristics x_1 and the variations $\delta_E = |\frac{\sigma_E}{E}| = |\frac{E(x+\delta_x)-E(x)}{E(x)}|$ of a relative change of the total energy for the systems ADS 2926 and ADS 6175 under consideration.

The study carried out has given the following results: 1) the variations of energy are $\delta_E \sim \kappa\ \delta_x$, κ = const for all values x_1; 2) the main contribution in δ_E for rather distant triple stars is given by the uncertainties in the parallaxes being a growth of δ_E with a decrease of π (Table 11).

Table 11

Dependence $\delta\pi$ on π

π	$\delta_\pi = \pm$ 0".005	$\delta_\pi = \pm$ 0".002
0".070	0.08	0.03
0.040	0.20	0.08
0.020	0.50	0.20
0.010	–	0.40

3) therefore, a reliable study of dynamics for the triple stars with $\delta_\pi = \pm$ 0".005 is possible only for $\pi \geqslant$ 0".020 (the probability of dynamical connection between components $P(E - 2\sigma_E \leqslant 0) \sim 1$ on $\delta_E \leqslant 0.50$ and $E < 0$); in the opposite case, the sign of the total energy and, therefore, the probability of dynamical connection is not determined. The study of triple stars with $\pi \geqslant$ 0".010 is possible for $\delta_\pi = \pm$ 0".002 (see Dommanget 1985);

4) taking into account the sizes Δz of triples along the line-of sight for $\delta_\pi = \pm$ 0".005 a reliable study is possible only for the triple star α Cen (Table 12) supposing Δz = 0.01 pc – a mean size of triple systems whose components are solar-type stars. Some attempts of analogous study for the triple star ADS 3093 are possible for $\delta_\pi = \pm$ 0".001–0".002 (using the observations by the cosmic observatories – see Dommanget 1985). Taking into account the sizes along the line-of-sight for more distant systems a reliable study is possible only statistically.

Table 12

$\Delta\pi$" (Δz = 0.01pc)	π"	triple system
± 0.010	0.756±0.003	α Cen
0.001	0.202±0.006	ADS 3093
0.0002	0.074±0.001	α Gem

In order to take into account the sizes of systems along the line of-sight by statistics one must obtain the relative distances R_{ij} between the components i and j with the angular separation ρ_{ij} and positional angle θ_{ij} according to the formula

$$R_{ij} = \frac{4}{\pi}\rho_{ij}$$

where $\rho_{ij} = R_{ij}\cos\omega$, ω is the angle between the vectors R_{ij} and ρ_{ij},

$$\rho_{ij} = \frac{1}{4}\int_{o}^{2\pi}\int_{-\pi/2}^{\pi/2} R_{ij}\cos^2\omega\, d\theta_{ij}\, d\omega = \frac{\pi}{4} R_{ij}$$

(according to Kleiber's theorem) assuming an equal distribution of angles ω and θ_{ij} within the intervals $[-\pi/2, \pi/2]$ and $[0, 2/\pi]$;

5) for the hierarchical triple stars, taking into account of observed parameters for a close pair (at first, the relative masses of components, then, their relative proper motions) plays a great role;

6) the smallest contribution in the variations δ_E of multiple systems is made by the uncertainties in the relative coordinates.

The necessary accuracy level of observations might be reached on the following conditions:

a) for the astrometrical observations an accuracy $\delta_\rho = \pm$0".005 and $\delta_\mu = \pm$0".0005 per year (ρ, μ are the relative coordinates and proper motions of components) may be achieved on $\rho >$ 3" by the dense series of observations at the long-focus refractors during 10–15 years (Kiselev and Kiyaeva 1980); for the systems containing the close pairs with $\rho < 2''$, one must carry out the specle interferometry observations;

b) the uncertainties of the radial velocities $\delta_V = \pm 0.1$–0.5 km/s are reached by the spectrocsopic observations using the equipment of CORAVEL's type (Anosova et al. 1987);

c) one may obtain the uncertainities $\delta_M = \pm 0.2$ M_0 of star masses using the differences of their apparent magnitudes (data from the photoelectric photometry) in the nearby triple systems with the well-known trigonometric parallaxes for every component provided that any peculiarity in their spectra is absent.

d) an accuracy level $\delta_\pi = \pm 0''.002$ of the stellar parallaxes is proposed to be reached by the observations on board of the European astrometric satellite HIPPARCOS;

e) an essential increase in the accuracy of astrophysical and astrometrical data (δ_μ, $\delta_\pi = \pm 0''.0003$) will be reached by the observations on board of the HUBBLE SPACE TELESCOPE.

A program of the Leningrad University Observatory consisting of 137 neaby and bright multiple stars and made with a purpose to study their dynamical states has been included in the HIPPARCOS Input Catalogue (in part, in accordance with the technical possibilities) and submitted to the HUBBLE SPACE TELESCOPE Science Institute.

REFERENCES

Abt, H. A., Levy, S.: 1976, *Astrophys. J. Suppl. Ser.*, **30**, 273.
Agekian, T. A. et al: 1962, *The Course of Astrophysics and Stellar Astronomy*, Moscow, Nauka, vol. 2.
Aivasian, C. A., Bezhaeva, S. I., Staroverov, O. W.: 1974, *Classification of Multivariate Observations*, Moscow, Statistics.
Anosova, J. P.: 1984, *Problems of Astrophysics*, Saransk, 75.
Anosova, J. P.: 1985, *Totals of Science and Technology*. Ser. Astronomy, **26**, 57.
Anosova, J. P.: 1986, *Astrophys. and Space Sci.*, **124**, 217.
Anosova, J. P.: 1990, *PH. D. Thesis*, Leningrad State University.
Anosova, J. P., Orlov, V. V.: 1985, *Transactions of Astron. Observ. of the Leningrad State Univ.*, **40**, 66.
Anosova, J. P., Sudakov, S. V.: 1987, *Transactions of Astron. Observ. of the Leningrad State Univ.*, 41, 80.
Anosova, J. P., Sementsov, V. N., Tokovinin, A. A.: 1987, *Sov. Astron.*, **64**, 2, 423.
Brosche, P.: 1964 *Astron. Nachr.*, **288**, 33.
Dahari, O.: 1985, *Astron. J.*, **90**, 1772.
Deutsch, A. N.: 1961, *Isv. of Pulkovo Observ.*, **22**, 79.
Dommanget, J.: 1977, *Revista Mex. Astron. y Astrofis.*, **3**, 67
Dommanget, J.: 1985, *Astrophys. and Space Sci.*, **110**, 47.
Geller, M., Huchra, J.: 1983, *Astrophys. J. Suppl. Ser.*, **52**, 61.
Gliese, W.: 1969, *Veroffentl. Astr. Rech-Inst.* Heidelberg, No 22.
Holmberg, E.: 1940, *Astrophys. J.*, **92**, 200.
Huchra J., Geller, M.: 1982, *Astrophys. J.* **257**, 423.
Jeffers, H., van den Bos, W., Greeby, F.: 1963, *Index catalogue of visual double stars, 1961*, **O–Univ.** Calif. Publ. Lick observ., 21.
Karachentsev, I. D.: 1976, *Problems of Cosmic Physics*, **5**, 201.
Karachentseva, V. E., Karachentsev, I. D., Shcherbanovskij, A. L.: 1979. *Izv. Spec. Astrofis. Observ.*, **11**, 3.
Kiselev, A. A., Kiyaeva, O. V.: 1980, *Sov. Astron.*, **57**, 1227.
Materne, J.: 1978, *Astron Astrophys.*, **63**, 401.
Poveda, A., Allen, C., Parrao, L.: 1982. *Astrophys. J.*, **258**, 589.
Terzadze, G. A.: 1962, *News Acad. Sci. Armenian SSSR*, **15**, 167.
Timoshkova, E. I., Kholshevnikov, K. V.: 1982, *Totals of Science and Technology, Ser Astron.*, **20**, 3.
Tully, R.: 1980, *Astrophys. J.* **237**, 390.
Turner, E. L., Gott, J.: 1977, *Astrophys. J.* **213**, 309.
Vennik, J.: 1984, *Tartu Astrophys. Observ.*, Prepring.
Wielen, R.: 1974, *Astron. Rechen-Inst. Heidelberg Mit.*, *A*, **86**, 395.
Worley, C.: 1977, *Revista Mex. Astron. y Astrofis.*, **3**, 57.

ТРАГАЊЕ И КЛАСИФИКАЦИЈА ВИШЕСТРУКИХ СИСТЕМА У ОПШТЕМ ПОЉУ

Ж. П. Аносова

Опсерваторија Лењинградског универзитета

УДК 523.83

Оригинални научни рад

Предмет овог рада је проучавање вишеструких звезда и галаксија са циљем да се класификују њихова динамичка стања и да се пронађу статистички критеријуми за разликовање случајних група објеката од неслучајних. Предложени статистички критеријум је примењен на неке вишеструке звезде и галаксије. Разрађен је одговарајући алгоритам и на крају су проучена динамичка стања тројног система ADS 9909 (Sco) узимајући у обзир грешке посматрачких података.

Bull. Obs. Astron. Belgrade N° 142 (1990), 17–21

UDC 521.174
Original scientific paper

AN APPROACH TO THE PROBLEM OF SECULAR ACCELERATION OF THE MOON

V. Protitch–Benishek, M. B. Protitch

Astronomical Observatory, Volgina 7, 11050 Belgrade, Yugoslavia

(Received: January 4, 1990)

SUMMARY: If we adopt the solution of extended method in the Delaunay theory of the Moon as real and entirely logical and substitute the square term in the Moon's mean longitude by the very long period inequality, the remaining residuals – fluctuations – can be treated as the consequence of collected effect of a few other inequalities. The frequencies of these periodical terms correspond to the identical relative positions of the Moon's node, Sun and Earth.
On the basis of such an approach to the problem of secular acceleration of the Moon and fluctuations, lunar observations in the period 1681 – 1985 are analysed.
The results are quite consistent with values presented by other authors.

1. INTRODUCTION

The secular quadratic term was introduced in the expression for the Moon's longitude on the basis of Halley's conclusion that the mean lunar motion was not constant (Halley, 1695). The term had an empirical character and from the very beginning there have been great difficulties in attempts of establishing its real amount and finding an acceptable theoretical explanation. Unfortunately, in spite of the efforts of many investigators during almost three whole centuries, we cannot claim that in this field significant progress has been achieved.

Even the theory of nonuniformity in the Earth's rotation based on the lunar tidal effect, contrary to expectations, has failed in giving a complete explanation of the difference between the lunar secular acceleration derived theoretically and the values resulting from observations. Brumberg and Kovalevsky (1986), and especially Seidelmann (1986), certainly for this reason put this problem among the unsolved problems of Celestial Mechanics since it is doubtlessly important also from the point of view of the Earth–Moon's stability system.

However, if one thinks about the reasons why the final solution of the problem is still unceratain, it is not difficult to suppose that this situation may be the consequence of assuming a priori the notion of the secular acceleration in the mean lunar motion as an evident fact and of accepting the existing formal theoretical explanation as a proof for its real existence. But such a concept certainly includes a quite different approach to the problem and a subsequent analytical solution, more adequate for the explanation of the phenomenon.

2. MEAN LONGITUDE OF THE MOON

Supposing that such a line of reasoning is correct and justified, it is of interest to envisage what kind of result can be obtained if the residuals found in the lunar longitude are expressed as a collective effect of several long–period inequalities; in other words, if an alternative assumption is introduced. The alternation possibility was also mentioned by Newcomb in his „Researches" (Newcomb, 1878), in addition to the hypothesis of nonuniformity in the Earth's rotation. However, we do not limit ourselves in this procedure to pure fluctuations alone, but we also take into account the secular quadratic term completely. A sufficiently reliable basis to such an approach is the already known analytical solutions of the differential equations of mass-point motion through the procedure applied in Delaunay's theory of the Moon. Solutions of this kind have been the subjects of many studies and cases of their application in Celestial Mechanics become more numerous today (e. g. the problem of motion near the libration points, the problem of central motion of an unlimited number of masive bodies, etc). The use of modern methods adapted to software application aimed at finding such solutions also contributes to this.

Without going into details, it will be enough to write down only the solution defining the mean longitude analytically:

$$L = L_0 + n \cdot t + \sum_{i=1}^{n} A_i \sin(\alpha_i \cdot t + \beta_i) \qquad (1)$$

mentioning that analogous relations are obtainable also for the cases of ω and Ω (pericentre longitude and node of an orbit) and that in the expressions yielding a, e, i (semi–major axis, eccentricity and inclination) there is no secular linear term. As for the parameters L_0, n, A_i, α_i, β_i, the best way is their determination from direct observations since according to the existing experience only then one can avoid the differences appearing usually between their real values and the theoretically derived ones.

As seen, there are no quadratic and mixed terms in which t is before the sign Σ, here. This means that such solutions are in accordance with the oscillatiory nature of central motions of celestial bodies being essentially true, but in macrodimensions. In addition they are not contradictory to Kepler's laws and the stability of a system is not violated, in particular of the Earth––Moon system.

It should be mentioned that Brown's theory of the Moon is practically also based on solutions of this kind, though the classical definition and the presentation of secular inequalities as a series are preserved in it:

$$P_1 \cdot t + P_2 \cdot t^2 + \ldots$$

In this way Brown, like Hansen and Newcomb before him, had no choice but to introduce also an empirical long–period term in the longitude expression. For residual deviations, the minor fluctuations as they were named by Newcomb, had been looked for and various solutions were found until de Sitter (1927) and later on, Spencer Jones (1939) proposed their solutions in which the fluctuations were interpreted as a set containing the difference between the observational and theoretical secular acceleration value and the minor fluctuations. The consequences of such an approach are well known.

3. OBSERVATIONAL DATA ANALYSIS AND RESULTS

By reducing the discrepancies (O–C) in the Moon's mean longitude to the quasi-keplerian motion, taking also into account the total amount of the secular acceleration, M. Protitch (1987) attempted their explanation following the conclusions mentioned above. In this way, he demonstrated after the revision and analysis of Newcomb's results from 1878 and 1917, firstly in Hansen's system and afterwards by reducing to Brown's system, that all ancient. Babylonian–Hellenic––Arabian, and later (by the end of 17th century) eclipses of the Moon can be well represented by substituting the quadratic term with an inequality of a very long period. He also established that as a consequence of such an interpretation a periodical character in the fluctuations is clearly seen and that their frequencies are correlated with cycles whose durations are determined by the time needed for the restitution of the same, or nearly the same, relative positions of the Sun, the Earth, the node and the perigee of the lunar orbit.

The plots presented here (Fig. 1, a, b) display the trend of the residuals in Hansen's system before and after the elimination of its secular quadratic term ($\dot{n}$ = = +26".68 arc sec/cy^2 epoch 1900.0). One should add that the parameters of this inequality are derived in a way similar to Newcomb's one (Newcomb, 1917) but omitting his correction to the secular acceleration.

These results gave us an impetus to carry out a verification of such an approach to the problem based on an analysis of later lunar observations (from the period 1681–1985) not considered by him and to establish whether an alternative concept of the secular acceleration, phenomenologically and according to what contains very different from the present one, is justified or not.

The data used by us for this purpose are taken from Brouwer's (1952) thorough study. On the basis of his values B, which are fluctuations in the Moon's mean longitude, by applying a corresponding correction G and also the long–period Venus term A, accepted from Hansen's theory, we obtain the residuals with respect to the quasi-keplerian motion. With regard to (1) we should have:

$$\delta L_k = (O-C)_k = \delta L_0 + \delta n \cdot t + \sum_{i=1}^{n} C_i \sin(\alpha_i \cdot t + \beta_i) = B + \dot{G} + A \qquad (2)$$

where: δL_0 and δn are the longitude corrections for the epoch and for the mean diurnal motion, C_i, α_i and β_i

are the parameters of the assumed inequalities which should be determined, B are Brouwer's fluctuation values derived from occultations, G and A are the corrections of the form:

$$G = 4''65 + 12''96T + 12''36T^2 + A$$
$$A = +14''27 \sin(131^\circ 92T + 344^\circ 82)$$

(T from 1900.0 in Julian centuries).

One should say that the values B do not contain Brown's great empirical term and that the quadratic term in G is the tropic value of the secular acceleration derived from observations (theoretical value+de Sitter's correction $7''14T + 5''22T^2$) also assumed by Spencer Jones (1939).

In Brouwer's series there are data by 1948.5 only. Therefore, to obtain the further data (by 1985) we use the published values of ΔT according to Clemence's (1948) definition:

$$B'' = 0''5491 \cdot T - 13''77 - 39''71 \cdot T - 16''44T^2$$

where T is in time seconds.

Though inhomogeneous the material prepared in this way gave nevertheless a sufficiently reliable base for solving the problem. The data from the period 1920–1950 are treated by use of the third–degree–five–points–least–square–smoothing procedure.

The main problem which should be solved requires a number of periodical terms, which can be important, to be known. One of them is found immediately: we assume the long–period inequality having been the substitution for the secular quadratic term in an earlier paper (Protitch, 1987). In addition, it is a part of global fluctuations so that finding a real solution for its residual part would be at the same time a confirmation to its reality.

The numerical value of this inequality derived from observations covering an interval greater than 24 centuries is: $+2369''9 \cdot \cos(6''883T + 270''33)$. Its period is 5230 tropic years, or 64686 synodic, 69325 anomalistic and 70197 draconistic lunar revolutions. The amplitude is, as seen, identical to the variation amplitude. The introducing of it implies a mean longitude correction for 1900.0 of: $\delta L_0 = -14''07$ and a reduction in the annual mean motion of $\delta n = -2''9316$. By omitting this term denoted as δL_1 one would obtain the fluctuation amount with respect to the quasi-keplerian motion:

$$B_k = \delta L - \delta L_1 = \Delta\delta L \qquad (3)$$

which should be represented through the corresponding long–period functions.

In our analysis we just interpret $\Delta\delta L$ and on the basis of the smoothed curve for the interval 1695–1985.

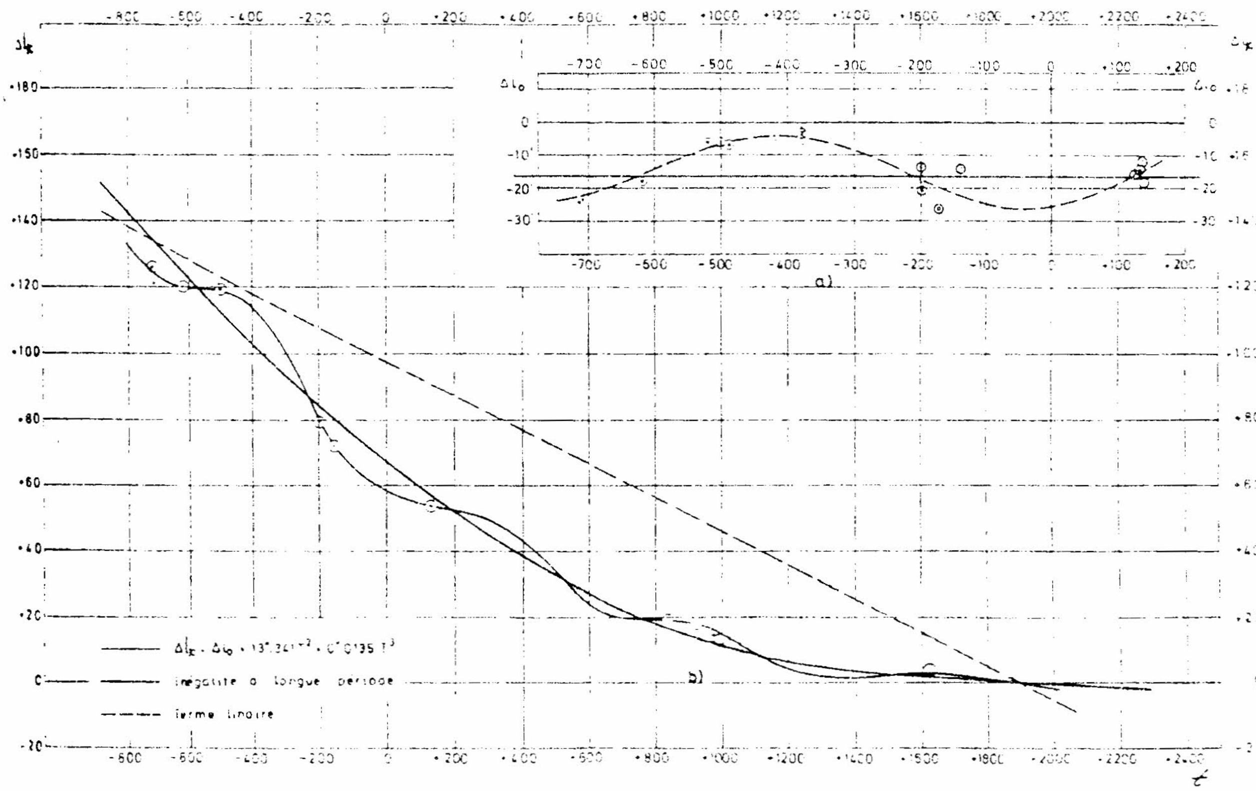


Figure 1. The trend of residuals in the mean longitude of the Moon (Hansen); a – secular quadratic term included, b – in the quasi–keplerian system secular quadratic term eliminated.

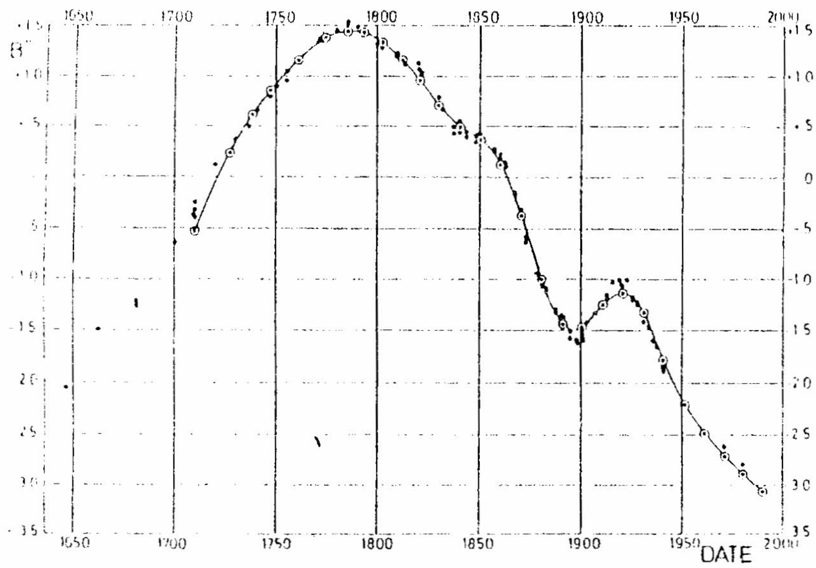


Figure 2. Fluctuations in the Moon's mean longitude. The dots represent observed values used by various authors (De Sitter, Sp. Jones, Brouwer, Morrison) and the full line represents the calculated values (Protitch).

in which a periodical character is clearly seen, we choose twenty equidistant values.

By applying the classical procedure of determining the parameters of a periodical function and assuming i = 4 we determine C_i, α_i, β_i. The obtained periods indicate their similarity to the commensurability periods for longitudes of the Sun, the Moon's node and the Earth and therefore they are reduced to the latter ones. However, the inspection of the residuals reveals the presence of at least two additional periodical terms. Repeating the procedure we find the periods for which the following rounded values are assumend: 46.5 and 74.5 years. These periods appear to be commensurable with the lenght of the eclipse year and begin at the times when the lunar nodes and the Sun are in the same point of ecliptic. An insight into Oppolzer's (1887) Canon or Meeuse–Mucke's (1983) Canon is in favour of their reality.

Without insisting upon a high precision in deriving the parameters C_i and β_i assuming that the seven long–period inequalities can be substituted as the input data with a sufficient accuracy (within +1 arc second) we determine the values $(B_o)_C$ by applying the inverse procedure. Their trend is presented in Fig. 2 together with the values used by other authors. True, as far as we know, Stoyko (1967) and Pejcev (1986) mentioned in their papers concerning the nonuniformity in the Earth's rotation that in this the longitude of the node of the lunar orbit and the Moon's relative position with respect to the Sun have some part, but without answering the question completely. If we wanted to use our results concerning this matter, we would establish that the correction ΔT has a tendency of further increase.

4. CONCLUSION

We are fully aware of criticisms which can be addressed to such an attempt of explaining the fluctuations in the mean lunar longitude and also the ones in its secular acceleration. It is well known that many authors before us (Cowell, Brown, Radau, Ross, etc) have tried and found in a similar way various long–period terms, but without attempting to look for any explanation of their nature. Examples are the long–period empirical terms introduced by Newcomb, Brown, Fotheringham and others. Similar analyses and attempts to express the trend of the corrections ΔT through periodical functions and consequently to determine the values for the near future by means of extrapolation, as done for example by Cholij (1989), are becoming more and more frequent nowadays.

REFERENCES

Halley, E.: 1695, *Phyl. Trans. Roy. Soc. London*, No 218.
Brumberg, V. A., Kovalevsky, J.: 1986, *Celest. Mech.*, 39, 133–140.
Seidelmann, P. K.: 1986, *Celest. Mech.*, 39, 141–146.
Newcomb, S.: 1878, *Researches on the Motion of the Moon*, Pt. I, Washington.
De Sitter, W.: 1927, *On the secular acceleration and the fluctuation of the longitude of the Sun. Mercury and Venus*, BAN, 4, 124.
Spencer Jones, H.: 1939, Mon. Not. R. Astr. Soc., 99.
Protitch, M. B.: 1987, *Les fluctuations dans la longitude de la Lune et la rotation de la Terre*, presented on Coll. N° 100 (unpubliched).
Newcomb, S.: 1917, Astron. Pap., Vol. IX, Pt. II.
Brouwer, D.: 1952, *Astron. J.*, 57, 125.
Clemence, G. N.: 1948, *Astron. J.*, 53, 169.
Cholij, V. Ya.: 1989, *Kinem. Fiz. Nebes. Tel*, 5, 7–12.

СЕКУЛАРНО УБРЗАЊЕ У СРЕДЊОЈ ЛОНГИТУДИ МЕСЕЦА: МОГУЋЕ ОБЈАШЊЕЊЕ

В. Протић – Бенишек, М. Б. Протић

Астрономска опсерваторија, 11050 Београд, Волгина 7, Југославија

УДК 521. 174
Оригинални научни рад

Ако се прихвате као реална и сасвим логична решења добивена генерализацијом метода примењеног у Delaunay-евој теорији Месеца, па уместо секуларног квадратног члана у његовој средњој лонгитуди уведе дугопериодична неједнакост, преостали резидуи /O–C/ – флуктуације – могу се објаснити као последица сумарног ефекта суперпоновања неколико других неједнакости, различитог трајања и амплитуда. Фреквенце тих неједнакости сразмерне су интервалима времена који деле тренутке наступања идентичних, или квази-идентичних релативних положаја чвора Месечеве путање, Земље и Сунца.

У овом раду приказани су резултати до којих се долази анализом података посматрања из периода 1681–1985. Тако изведене флуктуације добро се слажу са вредностима које су дали други аутори.

Bull. Obs. Astron. Belgrade N° 142 (1990), 23–27

UDC 524.7–85
Original scientific paper

A CONSIDERATION OF VELOCITY DISTRIBUTION WITHIN CORONAE OF GALAXIES

S. Ninković,

Astronomical Observatory, Volgina 7, 11050 Beograd, Yugoslavia

(Received: August 24, 1989)

SUMMARY: Coronae of galaxies are assumed to be spherically symmetric, self-consistent and in a steady state. The velocity distribution is studied on the basis of the hydrodynamical equation through the ratio $\overline{v_t^2}/\overline{v_r^2}$ (transversal aul radial velocity components, respectively). It is found that in the conditions supposed to occur in real galaxies the radial velocities prevail so that the fraction of the radial velocity in the total kinetic energy of the system attains even more than 50%. Applied to our Galaxy the results of the present paper suggest a value of the ratio mentioned above of a little bit greater than one at the galactocentric position of the Sun.

1. INTRODUCTION

It is well known that for the purpose of explaining some phenomena in stellar astronomy (rotation curves of spiral galaxies, etc) a concept of galactic coronae-vast, very massive systems, dominating the dynamics of their galaxies--has been developed (e. g. Trimble, 1987). Because of sufficiently flat rotation curves an inverse-square law has been usually assumed for the mass distribution within the coronae. Since the coronal constituents are unknown, there is no observational evidence on their velocity distribution. However, as well known, in the most simple case when spherically symmetric coronae are considered, the inverse-square law can be obtained by assuming an isotropic and isothermal velocity distribution. On the other hand Antonov and Chernin (1975, also Antonov et al., 1975) argued that an isotropic and isothermal velocity distribution cannot be expected within very rarefied systems such as coronae since their relaxation time is extremely long. The two authors proposed another velocity distribution characterised by a domination of radial velocities which may have resulted from the primordial conditions. One should point out that a pure inverse-square law is not realistic for two reasons:

i) it yields a singularity in the central density;

ii) integrated over infinity it yields an infinite total mass. To avoid the second disadvantage one can assume that the inverse-square law is valid only within a finite radius. However, in this case we have a discontinuity at the boundary of the system since at the inner side of the boundary the density is greater than zero and at the outer one it vanishes.

The purpose of the present paper is to introduce more realistic conditions for the density function and then to consider the velocity distribution under these conditions.

2. THEORETICAL BASE

For reasons of simplicity it is here assumed that the corona of a galaxy is a self-consistent system. In such a case the most simple decision is to assume also the spherical symmetry and the steady state. In reality the coronae co-exist with discs of their galaxies so that strictly speaking they cannot preserve the spherical symmetry which they might have if they existed separately.

These two assumptions mean that the Poisson equation and the hydrodynamical one (e. g. Ogorodnikov, 1958) are valid. The latter equation will be written here because in the present paper it is widely used

$$\overline{v_t^2} = u_c^2 + \frac{r\,d\rho}{\rho\,dr}\overline{v_r^2} + 2\overline{v_r^2} + r\frac{d\overline{v_r^2}}{dr} \qquad (1)$$

In equ. (1) the following designations are used: $\overline{v_t^2}$–the mean square of transversal velocity at a given radius r, $\overline{v_r^2}$–the mean square of radial velocity, u_c–the circular velocity and ρ the density.

It can be proved that at the centre (r=0) is valid $\overline{v_t^2} = 2\overline{v_r^2}$ provided that the density function is realistic, i. e. being decreasing, finite at the centre, almost constant near it and vanishing at a certain radius r_l, so that the derivative is always negative, except at the centre where it vanishes, but near it its absolute value is very small. The proof easily follows from (1) since under such conditions must be $u_c(0) = 0$. Therefore, it is clear why in different families of models describing the spherically symmetric and self-consistent systems in a steady state the velocity distribution is isotropic at the centre (Binney and Tremaine, 1987, p. 242).

Beyond the centre the velocity distribution of a spherically symmetric system is generally anisotropic because in such systems it depends on two integrals of motion-the energy and the modulus of the angular momentum. Imposing a realistic condition on $\overline{v_r^2}$, i. e. introducing it as

$$\overline{v_r^2} = \overline{v_r^2}(0)\, f(r), \qquad (2)$$

where f(r) is a montonously decreasing function so that

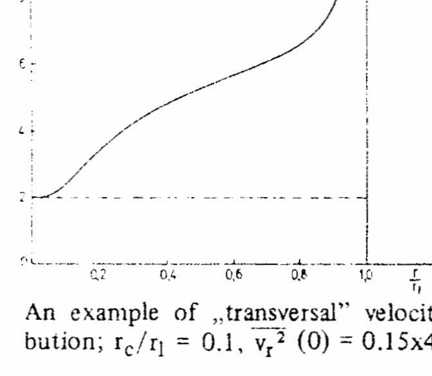


Figure 1 An example of „transversal" velocity distribution; $r_c/r_l = 0.1$, $\overline{v_r^2}(0) = 0.15 \times 4\pi G A r_c^2$

$f(0) = 1$ and $f(r_l) = 0$, one finds that with respect to the ratio $\overline{v_t^2}/\overline{v_r^2}$ one can define two kinds of velocity distributions for a given mass distribution. These are:

i) the „transversal" anisotropic – $\overline{v_t^2} \geqslant 2\overline{v_r^2}$ (the equality corresponds to r = 0, see Fig. 1);

ii) the „radial" anisotropic where within some part $r \in (0, r_a)$ is $\overline{v_t^2} < 2\overline{v_r^2}$ and beyond that interval, $r > r_a$, $\overline{v_t^2} > 2\overline{v_r^2}$ (Fig. 2). Since all the objects belonging to a corona are within their potential wells, the central value of the radial–velocity square, $\overline{v_r^2}(0)$, must satisfy the condition $\overline{v_r^2}(0) < (2/3)\Pi(0)$, where Π is the potential of the system.

The form of the function describing the mass distribution within the corona of a galaxy in the present paper is the same as that in an earlier paper of the present author (Ninković, 1988). The corresponding solution of the Poisson equation was also given there. The task is to specify possible constraints on the velocity distribution for these conditions using equation (1).

3. PROCEDURE

Since in equ. (1) there are only two physical quantities – the distance and the velocity square – their units should be specified. The distance unit will be r_l (limiting radius) and the velocity square will be expressed in $4\pi G A r_c^2$ (G is the gravitation constant, for the meaning of others see Ninković, 1988).

The scale parameter r_c must be specified, too. The circumstance that as a rough description of the distance dependence within a corona may be used the inverse–square law acts as a constraint to the choice of the ratio r_c/r_l. Intuitively one finds a value of 0.1 as the fair one. It agrees well with those values assumed in some models of our Galaxy (e. g. Caldwell and Ostriker, 1981; Rohlfs and Kreitschmann, 1981). With regard to the requirements concerning the function f(r) (2) it is convenient to choose expressions like $(1-r/r_l)$, i. e. $(1-r^2/r_l^2)$. The former expression raised to a power greater than 1 yields a sufficiently steep decrease in f(r) near the centre. The latter one acts as a smoothing term by enabling a more gradual decrease of f(r). This is seen from the following examples.

In the case $\overline{v_r^2}(0) = 1$ (units established above, equal to $0.56\Pi(0)$) a solution of (1) is obtained with

$$f(r) = a_1\,(1-r/r_l)^3 + a_2(1-r/r_l)^2 + a_3\,(1-r^2/r_l^2),$$

$$\sum_{i=1}^{3} a_i = 1;$$

in the particular case $a_1 = 0.09$, $a_2 = 0.89$, $a_3 = 0.02$ (Fig. 3). The role of the first ferm is to make the decrease sufficiently steep near the centre (on the contrary one would obtain a negative $\overline{v_t^2}$), the second one is the basic term (for this reason its coefficient is largest) and the role of the third term is to diminish the increase of $\overline{v^2}$ ($\overline{v^2} = \overline{v_r^2} + \overline{v_t^2}$) near the boundary. For values of $\overline{v_r^2}$ (0) as large as 1 this increase is inevitable because at $r = r_l$ as easy to see it will be $\overline{v_t^2} \approx u_c^2 - 4a_3 \overline{v_r^2}$ (0). Since $\overline{v_t^2}$ cannot be negative, this is a limitation for the value of a_3. Only at $\overline{v_r^2}$ (0) approximately as small as 0.8 (0.44Π(0)) this limitation is not so strong and it is possible to obtain a function $\overline{v^2}(r)$ always decreasing. However, as seen from Figs. 2–3 the minimum of the ratio $\overline{v_t^2}/\overline{v_r^2}$ is much deeper in the second case (larger $\overline{v_r^2}$ (0)) achieving about 0.01 and occuring at about $r = 0.55\ r_l$, whereas in the first case the value of the minimum is about 0.66 and it corresponds to the approximate value of r equal to 0.7 r_l. The „critical" value of $\overline{v_r^2}$ (0) above which is impossible to obtain a „transversal" solution of (1) (like in Fig. 1) occurs at about $\overline{v_r^2}$ (0) = 0.15 (0.08 Π (0)).

The present procedure is repeated for two more cases: $r_c/r_l = 0.01$ and $r_c/r_l = 0.5$. The latter one evidently does not correspond to the present purpose, thus it is used only as an illustrative one.

In the case $r_c/r_l = 0.01$ all the facts found in the former case ($r_c/r_l = 0.1$) become more strongly expressed. For example, if $\overline{v_r^2}$ (0) = 2 (about one half of Π (0)) the dependence of the radial velocity square is given by

$$f(r) = a_1\ (1-r/r_l)^4 + a_2\ (1-r^2/r_l^2);$$

$$a_1 = 0.975, \qquad a_2 = 0.025 \text{ (Fig. 4).}$$

The value of the coefficient a_2 is large enough to achieve smoothing $\overline{v^2}(r)$ is a monotonously decreasing function. The minimum in $\overline{v_t^2}/\overline{v_r^2}$ occurs at about $r/r_l = 0.26$ ($26 r_c$) and it is less than 0.001! A transversal solution is impossible to obtain above $\overline{v_r^2}$ (0) ≈ 0.2 (0.06 Π (0)).

For the case $r_c/r_l = 0.5$ the minima are not so deep by far and one can add that transversal solutions cess at about $\overline{v_r^2}$ (0) = 0.1 (0.25 Π (0)).

Therefore, it is seen that within self–consistent coronae of galaxies velocity distributions with prominent radial motions are generally acceptable. If the arguments of cosmogony are also invoked, then distributions characterised by prominent radial motions are very probable (e. g. Jaaniste and Saar, 1975).

4. DISCUSSION AND CONCLUSIONS

One could say that the general conclusions of the present paper and of that by Antonov and Chernin (1975) are similar. One should bear in mind that no quantitative comparison is possible since in the present paper a different mass distribution, with no singularity at the centre and no discontinuity at the boundary, is assumed. On account of this the ratio $\overline{v_t^2}/\overline{v_r^2}$ is a function of distance whose values generally depend on the mass distribution unlike Antonov and Chernin who

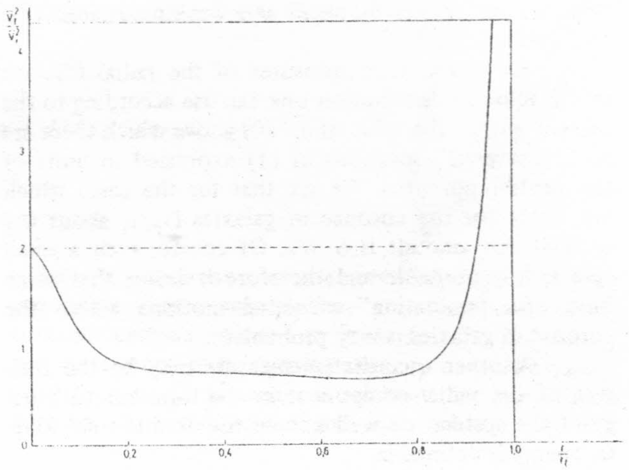


Figure 2 A „radial" solution; $r_c/r_l = 0.1$, $\overline{v_r^2}$ (0) = 0.7x x$4\pi G A r_c^2$, $f(r) = 0.0571(1-r/r_l)^3 + 0.7714 (1-r/r_l)^2 + 0.1714\ (1-r^2/r_l^2)$

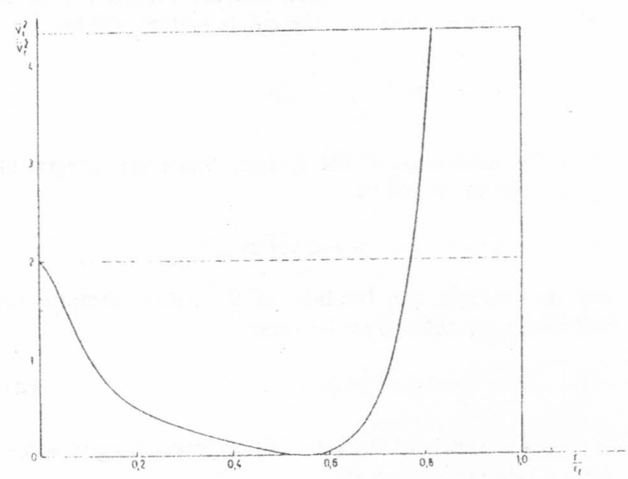


Figure 3 $r_c/r_l = 0.1$, $\overline{v_r^2}$ (0) = $4\pi G A r_c^2$, $f(r) = 0.09 (1-r/r_l)^3 + 0.89\ (1-r/r_l)^2 + 0.02\ (1-r^2/r_l^2)$

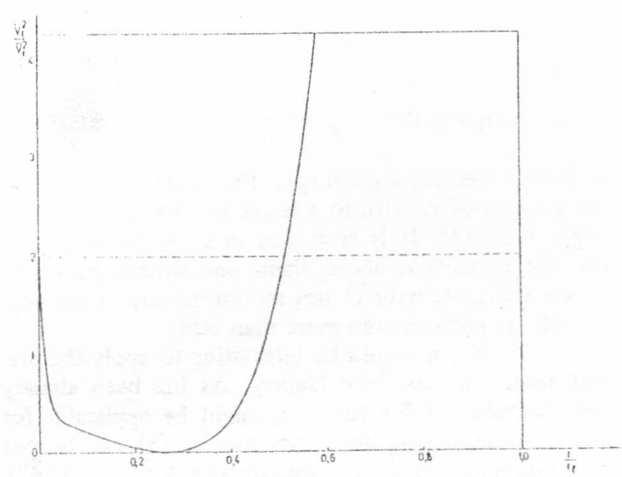


Figure 4 $r_c/r_l = 0.01$, $\overline{v_r^2}$ (0) = 2x$4\pi G A r_c^2$, $f(r) = 0.975 (1-r/r_l)^4 + 0.025\ (1-r^2/r_l^2)$

obtained an arbitrarily small and weakly variable $\overline{v_t^2}/\overline{v_r^2}$ ratio.

As quantitative measures of the radial fraction in the velocity distribution one can use according to the present author the value of $\overline{v_r^2}$ (0) above which there are no „transversal" solutions of (1) expressed in units of the central potential. We see that for the cases which are likely for the coronae of galaxies (r_c/r_l about 0.1 or less) this amount is 6–8%. Of course, such a small rate is low probable and therefore it seems that some kind of „domination" of radial motions within the coronae of galaxies is very probable.

Another quantitative measure may be the fraction of the radial component in the total kinetic energy of the system. As well known the double total kinetic energy is defined as

$$2W_k = \int_0^{r_l} \overline{v^2}\, dM,$$

where dM is the mass differential. Accordingly the mean velocity square taken over the entire system will be

$$<\overline{v^2}> = M^{-1} \int_0^{r_l} \overline{v^2}\, dM; \qquad (3)$$

M is the total mass of the system. Since the integral in (3) is additive, it will be

$$<\overline{v^2}> = <\overline{v_r^2}> + <\overline{v_t^2}>$$

and accordingly the fraction of the radial component will be simply defined as the ratio

$$<\overline{v_r^2}> / <\overline{v^2}> \ . \qquad (4)$$

The values of the ratio (4) corresponding to some cases considered above are

$r_c/r_l = 0.1$	$\overline{v_r^2}\,(0) = 0.15$	0.19
	$\overline{v_r^2}\,(0) = 0.7$	0.55
	$\overline{v_r^2}\,(0) = 1$	0.66
$r_c/r_l = 0.01$	$\overline{v_r^2}\,(0) = 2$	0.67 .

It is clear that for a given r_c/r_l the ratio (4) depends on the amount of $\overline{v_r^2}$ (0); to a larger $\overline{v_r^2}$ (0) corresponds a larger ratio (4). It is seen that in some limiting cases (in the sense that above them one already begins to obtain solutions with $\overline{v^2}$ not monotonously decreasing) the ratio (4) attains even more than 50%.

Finally, it would be interesting to apply the present results to our own Galaxy. As has been already said the value of 0.1 for r_c/r_l might be applicable for this purpose. Then, since the integral (3) can be put into a dimensionless form, one obtains $<\overline{v^2}> = 0.547 \times 4\pi G A r_c^2$ regardless of $\overline{v_r^2}$ (0) assumed. If one assumes as rough values r_c = 10 kpc and A = 0.01 $M_\odot$ pc^{-3}, one obtains $<\overline{v^2}> = 175^2$ km^2 s^{-2}. The mean square of the radial velocity taken over the entire system naturally depends on $\overline{v_r^2}$ (0) assumed in the analysis. For the two cases presented in Figs. 2–3 it is $<\overline{v_r^2}>$ = $= 0.298 \times 4\pi G A r_c^2$, i. e. $0.363 \times 4\pi G A r_c^2$, or 129^2 km^2 s^{-2}, 143^2 km^2 s^{-2}. If the value of 8.5 kpc is assumed for the galactocentirc distance of the Sun according to the IAU, then at the Sun we shall have $\overline{v_t^2}/\overline{v_r^2} \approx 1$. Of course, all these conclusions are tentative since they are valid for the case of a spherically symmetric and self–consistent galactic corona which, strictly speaking, is not true. Perhaps, such a situation is not far from the truth (see galactic models, e. g. by Caldwell and Ostriker, 1981 and by Rohlfs and Kreitschmann, 1981). In any case a study taking into account these circumstances is desirable.

One should certainly emphasize once again that the coronal constituents are unknown, so that any observational verification of the present conclusions meets extremely serious difficulties. The only chance is to study eventual consequences for models of the Galaxy (and also for other galaxies).

The principal conclusion of the present paper is that the conclusions of Antonov and Chernin (1975) are confirmed in principle and that they are made more complete by introducing the ratio (4) as a quantitative measure of the radial–component fraction in the kinetic energy of the coronae of galaxies.

NOTE

A preliminary report on the present work was presented at the IX National Conference of Yugoslav Astronomers held in Sarajevo (October 1988).

ACKNOWLEDGEMENT

This work has been supported by RZNS (Republican Community for Science of Serbia) through the project „Physics and Motions of Celestial Bodies and Artificial Satellites".

REFERENCES

Antonov, V. A., Osipkov, L. P., Chernin, A. D.: 1975, in *Dinamika i évolyutsiya zvezdnykh sistem*, ed. K. F. Ogorodnikov, vyp. 4 ser. Problemy issledovaniya vselennoj, izd. AN SSSR VAGO GAO, Moskva–Leningrad, p. 289.
Antonov, V. A., Chernin, A. D.: 1975, *Pis'ma v Astron. Zh.*, **1**, 18.
Binney, J., Tremaine, S.: 1987, *Galactic Dynamics*, Princeton University Press, Princeton, New Jersey.
Caldwell, J. A. R., Ostriker, J. P.: 1981, *Astrophys. J.*, **251**, 61.
Jaaniste, J., Saar, E.: 1975, *Publ. Tart. Astrof. observ.*, **43**, 216.
Ninković, S.: 1988, *Bull. Observ. Astron. Belgrade*, **139**, 21.
Ogorodnikov, K. F.: 1958, *Dinamika zvezdnykh sistem*, Gos. izdat. fiz. – mat. literatury, Moskva, ch. IX.
Rohlfs, K., Kreitschmann, J.: 1981, *Astrophys. Space Sci.*, **79**, 289.
Trimble, V.: 1987, *Ann. Rev. Astron. Astrophys.*, **25**, 425.

РАЗМАТРАЊЕ РАСПОДЕЛЕ БРЗИНЕ У КОРОНАМА ГАЛАКСИЈА

С. Нинковић,

Астрономска опсерваторија, Волгина 7, 11050 Београд, Југославија

УДК 524.7–85
Оригинални научни рад

Претпоставља се да су короне галаксија сферно-симетричне, само-усаглашене и у стационарном стању. Расподела брзине се проучава на основу хидродинамичке једначине преко односа $\overline{v_t^2}/\overline{v_r^2}$ /трансверзална и радијална компонента брзине, респективно/. Нађено је да у условима који се срећу у стварним галаксијама радијална кретања преовлађују тако да удео радијалне компоненте брзине у укупној кинетичкој енергији система достиже и више од 50%. На основу резултата овог рада примењених на нашу Галаксију проистиче да је за галактоцентрични положај Сунца вредност горњег односа нешто мало већа од јединице.

Bull. Obs. Astron. Belgrade N° 142 (1990), 29–57

UDC 52–355,3
Preliminary report

STARK BROADENING OF K I LINES

Milan S. Dimitrijević[1] and Sylvie Sahal–Bréchot[2]

[1]*Astronomical observatory, Volgina 7, 11050 Beograd, Yugoslavia*
[2]*Departement „Atomes et molecules en astrophysique", Unité associée au C. N. R. S. No 812, Observatoire de Paris Meudon, France*

(Received: July 19, 1989)

SUMMARY: Using a semiclassical approach, we have calculated electron–, proton– and ionized helium–impact widths and shifts of 51 neutral potassium multiplets as a function of electron temperature and electron density.

1. INTRODUCTION

Stark broadening parameters for potassium lines are useful in astrophysics as well as in plasma diagnostics, technology of high pressure discharge lamps etc. Solar abundance of potassium is 4.70 (Hack and Struve, 1969). K abundance is also determined by using line profiles, e.g. for γ Ser and ζ Her (Hack and Struve, 1969). Potassium line profiles are also important for the study of pulsed lamps at medium and high pressures, containing K vapors. Such lamps are important for neodymium laser optical pumping, since potassium lines coincide with absorption bands of laser material.

Using a semiclassical–perturbation formalism (Sahal–Bréchot, 1969a, b) we have calculated recently (Dimitrijević and Sahal–Bréchot, 1987) electron–, proton– and ArII–impact line widths and shifts of 50 neutral potassium multiplets at electron density $N_e = 10^{15}$ cm^{-3}. Due to Debye screening, obtained data are not always linear with electron density, especially in the case of transitions between more excited states. Since the corrections proposed e. g. by Griem (1974) are not simple to do, we recalculated Stark broadening data as a function of electron density also. Moreover, we improved the integration procedure (the improvements influence especially the shift at higher temperatures) and we included ionized helium–impact broadening parameters due to its astrophysical meaning.

2. THEORY

Details concerning the calculation procedure are given elsewhere (Sahal–Bréchot, 1969a, b) and only a few details will be given here. Within the framework of semiclassical–perturbational formalism developed using impact approximation, the full halfwidth (2W) and shift (D) of an electron–impact broadened line can be expressed as (Sahal–Bréchot, 1969a, b):

$$2W = N_e \int_0^\infty vf(v)\,dv \left[\sum_{i'\neq i} \sigma_{ii'}(v) + \sum_{f'\neq f} \sigma_{ff'}(v) + \sigma_{el}(v)\right] \quad (1)$$

$$D = N_e \int_0^\infty vf(v)\,dv \int_{R_3}^{R_D} 2\pi\rho\, d\rho \sin 2\varphi_p .$$

Here, N_e is the electron density, f(v) the Maxwellian velocity distribution function for electrons, ρ denotes the impact parameter of the incoming electron, i and f denote the initial and final atomic energy level and i', f' their perturbing levels. The inelastic cross section $\sigma_{ii'}(v)$ can be expressed by an integration over the impact parameter of the transition probability $P_{ii'}(\rho,v)$

$$\sum_{i'\neq i} \sigma_{ii'}(v) = \frac{1}{2}\pi R_1^2 + \int_{R_1}^{R_D} 2\pi\rho d\rho \sum_{i'\neq i} P_{ii'}(\rho,v) \quad (2)$$

and the elastic cross section is given by

$$\sigma_{el} = 2\pi R_2^2 + \int_{R_2}^{R_D} 8\pi\rho d\rho \sin^2\delta \tag{3}$$

$$\delta = [\varphi_p^2 + \varphi_q^2]^{1/2}.$$

The phase shifts φ_p and φ_q due respectively to the polarization potential (r^{-4}) and to the quadrupolar potential (r^{-3}) part, are given in §3 of Section 3 in the paper of Sahal–Bréchot (1969a). All the cut offs R_1, R_2, R_3, R_D are described in § 1 of Section 3 of Sahal–Bréchot (1969b).

If we want to make certain that a line is isolated, we can use the parameter c defined by Dimitrijević and Sahal–Bréchot (1984) and given in Table. For an electron concentration lower than

$$N_e(cm^{-3}) = [c/2W(Å)]\,[N(cm^{-3})/10^{15}] \tag{4}$$

the line can be treated as isolated in the core, even if weak forbidden components due to the failure of this approximation still appear in the wing.

3. RESULTS AND DISCUSSION

Data for needed energy levels were taken from Bashkin and Stoner (1975). Oscillator strengths have been calculated using the method of Bates and Damgaard (1949) and tables of Oertel and Shomo (1968), while for low–lying levels, the oscillator strengths were taken from Wiese, Smith and Miles (1969). For higher levels, when tables of Oertel and Shomo are not applicable, the method described by Van Regemorter, Hoang Binh Dy and Prud'homme (1979) was used.

The results are shown in Table 1 for a number of temperatures (2500; 5000; 10000; 20000; 40000 and 80000 K) and for electron densities from 10^{13} cm^{-3} to 10^{18} cm^{-3}. In table is also given a parameter denoted by c (see Eq. 4) which can be used to obtain an estimate for the maximum electron density for which the line may be treated as isolated.

We checked also is the collision volume (V) multiplied by the electron density (N_e) much lesser than one for values given in the table. In such a case, the impact approximation is valid (Sahal–Bréchot, 1969). The values for which $N_eV > 0.5$ are not given in the table, while values where $0.1 < N_eV \leqslant 0.5$ are denoted with an asterisk and are given in order to enable interpolation to lower densities. In the cases when the impact approximation is not valid, the ion broadening contribution may be estimated by the quasistatic ion-broadening parameter (Griem, 1974) introduced by Griem et al (1962). Ar II impact linewidths and shifts for 50 neutral potassium multiplets at $N_e = 10^{15}$ cm^{-3} may be found in Dimitrijević and Sahal–Bréchot (1987).

ACKNOWLEDGEMENTS

One of us (M. D.) has been supported by the Observatoire de Paris. This work, supported by the C. N. R. S. is a part of French–Yugoslav collaboration through the project " L'éllargissement Stark des raies spectrales des plasmas astrophysiques et de la laboratoire". Also this is a part of the project „Atomic, molecular and plasma spectroscopy" supported by SKNTI and RZN of Serbia.

REFERENCES

Bashkin, S. and Stoner, J. O. Jr.: 1975, *Atomic Energy Levels and Grotrian Diagrams,* Vol. I North Holland, Amsterdam.

Bates, D. R. and Damgaard, A.: 1949, *Phil. Trans. R. Soc. London Ser. A* **242,** 101.

Dimitrijević, M. S. and Sahal–Bréchot, S.: 1984, *JQSRT* **31,** 301.

Dimitrijević, M. S. and Sahal–Bréchot, S.: 1987, *JQSRT* **38,** 37.

Griem, H. R.: 1974, *Spectral Line Broadening by Plasmas,* Academic Press, New York.

Griem, H. R., Baranger, M., Kolb, A. C. and Oertel, G. K.: 1962, *Phys. Rev.* **125,** 177.

Hack, M., Struve, O.: 1969, *Stellar Spectroscopy (Normal stars),* Osservatorio astronomico di Trieste.

Oertel, G. K. and Shomo, L. P.: 1968, *Astrophys. J. Suppl. Series* **16,** 175

Sahal–Bréchot, S.: 1969a, *Astron. Astrophys.* **1,** 91.

Sahal–Bréchot, S.: 1969b, *Astron. Astrophys.* **2,** 322.

Van Regemorter, H., Hoang Binh Dy and Prud'homme, M.: 1979, *J. Phys. B* **12,** 1073.

Wiese, W. L., Smith, M. W. and Miles, B. M.: 1969, *Atomic Transition Probabilities,* Vol. II U. S. Government Printing Office, Washington, D. C.

Table 1. This table lists electron–, proton– and ionized helium–impact broadening parameters for K I lines for electron densities from 10^{13} cm^{-3} to 10^{18} cm^{-3} and temperatures from 2500 K to 80000 K. Transitions and averaged wavelengths for the multiplet (in Å) are also given. Under 2W are given full halfwidths (in Å) while D denote corresponding shifts. By using c [see Eq. (4)], we obtain an estimate for the maximum electron density for which the line may be treated as isolated and the tabulated values may be used. Asterisk denotes cases when the collision volume multiplied by the electron density (condition for the validity of the impact approximation) lies between 0.1 and 0.5.

NE= 0.1E+14

		ELECTRONS		PROTONS		IONIZED HELIUM	
TRANSITION	T(K)	2WE(A)	DE(A)	2WI(A)	DI(A)	2WI(A)	DI(A)
3D - 4P	2500.	3.60	-0.470E-01	1.61*	1.38*	1.27*	1.09*
91050.0A	5000.	3.39	-0.877E-01	1.86	1.61	1.44*	1.27*
C= 0.27E+19	10000.	3.11	-0.110	2.11	1.89	1.64*	1.46*
	20000.	2.80	-0.619E-01	2.17	2.26	1.89	1.67
	30000.	2.62	-0.510E-01	2.04	2.45	2.04	1.83
	80000.	2.17	-0.242E-01	1.43	2.50	2.15	2.31
3D - 5P	2500.	0.573E-02	0.333E-02	0.210E-02	0.883E-03	0.205E-02	0.709E-03
31453.0A	5000.	0.655E-02	0.398E-02	0.215E-02	0.993E-03	0.207E-02	0.798E-03
C= 0.27E+21	10000.	0.770E-02	0.404E-02	0.220E-02	0.112E-02	0.211E-02	0.897E-03
	20000.	0.942E-02	0.364E-02	0.227E-02	0.125E-02	0.215E-02	0.101E-02
	30000.	0.107E-01	0.311E-02	0.232E-02	0.134E-02	0.218E-02	0.108E-02
	80000.	0.140E-01	0.240E-02	0.247E-02	0.158E-02	0.228E-02	0.127E-02
3D - 6P	2500.	0.352E-02	0.230E-02	0.132E-02	0.605E-03	0.127E-02	0.486E-03
13384.0A	5000.	0.410E-02	0.270E-02	0.135E-02	0.681E-03	0.129E-02	0.547E-03
C= 0.21E+20	10000.	0.480E-02	0.264E-02	0.139E-02	0.767E-03	0.132E-02	0.616E-03
	20000.	0.572E-02	0.243E-02	0.145E-02	0.862E-03	0.136E-02	0.693E-03
	30000.	0.640E-02	0.218E-02	0.149E-02	0.922E-03	0.138E-02	0.741E-03
	80000.	0.788E-02	0.167E-02	0.160E-02	0.109E-02	0.146E-02	0.873E-03
3D - 7P	2500.	0.560E-02	0.370E-02	0.201E-02	0.961E-03	0.193E-02	0.769E-03
10482.0A	5000.	0.655E-02	0.420E-02	0.206E-02	0.109E-02	0.197E-02	0.871E-03
C= 0.68E+19	10000.	0.772E-02	0.418E-02	0.214E-02	0.122E-02	0.201E-02	0.981E-03
	20000.	0.925E-02	0.343E-02	0.223E-02	0.137E-02	0.207E-02	0.110E-02
	30000.	0.103E-01	0.298E-02	0.229E-02	0.147E-02	0.211E-02	0.118E-02
	80000.	0.123E-01	0.197E-02	0.248E-02	0.173E-02	0.224E-02	0.139E-02
3D - 8P	2500.	0.974E-02	0.646E-02	0.332E-02	0.164E-02	0.318E-02	0.131E-02
9348.6A	5000.	0.114E-01	0.694E-02	0.342E-02	0.186E-02	0.324E-02	0.149E-02
C= 0.32E+19	10000.	0.136E-01	0.650E-02	0.355E-02	0.209E-02	0.333E-02	0.168E-02
	20000.	0.164E-01	0.505E-02	0.372E-02	0.236E-02	0.343E-02	0.189E-02
	30000.	0.183E-01	0.410E-02	0.383E-02	0.253E-02	0.351E-02	0.203E-02
	80000.	0.212E-01	0.220E-02	0.417E-02	0.298E-02	0.374E-02	0.240E-02
3D - 9P	2500.	0.167E-01	0.107E-01	0.539E-02	0.274E-02	0.515E-02	0.218E-02
8764.8A	5000.	0.196E-01	0.112E-01	0.558E-02	0.311E-02	0.527E-02	0.249E-02
C= 0.18E+19	10000.	0.236E-01	0.102E-01	0.582E-02	0.352E-02	0.542E-02	0.282E-02
	20000.	0.288E-01	0.740E-02	0.610E-02	0.397E-02	0.561E-02	0.319E-02
	30000.	0.318E-01	0.557E-02	0.630E-02	0.425E-02	0.574E-02	0.341E-02
	80000.	0.361E-01	0.247E-02	0.689E-02	0.502E-02	0.614E-02	0.403E-02
3D - 4F	2500.	0.264E-02	-0.110E-02	0.595E-03	-0.377E-03	0.550E-03	-0.302E-03
15165.0A	5000.	0.295E-02	-0.702E-03	0.627E-03	-0.424E-03	0.571E-03	-0.340E-03
C= 0.17E+20	10000.	0.355E-02	-0.358E-03	0.666E-03	-0.476E-03	0.598E-03	-0.383E-03
	20000.	0.408E-02	-0.111E-03	0.713E-03	-0.535E-03	0.631E-03	-0.430E-03
	30000.	0.439E-02	-0.114E-03	0.745E-03	-0.572E-03	0.654E-03	-0.460E-03
	80000.	0.508E-02	0.416E-04	0.837E-03	-0.674E-03	0.719E-03	-0.542E-03

NE= 0.1E+14

		ELECTRONS		PROTONS		IONIZED HELIUM	
TRANSITION	T(K)	2WE(A)	DE(A)	2WI(A)	DI(A)	2WI(A)	DI(A)
3D - 5F	2500.	0.236E-01	0.348E-02	0.839E-02	0.754E-02	0.674E-02	0.600E-02
11022.3A	5000.	0.216E-01	0.137E-02	0.949E-02	0.859E-02	0.756E-02	0.687E-02
C= 0.14E+18	10000.	0.197E-01	0.734E-03	0.108E-01	0.977E-02	0.851E-02	0.781E-02
	20000.	0.180E-01	-0.200E-03	0.125E-01	0.112E-01	0.963E-02	0.885E-02
	30000.	0.170E-01	-0.202E-03	0.134E-01	0.124E-01	0.104E-01	0.950E-02
	80000.	0.147E-01	-0.975E-04	0.136E-01	0.152E-01	0.127E-01	0.114E-01
4S - 4P	2500.	0.448E-04	0.339E-04	0.277E-04	0.942E-05	0.273E-04	0.757E-05
7676.2A	5000.	0.509E-04	0.401E-04	0.280E-04	0.106E-04	0.275E-04	0.850E-05
C= 0.47E+20	10000.	0.624E-04	0.454E-04	0.284E-04	0.119E-04	0.277E-04	0.955E-05
	20000.	0.825E-04	0.461E-04	0.290E-04	0.133E-04	0.281E-04	0.107E-04
	30000.	0.973E-04	0.410E-04	0.294E-04	0.143E-04	0.283E-04	0.115E-04
	80000.	0.139E-03	0.285E-04	0.306E-04	0.168E-04	0.291E-04	0.135E-04
4S - 5P	2500.	0.963E-04	0.606E-04	0.406E-04	0.165E-04	0.397E-04	0.133E-04
4045.2A	5000.	0.110E-03	0.719E-04	0.414E-04	0.186E-04	0.401E-04	0.149E-04
C= 0.44E+19	10000.	0.126E-03	0.777E-04	0.424E-04	0.209E-04	0.407E-04	0.168E-04
	20000.	0.148E-03	0.763E-04	0.436E-04	0.235E-04	0.415E-04	0.189E-04
	30000.	0.164E-03	0.670E-04	0.445E-04	0.251E-04	0.420E-04	0.202E-04
	80000.	0.206E-03	0.492E-04	0.472E-04	0.296E-04	0.438E-04	0.238E-04
4S - 6P	2500.	0.233E-03	0.152E-03	0.920E-04	0.409E-04	0.893E-04	0.328E-04
3446.7A	5000.	0.271E-03	0.176E-03	0.942E-04	0.460E-04	0.906E-04	0.370E-04
C= 0.14E+19	10000.	0.315E-03	0.183E-03	0.969E-04	0.518E-04	0.922E-04	0.416E-04
	20000.	0.373E-03	0.171E-03	0.100E-03	0.582E-04	0.945E-04	0.468E-04
	30000.	0.414E-03	0.150E-03	0.103E-03	0.623E-04	0.960E-04	0.501E-04
	80000.	0.505E-03	0.107E-03	0.110E-03	0.734E-04	0.101E-03	0.590E-04
4S - 7P	2500.	0.526E-03	0.346E-03	0.193E-03	0.909E-04	0.186E-03	0.728E-04
3217.3A	5000.	0.615E-03	0.395E-03	0.198E-03	0.103E-03	0.190E-03	0.824E-04
C= 0.64E+18	10000.	0.723E-03	0.385E-03	0.205E-03	0.116E-03	0.194E-03	0.928E-04
	20000.	0.864E-03	0.333E-03	0.214E-03	0.130E-03	0.199E-03	0.104E-03
	30000.	0.961E-03	0.282E-03	0.220E-03	0.139E-03	0.203E-03	0.112E-03
	80000.	0.114E-02	0.184E-03	0.237E-03	0.164E-03	0.215E-03	0.132E-03
4S - 8P	2500.	0.107E-02	0.700E-03	0.368E-03	0.180E-03	0.354E-03	0.144E-03
3101.9A	5000.	0.125E-02	0.765E-03	0.380E-03	0.204E-03	0.361E-03	0.164E-03
C= 0.36E+18	10000.	0.149E-02	0.738E-03	0.394E-03	0.230E-03	0.370E-03	0.185E-03
	20000.	0.180E-02	0.580E-03	0.412E-03	0.259E-03	0.381E-03	0.208E-03
	30000.	0.200E-02	0.479E-03	0.425E-03	0.278E-03	0.390E-03	0.223E-03
	80000.	0.232E-02	0.277E-03	0.461E-03	0.328E-03	0.415E-03	0.264E-03
4S - 9P	2500.	0.199E-02	0.128E-02	0.650E-03	0.328E-03	0.621E-03	0.262E-03
3034.8A	5000.	0.235E-02	0.134E-02	0.672E-03	0.373E-03	0.635E-03	0.298E-03
C= 0.22E+18	10000.	0.282E-02	0.124E-02	0.700E-03	0.422E-03	0.653E-03	0.338E-03
	20000.	0.344E-02	0.931E-03	0.735E-03	0.476E-03	0.675E-03	0.382E-03
	30000.	0.380E-02	0.760E-03	0.758E-03	0.510E-03	0.691E-03	0.409E-03
	80000.	0.431E-02	0.395E-03	0.828E-03	0.602E-03	0.739E-03	0.484E-03

NE= 0.1E+14

TRANSITION	T(K)	ELECTRONS 2WE(A)	DE(A)	PROTONS 2WI(A)	DI(A)	IONIZED HELIUM 2WI(A)	DI(A)
4P - 5S	2500.	0.584E-03	0.412E-03	0.136E-03	0.114E-03	0.116E-03	0.914E-04
12492.0A	5000.	0.672E-03	0.490E-03	0.150E-03	0.128E-03	0.126E-03	0.103E-03
C= 0.58E+20	10000.	0.748E-03	0.573E-03	0.165E-03	0.144E-03	0.138E-03	0.116E-03
	20000.	0.844E-03	0.566E-03	0.182E-03	0.161E-03	0.151E-03	0.130E-03
	30000.	0.900E-03	0.513E-03	0.193E-03	0.173E-03	0.160E-03	0.139E-03
	80000.	0.115E-02	0.361E-03	0.224E-03	0.203E-03	0.184E-03	0.163E-03
4P - 6S	2500.	0.665E-03	0.488E-03	0.143E-03	0.133E-03	0.116E-03	0.107E-03
6929.5A	5000.	0.765E-03	0.572E-03	0.160E-03	0.150E-03	0.130E-03	0.120E-03
C= 0.75E+19	10000.	0.824E-03	0.625E-03	0.180E-03	0.169E-03	0.145E-03	0.136E-03
	20000.	0.916E-03	0.619E-03	0.202E-03	0.190E-03	0.163E-03	0.152E-03
	30000.	0.950E-03	0.554E-03	0.216E-03	0.203E-03	0.174E-03	0.163E-03
	80000.	0.117E-02	0.413E-03	0.254E-03	0.239E-03	0.204E-03	0.192E-03
4P - 7S	2500.	0.126E-02	0.936E-03	0.265E-03	0.247E-03	0.213E-03	0.198E-03
5795.3A	5000.	0.151E-02	0.110E-02	0.297E-03	0.278E-03	0.239E-03	0.223E-03
C= 0.27E+19	10000.	0.154E-02	0.110E-02	0.333E-03	0.313E-03	0.268E-03	0.252E-03
	20000.	0.170E-02	0.103E-02	0.374E-03	0.352E-03	0.301E-03	0.283E-03
	30000.	0.184E-02	0.896E-03	0.400E-03	0.377E-03	0.322E-03	0.303E-03
	80000.	0.224E-02	0.642E-03	0.471E-03	0.445E-03	0.379E-03	0.358E-03
4P - 8S	2500.	0.232E-02	0.168E-02	0.468E-03	0.434E-03	0.377E-03	0.347E-03
5334.3A	5000.	0.260E-02	0.191E-02	0.526E-03	0.492E-03	0.423E-03	0.394E-03
C= 0.13E+19	10000.	0.298E-02	0.189E-02	0.590E-03	0.554E-03	0.474E-03	0.445E-03
	20000.	0.323E-02	0.153E-02	0.662E-03	0.624E-03	0.533E-03	0.501E-03
	30000.	0.360E-02	0.127E-02	0.709E-03	0.668E-03	0.570E-03	0.537E-03
	80000.	0.425E-02	0.762E-03	0.835E-03	0.788E-03	0.671E-03	0.634E-03
4P - 9S	2500.	0.431E-02	0.317E-02	0.870E-03	0.800E-03	0.700E-03	0.638E-03
5094.3A	5000.	0.475E-02	0.346E-02	0.977E-03	0.908E-03	0.786E-03	0.727E-03
C= 0.76E+18	10000.	0.537E-02	0.319E-02	0.110E-02	0.103E-02	0.882E-03	0.824E-03
	20000.	0.623E-02	0.244E-02	0.123E-02	0.116E-02	0.990E-03	0.929E-03
	30000.	0.695E-02	0.189E-02	0.132E-02	0.124E-02	0.106E-02	0.996E-03
	80000.	0.796E-02	0.907E-03	0.155E-02	0.146E-02	0.125E-02	0.118E-02
4P -10S	2500.	0.730E-02	0.522E-02	0.146E-02	0.133E-02	0.118E-02	0.106E-02
4951.4A	5000.	0.807E-02	0.544E-02	0.164E-02	0.152E-02	0.132E-02	0.121E-02
C= 0.48E+18	10000.	0.924E-02	0.498E-02	0.184E-02	0.172E-02	0.148E-02	0.138E-02
	20000.	0.111E-01	0.357E-02	0.207E-02	0.194E-02	0.166E-02	0.156E-02
	30000.	0.123E-01	0.261E-02	0.222E-02	0.208E-02	0.178E-02	0.167E-02
	80000.	0.138E-01	0.105E-02	0.261E-02	0.246E-02	0.210E-02	0.198E-02
4P -11S	2500.	0.119E-01	0.843E-02	0.230E-02	0.207E-02	0.185E-02	0.164E-02
4859.0A	5000.	0.131E-01	0.818E-02	0.259E-02	0.237E-02	0.208E-02	0.189E-02
C= 0.33E+18	10000.	0.152E-01	0.706E-02	0.290E-02	0.270E-02	0.234E-02	0.216E-02
	20000.	0.187E-01	0.491E-02	0.326E-02	0.305E-02	0.262E-02	0.245E-02
	30000.	0.206E-01	0.364E-02	0.349E-02	0.327E-02	0.281E-02	0.263E-02
	80000.	0.228E-01	0.124E-02	0.412E-02	0.387E-02	0.330E-02	0.311E-02

NE= 0.1E+14

TRANSITION	T(K)	ELECTRONS 2WE(A)	DE(A)	PROTONS 2WI(A)	DI(A)	IONIZED HELIUM 2WI(A)	DI(A)
4P -12S	2500.	0.173E-01	0.118E-01	0.334E-02	0.297E-02	0.269E-02*	0.235E-02*
4795.7A	5000.	0.206E-01	0.116E-01	0.375E-02	0.341E-02	0.301E-02	0.272E-02
C= 0.24E+18	10000.	0.238E-01	0.917E-02	0.421E-02	0.389E-02	0.338E-02	0.311E-02
	20000.	0.298E-01	0.624E-02	0.473E-02	0.441E-02	0.380E-02	0.353E-02
	30000.	0.327E-01	0.465E-02	0.506E-02	0.474E-02	0.407E-02	0.380E-02
	80000.	0.358E-01	0.144E-02	0.597E-02	0.560E-02	0.479E-02	0.450E-02
4P - 3D	2500.	0.253E-03	0.131E-03	0.873E-04	0.348E-04	0.854E-04	0.279E-04
11745.0A	5000.	0.271E-03	0.144E-03	0.888E-04	0.390E-04	0.863E-04	0.314E-04
C= 0.44E+20	10000.	0.312E-03	0.142E-03	0.908E-04	0.438E-04	0.875E-04	0.352E-04
	20000.	0.394E-03	0.111E-03	0.933E-04	0.492E-04	0.890E-04	0.396E-04
	30000.	0.464E-03	0.944E-04	0.952E-04	0.526E-04	0.901E-04	0.423E-04
	80000.	0.639E-03	0.673E-04	0.101E-03	0.620E-04	0.937E-04	0.498E-04
4P - 4D	2500.	0.766E-03	0.563E-03	0.200E-03	0.147E-03	0.177E-03	0.118E-03
6955.2A	5000.	0.839E-03	0.605E-03	0.215E-03	0.166E-03	0.188E-03	0.133E-03
C= 0.35E+19	10000.	0.914E-03	0.579E-03	0.232E-03	0.186E-03	0.201E-03	0.150E-03
	20000.	0.101E-02	0.457E-03	0.253E-03	0.210E-03	0.217E-03	0.168E-03
	30000.	0.109E-02	0.406E-03	0.267E-03	0.224E-03	0.227E-03	0.180E-03
	80000.	0.120E-02	0.282E-03	0.305E-03	0.264E-03	0.256E-03	0.212E-03
4P - 5D	2500.	0.166E-02	0.124E-02	0.422E-03	0.316E-03	0.373E-03	0.253E-03
5825.3A	5000.	0.181E-02	0.128E-02	0.455E-03	0.357E-03	0.397E-03	0.286E-03
C= 0.14E+19	10000.	0.197E-02	0.122E-02	0.494E-03	0.401E-03	0.426E-03	0.322E-03
	20000.	0.221E-02	0.923E-03	0.540E-03	0.451E-03	0.460E-03	0.363E-03
	30000.	0.236E-02	0.776E-03	0.570E-03	0.483E-03	0.482E-03	0.388E-03
	80000.	0.254E-02	0.453E-03	0.654E-03	0.570E-03	0.546E-03	0.458E-03
4P - 6D	2500.	0.333E-02	0.249E-02	0.833E-03	0.626E-03	0.731E-03	0.500E-03
5354.1A	5000.	0.364E-02	0.252E-02	0.901E-03	0.710E-03	0.781E-03	0.568E-03
C= 0.74E+18	10000.	0.398E-02	0.225E-02	0.980E-03	0.802E-03	0.840E-03	0.644E-03
	20000.	0.452E-02	0.165E-02	0.107E-02	0.902E-03	0.909E-03	0.725E-03
	30000.	0.483E-02	0.128E-02	0.113E-02	0.967E-03	0.955E-03	0.776E-03
	80000.	0.512E-02	0.581E-03	0.130E-02	0.114E-02	0.108E-02	0.917E-03
4P - 7D	2500.	0.624E-02	0.467E-02	0.153E-02	0.116E-02	0.134E-02	0.923E-03
5107.2A	5000.	0.683E-02	0.445E-02	0.166E-02	0.132E-02	0.143E-02	0.105E-02
C= 0.43E+18	10000.	0.752E-02	0.385E-02	0.181E-02	0.149E-02	0.155E-02	0.120E-02
	20000.	0.863E-02	0.274E-02	0.199E-02	0.168E-02	0.168E-02	0.135E-02
	30000.	0.917E-02	0.204E-02	0.210E-02	0.180E-02	0.177E-02	0.145E-02
	80000.	0.960E-02	0.736E-03	0.242E-02	0.213E-02	0.201E-02	0.171E-02
4P - 8D	2500.	0.109E-01	0.789E-02	0.265E-02	0.200E-02	0.230E-02	0.159E-02
4960.2A	5000.	0.120E-01	0.778E-02	0.288E-02	0.229E-02	0.247E-02	0.183E-02
C= 0.28E+18	10000.	0.134E-01	0.616E-02	0.315E-02	0.260E-02	0.267E-02	0.208E-02
	20000.	0.154E-01	0.429E-02	0.346E-02	0.295E-02	0.291E-02	0.236E-02
	30000.	0.162E-01	0.314E-02	0.366E-02	0.316E-02	0.306E-02	0.254E-02
	80000.	0.168E-01	0.986E-03	0.423E-02	0.373E-02	0.349E-02	0.300E-02

NE= 0.1E+14

		ELECTRONS		PROTONS		IONIZED HELIUM	
TRANSITION	T(K)	2WE(A)	DE(A)	2WI(A)	DI(A)	2WI(A)	DI(A)
4P - 9D	2500.	0.180E-01	0.128E-01	0.432E-02*	0.325E-02*	0.373E-02*	0.257E-02*
4865.2A	5000.	0.199E-01	0.122E-01	0.470E-02	0.375E-02	0.402E-02*	0.298E-02*
C= 0.19E+18	10000.	0.224E-01	0.926E-02	0.515E-02	0.427E-02	0.436E-02	0.341E-02
	20000.	0.258E-01	0.642E-02	0.567E-02	0.484E-02	0.475E-02	0.388E-02
	30000.	0.270E-01	0.461E-02	0.600E-02	0.521E-02	0.501E-02	0.417E-02
	80000.	0.277E-01	0.134E-02	0.695E-02	0.616E-02	0.573E-02	0.495E-02
4D - 6P	2500.	0.675E-01	0.173E-01	0.231E-01	0.395E-02	0.231E-01	0.317E-02
62191.0A	5000.	0.935E-01	0.218E-01	0.231E-01	0.444E-02	0.231E-01	0.357E-02
C= 0.28E+21	10000.	0.127	0.235E-01	0.232E-01	0.499E-02	0.231E-01	0.401E-02
	20000.	0.166	0.206E-01	0.233E-01	0.560E-02	0.231E-01	0.450E-02
	30000.	0.189	0.184E-01	0.233E-01	0.599E-02	0.232E-01	0.482E-02
	80000.	0.232	0.154E-01	0.235E-01	0.707E-02	0.233E-01	0.567E-02
4D - 7P	2500.	0.369E-01	0.215E-01	0.124E-01	0.559E-02	0.120E-01	0.448E-02
27199.0A	5000.	0.451E-01	0.232E-01	0.127E-01	0.630E-02	0.122E-01	0.506E-02
C= 0.46E+20	10000.	0.561E-01	0.225E-01	0.131E-01	0.710E-02	0.124E-01	0.570E-02
	20000.	0.701E-01	0.178E-01	0.136E-01	0.799E-02	0.127E-01	0.642E-02
	30000.	0.790E-01	0.154E-01	0.139E-01	0.855E-02	0.129E-01	0.687E-02
	80000.	0.941E-01	0.945E-02	0.150E-01	0.101E-01	0.136E-01	0.810E-02
4D - 8P	2500.	0.477E-01	0.296E-01	0.156E-01	0.767E-02	0.150E-01	0.614E-02
20691.0A	5000.	0.569E-01	0.315E-01	0.161E-01	0.870E-02	0.153E-01	0.697E-02
C= 0.16E+20	10000.	0.690E-01	0.293E-01	0.167E-01	0.981E-02	0.157E-01	0.788E-02
	20000.	0.852E-01	0.212E-01	0.175E-01	0.110E-01	0.162E-01	0.887E-02
	30000.	0.951E-01	0.172E-01	0.180E-01	0.118E-01	0.165E-01	0.950E-02
	80000.	0.110	0.868E-02	0.196E-01	0.140E-01	0.176E-01	0.112E-01
4D - 4F	2500.	0.441	-0.263	0.803E-01	-0.704E-01	0.668E-01	-0.565E-01
136923.A	5000.	0.484	-0.276	0.889E-01	-0.792E-01	0.735E-01	-0.636E-01
C= 0.14E+22	10000.	0.527	-0.228	0.987E-01	-0.891E-01	0.812E-01	-0.716E-01
	20000.	0.617	-0.172	0.110	-0.100	0.900E-01	-0.805E-01
	30000.	0.670	-0.156	0.117	-0.107	0.956E-01	-0.862E-01
	80000.	0.737	-0.953E-01	0.137	-0.126	0.111	-0.102
4D - 5F	2500.	0.199	0.183E-01	0.665E-01	0.598E-01	0.533E-01	0.476E-01
31162.0A	5000.	0.184	0.184E-02	0.752E-01	0.682E-01	0.599E-01	0.545E-01
C= 0.11E+19	10000.	0.168	-0.103E-01	0.861E-01	0.776E-01	0.674E-01	0.620E-01
	20000.	0.157	-0.943E-02	0.991E-01	0.887E-01	0.764E-01	0.702E-01
	30000.	0.151	-0.100E-01	0.106	0.968E-01	0.825E-01	0.754E-01
	80000.	0.133	-0.642E-02	0.107	0.120	0.101	0.906E-01
5S - 5P	2500.	0.350E-02	0.127E-02	0.174E-02	0.362E-03	0.174E-02	0.291E-03
27114.0A	5000.	0.416E-02	0.120E-02	0.175E-02	0.407E-03	0.174E-02	0.327E-03
C= 0.20E+21	10000.	0.550E-02	0.767E-03	0.176E-02	0.456E-03	0.175E-02	0.367E-03
	20000.	0.767E-02	0.485E-03	0.177E-02	0.512E-03	0.175E-02	0.412E-03
	30000.	0.913E-02	0.402E-03	0.177E-02	0.548E-03	0.175E-02	0.441E-03
	80000.	0.123E-01	0.272E-03	0.180E-02	0.646E-03	0.177E-02	0.519E-03

NE= 0.1E+14

TRANSITION	T(K)	ELECTRONS 2WE(A)	DE(A)	PROTONS 2WI(A)	DI(A)	IONIZED HELIUM 2WI(A)	DI(A)
5S - 6P	2500.	0.302E-02	0.191E-02	0.120E-02	0.502E-03	0.117E-02	0.403E-03
12531.0A	5000.	0.352E-02	0.215E-02	0.123E-02	0.565E-03	0.119E-02	0.454E-03
C= 0.19E+20	10000.	0.420E-02	0.217E-02	0.126E-02	0.636E-03	0.120E-02	0.511E-03
	20000.	0.514E-02	0.176E-02	0.130E-02	0.715E-03	0.123E-02	0.574E-03
	30000.	0.585E-02	0.153E-02	0.133E-02	0.765E-03	0.125E-02	0.615E-03
	80000.	0.732E-02	0.116E-02	0.141E-02	0.901E-03	0.130E-02	0.724E-03
5S - 7P	2500.	0.503E-02	0.329E-02	0.184E-02	0.855E-03	0.178E-02	0.685E-03
9951.3A	5000.	0.588E-02	0.368E-02	0.189E-02	0.965E-03	0.181E-02	0.775E-03
C= 0.62E+19	10000.	0.699E-02	0.370E-02	0.195E-02	0.109E-02	0.185E-02	0.873E-03
	20000.	0.844E-02	0.299E-02	0.203E-02	0.122E-02	0.190E-02	0.983E-03
	30000.	0.946E-02	0.247E-02	0.209E-02	0.131E-02	0.193E-02	0.105E-02
	80000.	0.113E-01	0.160E-02	0.225E-02	0.154E-02	0.204E-02	0.124E-02
5S - 8P	2500.	0.886E-02	0.588E-02	0.305E-02	0.148E-02	0.292E-02	0.119E-02
8924.4A	5000.	0.104E-01	0.623E-02	0.314E-02	0.168E-02	0.298E-02	0.135E-02
C= 0.29E+19	10000.	0.124E-01	0.598E-02	0.326E-02	0.190E-02	0.306E-02	0.152E-02
	20000.	0.151E-01	0.433E-02	0.340E-02	0.214E-02	0.315E-02	0.172E-02
	30000.	0.168E-01	0.351E-02	0.351E-02	0.229E-02	0.322E-02	0.184E-02
	80000.	0.195E-01	0.183E-02	0.381E-02	0.270E-02	0.342E-02	0.217E-02
5S - 9P	2500.	0.153E-01	0.101E-01	0.497E-02	0.250E-02	0.474E-02	0.200E-02
8390.7A	5000.	0.180E-01	0.104E-01	0.514E-02	0.285E-02	0.485E-02	0.228E-02
C= 0.17E+19	10000.	0.216E-01	0.906E-02	0.535E-02	0.322E-02	0.499E-02	0.258E-02
	20000.	0.265E-01	0.597E-02	0.561E-02	0.363E-02	0.516E-02	0.292E-02
	30000.	0.292E-01	0.505E-02	0.579E-02	0.389E-02	0.528E-02	0.312E-02
	80000.	0.332E-01	0.210E-02	0.632E-02	0.459E-02	0.564E-02	0.369E-02
5P - 6S	2500.	0.180E-01	0.121E-01	0.442E-02	0.317E-02	0.396E-02	0.255E-02
36529.0A	5000.	0.209E-01	0.142E-01	0.473E-02	0.357E-02	0.418E-02	0.287E-02
C= 0.21E+21	10000.	0.247E-01	0.146E-01	0.511E-02	0.402E-02	0.445E-02	0.323E-02
	20000.	0.299E-01	0.126E-01	0.554E-02	0.451E-02	0.477E-02	0.363E-02
	30000.	0.344E-01	0.110E-01	0.583E-02	0.483E-02	0.499E-02	0.388E-02
	80000.	0.445E-01	0.868E-02	0.664E-02	0.569E-02	0.560E-02	0.457E-02
5P - 7S	2500.	0.122E-01	0.881E-02	0.255E-02	0.230E-02	0.209E-02	0.184E-02
17979.0A	5000.	0.139E-01	0.104E-01	0.284E-02	0.259E-02	0.232E-02	0.208E-02
C= 0.26E+20	10000.	0.154E-01	0.985E-02	0.317E-02	0.292E-02	0.258E-02	0.234E-02
	20000.	0.175E-01	0.896E-02	0.354E-02	0.328E-02	0.288E-02	0.264E-02
	30000.	0.197E-01	0.775E-02	0.378E-02	0.352E-02	0.307E-02	0.283E-02
	80000.	0.243E-01	0.543E-02	0.444E-02	0.414E-02	0.359E-02	0.333E-02
5P - 8S	2500.	0.169E-01	0.123E-01	0.345E-02	0.318E-02	0.279E-02	0.254E-02
14178.0A	5000.	0.188E-01	0.138E-01	0.387E-02	0.360E-02	0.312E-02	0.288E-02
C= 0.93E+19	10000.	0.217E-01	0.137E-01	0.434E-02	0.406E-02	0.350E-02	0.326E-02
	20000.	0.242E-01	0.107E-01	0.487E-02	0.457E-02	0.392E-02	0.367E-02
	30000.	0.272E-01	0.869E-02	0.521E-02	0.489E-02	0.419E-02	0.393E-02
	80000.	0.322E-01	0.509E-02	0.613E-02	0.577E-02	0.493E-02	0.464E-02

NE= 0.1E+14

TRANSITION	T(K)	ELECTRONS 2WE(A)	DE(A)	PROTONS 2WI(A)	DI(A)	IONIZED HELIUM 2WI(A)	DI(A)
5P - 9S	2500.	0.263E-01	0.195E-01	0.531E-02	0.487E-02	0.428E-02	0.389E-02
12600.0A	5000.	0.290E-01	0.208E-01	0.596E-02	0.553E-02	0.480E-02	0.443E-02
C= 0.46E+19	10000.	0.332E-01	0.192E-01	0.669E-02	0.627E-02	0.539E-02	0.502E-02
	20000.	0.389E-01	0.134E-01	0.751E-02	0.705E-02	0.604E-02	0.566E-02
	30000.	0.436E-01	0.109E-01	0.804E-02	0.756E-02	0.646E-02	0.607E-02
	80000.	0.501E-01	0.509E-02	0.948E-02	0.892E-02	0.761E-02	0.717E-02
5P -10S	2500.	0.412E-01	0.294E-01	0.824E-02	0.750E-02	0.663E-02	0.597E-02
11761.0A	5000.	0.456E-01	0.303E-01	0.926E-02	0.854E-02	0.744E-02	0.683E-02
C= 0.27E+19	10000.	0.523E-01	0.269E-01	0.104E-01	0.969E-02	0.836E-02	0.776E-02
	20000.	0.635E-01	0.174E-01	0.117E-01	0.109E-01	0.938E-02	0.878E-02
	30000.	0.706E-01	0.142E-01	0.125E-01	0.117E-01	0.100E-01	0.941E-02
	80000.	0.794E-01	0.557E-02	0.147E-01	0.139E-01	0.118E-01	0.111E-01
5P -11S	2500.	0.639E-01	0.461E-01	0.124E-01	0.111E-01	0.993E-02	0.881E-02
11253.0A	5000.	0.702E-01	0.435E-01	0.139E-01	0.127E-01	0.112E-01	0.101E-01
C= 0.18E+19	10000.	0.817E-01	0.362E-01	0.156E-01	0.144E-01	0.125E-01	0.116E-01
	20000.	0.101	0.220E-01	0.175E-01	0.164E-01	0.141E-01	0.131E-01
	30000.	0.112	0.186E-01	0.187E-01	0.175E-01	0.150E-01	0.141E-01
	80000.	0.124	0.641E-02	0.221E-01	0.207E-01	0.177E-01	0.167E-01
5P - 4D	2500.	0.201E-01	0.138E-01	0.505E-02	0.369E-02	0.451E-02	0.296E-02
37255.0A	5000.	0.232E-01	0.135E-01	0.543E-02	0.416E-02	0.477E-02	0.334E-02
C= 0.10E+21	10000.	0.271E-01	0.101E-01	0.587E-02	0.467E-02	0.509E-02	0.376E-02
	20000.	0.341E-01	0.787E-02	0.639E-02	0.525E-02	0.548E-02	0.422E-02
	30000.	0.379E-01	0.673E-02	0.673E-02	0.562E-02	0.573E-02	0.452E-02
	80000.	0.446E-01	0.391E-02	0.769E-02	0.662E-02	0.645E-02	0.532E-02
5P - 5D	2500.	0.161E-01	0.115E-01	0.393E-02	0.303E-02	0.343E-02	0.243E-02
18272.0A	5000.	0.176E-01	0.121E-01	0.426E-02	0.343E-02	0.368E-02	0.275E-02
C= 0.14E+20	10000.	0.195E-01	0.106E-01	0.465E-02	0.386E-02	0.397E-02	0.310E-02
	20000.	0.227E-01	0.791E-02	0.509E-02	0.434E-02	0.430E-02	0.348E-02
	30000.	0.247E-01	0.670E-02	0.539E-02	0.465E-02	0.453E-02	0.373E-02
	80000.	0.273E-01	0.352E-02	0.621E-02	0.548E-02	0.515E-02	0.440E-02
5P - 6D	2500.	0.238E-01	0.171E-01	0.582E-02	0.445E-02	0.508E-02	0.355E-02
14319.0A	5000.	0.260E-01	0.172E-01	0.631E-02	0.504E-02	0.544E-02	0.404E-02
C= 0.53E+19	10000.	0.286E-01	0.151E-01	0.688E-02	0.569E-02	0.587E-02	0.457E-02
	20000.	0.330E-01	0.104E-01	0.754E-02	0.641E-02	0.637E-02	0.515E-02
	30000.	0.354E-01	0.839E-02	0.798E-02	0.687E-02	0.670E-02	0.552E-02
	80000.	0.380E-01	0.366E-02	0.919E-02	0.811E-02	0.762E-02	0.652E-02
5P - 7D	2500.	0.385E-01	0.290E-01	0.935E-02	0.712E-02	0.814E-02	0.568E-02
12679.0A	5000.	0.422E-01	0.270E-01	0.102E-01	0.811E-02	0.873E-02	0.648E-02
C= 0.27E+19	10000.	0.466E-01	0.224E-01	0.111E-01	0.919E-02	0.944E-02	0.736E-02
	20000.	0.537E-01	0.141E-01	0.122E-01	0.104E-01	0.103E-01	0.832E-02
	30000.	0.572E-01	0.118E-01	0.129E-01	0.111E-01	0.108E-01	0.892E-02
	80000.	0.603E-01	0.424E-02	0.149E-01	0.131E-01	0.123E-01	0.105E-01

TRANSITION	T(K)	ELECTRONS 2WE(A)	DE(A)	PROTONS 2WI(A)	DI(A)	IONIZED HELIUM 2WI(A)	DI(A)
NE= 0.1E+14							
5P - 8D	2500.	0.620E-01	0.450E-01	0.149E-01	0.113E-01	0.129E-01	0.901E-02
11811.0A	5000.	0.682E-01	0.441E-01	0.162E-01	0.130E-01	0.139E-01	0.104E-01
C= 0.16E+19	10000.	0.760E-01	0.334E-01	0.178E-01	0.147E-01	0.151E-01	0.118E-01
	20000.	0.876E-01	0.200E-01	0.195E-01	0.167E-01	0.164E-01	0.134E-01
	30000.	0.926E-01	0.176E-01	0.207E-01	0.179E-01	0.173E-01	0.144E-01
	80000.	0.962E-01	0.540E-02	0.239E-01	0.212E-01	0.197E-01	0.170E-01
5P - 9D	2500.	0.968E-01	0.684E-01	0.232E-01*	0.175E-01*	0.200E-01*	0.138E-01*
11286.0A	5000.	0.107	0.661E-01	0.252E-01	0.201E-01	0.216E-01*	0.160E-01*
C= 0.10E+19	10000.	0.121	0.480E-01	0.277E-01	0.230E-01	0.234E-01	0.184E-01
	20000.	0.139	0.294E-01	0.304E-01	0.261E-01	0.255E-01	0.209E-01
	30000.	0.146	0.250E-01	0.322E-01	0.280E-01	0.269E-01	0.224E-01
	80000.	0.150	0.715E-02	0.373E-01	0.331E-01	0.308E-01	0.266E-01
NE= 0.1E+15							
3D - 4P	2500.	33.5	-1.79				
91050.0A	5000.	32.1	-1.36				
C= 0.27E+19	10000.	29.8	-1.14				
	20000.	27.2	-0.619	21.7*	21.8*		
	30000.	25.5	-0.510	20.3*	23.8*		
	80000.	21.3	-0.242	14.3	24.7	21.5*	22.7*
3D - 5P	2500.	0.573E-01	0.333E-01	0.210E-01	0.874E-02	0.205E-01	0.700E-02
31453.0A	5000.	0.655E-01	0.397E-01	0.214E-01	0.987E-02	0.207E-01	0.792E-02
C= 0.27E+21	10000.	0.770E-01	0.404E-01	0.220E-01	0.111E-01	0.211E-01	0.892E-02
	20000.	0.942E-01	0.364E-01	0.227E-01	0.125E-01	0.215E-01	0.100E-01
	30000.	0.107	0.311E-01	0.232E-01	0.134E-01	0.218E-01	0.108E-01
	80000.	0.140	0.240E-01	0.247E-01	0.158E-01	0.228E-01	0.127E-01
3D - 6P	2500.	0.352E-01	0.229E-01	0.132E-01	0.592E-02	0.127E-01	0.472E-02
13384.0A	5000.	0.410E-01	0.270E-01	0.135E-01	0.672E-02	0.129E-01	0.538E-02
C= 0.21E+20	10000.	0.480E-01	0.263E-01	0.139E-01	0.761E-02	0.132E-01	0.610E-02
	20000.	0.572E-01	0.243E-01	0.145E-01	0.857E-02	0.136E-01	0.688E-02
	30000.	0.640E-01	0.218E-01	0.149E-01	0.919E-02	0.138E-01	0.738E-02
	80000.	0.788E-01	0.167E-01	0.160E-01	0.108E-01	0.146E-01	0.872E-02
3D - 7P	2500.	0.560E-01	0.368E-01	0.200E-01	0.927E-02	0.193E-01	0.736E-02
10482.0A	5000.	0.655E-01	0.419E-01	0.206E-01	0.106E-01	0.197E-01	0.846E-02
C= 0.68E+19	10000.	0.772E-01	0.417E-01	0.214E-01	0.121E-01	0.201E-01	0.964E-02
	20000.	0.925E-01	0.343E-01	0.223E-01	0.136E-01	0.207E-01	0.109E-01
	30000.	0.103	0.298E-01	0.229E-01	0.146E-01	0.211E-01	0.118E-01
	80000.	0.123	0.197E-01	0.248E-01	0.173E-01	0.224E-01	0.139E-01
3D - 8P	2500.	0.974E-01	0.642E-01	0.330E-01	0.155E-01	0.316E-01	0.123E-01
9348.6A	5000.	0.114	0.690E-01	0.342E-01	0.180E-01	0.324E-01	0.143E-01
C= 0.32E+19	10000.	0.136	0.648E-01	0.355E-01	0.205E-01	0.332E-01	0.164E-01
	20000.	0.164	0.504E-01	0.372E-01	0.233E-01	0.343E-01	0.186E-01
	30000.	0.183	0.410E-01	0.383E-01	0.251E-01	0.351E-01	0.201E-01
	80000.	0.212	0.220E-01	0.417E-01	0.297E-01	0.374E-01	0.238E-01

NE= 0.1E+15

		ELECTRONS		PROTONS		IONIZED HELIUM	
TRANSITION	T(K)	2WE(A)	DE(A)	2WI(A)	DI(A)	2WI(A)	DI(A)
3D - 9P	2500.	0.167	0.105	0.536E-01*	0.254E-01*		
8764.8A	5000.	0.196	0.111	0.557E-01*	0.297E-01*	0.524E-01*	0.235E-01*
C= 0.18E+19	10000.	0.236	0.102	0.581E-01	0.342E-01	0.541E-01*	0.272E-01*
	20000.	0.288	0.740E-01	0.610E-01	0.390E-01	0.560E-01*	0.311E-01*
	30000.	0.318	0.556E-01	0.630E-01	0.419E-01	0.574E-01*	0.336E-01*
	80000.	0.361	0.247E-01	0.689E-01	0.499E-01	0.614E-01	0.401E-01
3D - 4F	2500.	0.264E-01	-0.110E-01	0.595E-02	-0.371E-02	0.550E-02	-0.297E-02
15165.0A	5000.	0.295E-01	-0.701E-02	0.627E-02	-0.421E-02	0.571E-02	-0.337E-02
C= 0.17E+20	10000.	0.355E-01	-0.358E-02	0.666E-02	-0.474E-02	0.598E-02	-0.381E-02
	20000.	0.408E-01	-0.111E-02	0.713E-02	-0.533E-02	0.631E-02	-0.428E-02
	30000.	0.439E-01	-0.114E-02	0.745E-02	-0.571E-02	0.654E-02	-0.459E-02
	80000.	0.508E-01	0.416E-03	0.837E-02	-0.674E-02	0.719E-02	-0.542E-02
3D - 5F	2500.	0.235	0.286E-01	0.839E-01*	0.681E-01*	0.674E-01*	0.527E-01*
11022.3A	5000.	0.215	0.118E-01	0.948E-01*	0.808E-01*	0.756E-01*	0.636E-01*
C= 0.14E+18	10000.	0.196	0.687E-02	0.108*	0.940E-01*	0.851E-01*	0.745E-01*
	20000.	0.180	-0.200E-02	0.125*	0.109*	0.962E-01*	0.857E-01*
	30000.	0.169	-0.202E-02	0.134	0.122	0.104*	0.927E-01*
	80000.	0.147	-0.975E-03	0.136	0.151	0.127	0.113
4S - 4P	2500.	0.448E-03	0.339E-03	0.277E-03	0.938E-04	0.273E-03	0.753E-04
7676.2A	5000.	0.509E-03	0.401E-03	0.280E-03	0.106E-03	0.275E-03	0.848E-04
C= 0.47E+20	10000.	0.624E-03	0.454E-03	0.284E-03	0.119E-03	0.277E-03	0.953E-04
	20000.	0.825E-03	0.461E-03	0.290E-03	0.133E-03	0.281E-03	0.107E-03
	30000.	0.973E-03	0.410E-03	0.294E-03	0.143E-03	0.283E-03	0.115E-03
	80000.	0.139E-02	0.285E-03	0.306E-03	0.168E-03	0.291E-03	0.135E-03
4S - 5P	2500.	0.963E-03	0.604E-03	0.406E-03	0.164E-03	0.397E-03	0.131E-03
4045.2A	5000.	0.110E-02	0.719E-03	0.414E-03	0.185E-03	0.401E-03	0.148E-03
C= 0.44E+19	10000.	0.126E-02	0.777E-03	0.424E-03	0.208E-03	0.407E-03	0.167E-03
	20000.	0.148E-02	0.763E-03	0.436E-03	0.234E-03	0.415E-03	0.188E-03
	30000.	0.164E-02	0.670E-03	0.445E-03	0.251E-03	0.420E-03	0.202E-03
	80000.	0.206E-02	0.492E-03	0.472E-03	0.296E-03	0.438E-03	0.238E-03
4S - 6P	2500.	0.233E-02	0.151E-02	0.919E-03	0.400E-03	0.891E-03	0.319E-03
3446.7A	5000.	0.271E-02	0.175E-02	0.941E-03	0.454E-03	0.905E-03	0.363E-03
C= 0.14E+19	10000.	0.315E-02	0.183E-02	0.969E-03	0.514E-03	0.922E-03	0.412E-03
	20000.	0.373E-02	0.171E-02	0.100E-02	0.579E-03	0.944E-03	0.465E-03
	30000.	0.414E-02	0.150E-02	0.103E-02	0.621E-03	0.960E-03	0.498E-03
	80000.	0.505E-02	0.107E-02	0.110E-02	0.733E-03	0.101E-02	0.589E-03
4S - 7P	2500.	0.526E-02	0.343E-02	0.193E-02	0.877E-03	0.186E-02	0.696E-03
3217.3A	5000.	0.615E-02	0.394E-02	0.198E-02	0.100E-02	0.189E-02	0.801E-03
C= 0.64E+18	10000.	0.723E-02	0.384E-02	0.205E-02	0.114E-02	0.194E-02	0.912E-03
	20000.	0.864E-02	0.333E-02	0.214E-02	0.129E-02	0.199E-02	0.103E-02
	30000.	0.961E-02	0.282E-02	0.220E-02	0.138E-02	0.203E-02	0.111E-02
	80000.	0.114E-01	0.184E-02	0.237E-02	0.164E-02	0.215E-02	0.131E-02

NE= 0.1E+15

TRANSITION	T(K)	ELECTRONS 2WE(A)	DE(A)	PROTONS 2WI(A)	DI(A)	IONIZED HELIUM 2WI(A)	DI(A)
4S - 8P	2500.	0.107E-01	0.692E-02	0.367E-02	0.171E-02	0.351E-02*	0.135E-02*
3101.9A	5000.	0.125E-01	0.761E-02	0.379E-02	0.198E-02	0.360E-02*	0.157E-02*
C= 0.36E+18	10000.	0.149E-01	0.738E-02	0.394E-02	0.226E-02	0.369E-02	0.180E-02
	20000.	0.180E-01	0.579E-02	0.412E-02	0.256E-02	0.381E-02	0.205E-02
	30000.	0.200E-01	0.479E-02	0.425E-02	0.276E-02	0.390E-02	0.221E-02
	80000.	0.232E-01	0.277E-02	0.461E-02	0.326E-02	0.415E-02	0.262E-02
4S - 9P	2500.	0.199E-01	0.126E-01	0.646E-02*	0.305E-02*		
3034.8A	5000.	0.235E-01	0.133E-01	0.671E-02*	0.356E-02*	0.632E-02*	0.282E-02*
C= 0.22E+18	10000.	0.282E-01	0.124E-01	0.700E-02	0.410E-02	0.652E-02*	0.326E-02*
	20000.	0.344E-01	0.930E-02	0.734E-02	0.467E-02	0.675E-02*	0.373E-02*
	30000.	0.380E-01	0.760E-02	0.758E-02	0.503E-02	0.691E-02	0.403E-02
	80000.	0.431E-01	0.395E-02	0.828E-02	0.599E-02	0.739E-02	0.480E-02
4P - 5S	2500.	0.584E-02	0.411E-02	0.136E-02	0.113E-02	0.116E-02	0.903E-03
12492.0A	5000.	0.672E-02	0.489E-02	0.150E-02	0.127E-02	0.126E-02	0.102E-02
C= 0.58E+20	10000.	0.748E-02	0.573E-02	0.165E-02	0.143E-02	0.138E-02	0.115E-02
	20000.	0.844E-02	0.566E-02	0.182E-02	0.161E-02	0.151E-02	0.129E-02
	30000.	0.900E-02	0.513E-02	0.193E-02	0.172E-02	0.160E-02	0.139E-02
	80000.	0.115E-01	0.361E-02	0.224E-02	0.203E-02	0.184E-02	0.163E-02
4P - 6S	2500.	0.665E-02	0.486E-02	0.143E-02	0.131E-02	0.116E-02	0.104E-02
6929.5A	5000.	0.765E-02	0.571E-02	0.161E-02	0.148E-02	0.130E-02	0.119E-02
C= 0.75E+19	10000.	0.824E-02	0.625E-02	0.180E-02	0.168E-02	0.145E-02	0.135E-02
	20000.	0.916E-02	0.619E-02	0.202E-02	0.189E-02	0.163E-02	0.152E-02
	30000.	0.950E-02	0.554E-02	0.216E-02	0.202E-02	0.174E-02	0.162E-02
	80000.	0.117E-01	0.413E-02	0.254E-02	0.239E-02	0.204E-02	0.192E-02
4P - 7S	2500.	0.126E-01	0.930E-02	0.264E-02	0.239E-02	0.213E-02	0.190E-02
5795.3A	5000.	0.151E-01	0.110E-01	0.297E-02	0.273E-02	0.239E-02	0.218E-02
C= 0.27E+19	10000.	0.154E-01	0.110E-01	0.333E-02	0.310E-02	0.268E-02	0.248E-02
	20000.	0.170E-01	0.103E-01	0.374E-02	0.350E-02	0.301E-02	0.281E-02
	30000.	0.184E-01	0.895E-02	0.400E-02	0.375E-02	0.322E-02	0.301E-02
	80000.	0.224E-01	0.642E-02	0.471E-02	0.444E-02	0.379E-02	0.356E-02
4P - 8S	2500.	0.232E-01	0.166E-01	0.468E-02	0.414E-02	0.376E-02	0.327E-02
5334.3A	5000.	0.260E-01	0.190E-01	0.525E-02	0.477E-02	0.423E-02	0.379E-02
C= 0.13E+19	10000.	0.298E-01	0.189E-01	0.590E-02	0.544E-02	0.474E-02	0.435E-02
	20000.	0.323E-01	0.153E-01	0.662E-02	0.617E-02	0.533E-02	0.494E-02
	30000.	0.360E-01	0.127E-01	0.709E-02	0.663E-02	0.570E-02	0.531E-02
	80000.	0.425E-01	0.762E-02	0.835E-02	0.785E-02	0.671E-02	0.630E-02
4P - 9S	2500.	0.431E-01	0.314E-01	0.870E-02	0.747E-02	0.700E-02*	0.585E-02*
5094.3A	5000.	0.475E-01	0.345E-01	0.977E-02	0.870E-02	0.785E-02*	0.689E-02*
C= 0.76E+18	10000.	0.537E-01	0.318E-01	0.110E-01	0.100E-01	0.882E-02	0.796E-02
	20000.	0.623E-01	0.243E-01	0.123E-01	0.114E-01	0.990E-02	0.910E-02
	30000.	0.695E-01	0.189E-01	0.132E-01	0.123E-01	0.106E-01	0.981E-02
	80000.	0.796E-01	0.907E-02	0.155E-01	0.145E-01	0.125E-01	0.117E-01

NE= 0.1E+15

TRANSITION	T(K)	ELECTRONS 2WE(A)	DE(A)	PROTONS 2WI(A)	DI(A)	IONIZED HELIUM 2WI(A)	DI(A)
4P -10S	2500.	0.730E-01	0.512E-01	0.146E-01*	0.121E-01*	0.118E-01*	0.940E-02*
4951.4A	5000.	0.807E-01	0.540E-01	0.164E-01*	0.143E-01*	0.132E-01*	0.113E-01*
C= 0.48E+18	10000.	0.924E-01	0.497E-01	0.184E-01	0.166E-01	0.148E-01*	0.132E-01*
	20000.	0.111	0.357E-01	0.207E-01	0.190E-01	0.166E-01*	0.151E-01*
	30000.	0.123	0.260E-01	0.221E-01	0.205E-01	0.178E-01*	0.164E-01*
	80000.	0.138	0.105E-01	0.261E-01	0.244E-01	0.210E-01	0.196E-01
4P -11S	2500.	0.119	0.840E-01	0.230E-01*	0.183E-01*		
4859.0A	5000.	0.131	0.809E-01	0.259E-01*	0.220E-01*		
C= 0.33E+18	10000.	0.152	0.705E-01	0.290E-01*	0.257E-01*	0.233E-01*	0.204E-01*
	20000.	0.187	0.490E-01	0.326E-01*	0.296E-01*	0.262E-01*	0.236E-01*
	30000.	0.206	0.364E-01	0.349E-01*	0.320E-01*	0.280E-01*	0.255E-01*
	80000.	0.228	0.124E-01	0.412E-01	0.383E-01	0.331E-01*	0.307E-01*
4P -12S	2500.	0.173	0.116				
4795.7A	5000.	0.206	0.116				
C= 0.24E+18	10000.	0.238	0.914E-01	0.421E-01*	0.368E-01*		
	20000.	0.298	0.622E-01	0.472E-01*	0.425E-01*	0.380E-01*	0.338E-01*
	30000.	0.327	0.465E-01	0.506E-01*	0.461E-01*	0.406E-01*	0.367E-01*
	80000.	0.358	0.144E-01	0.598E-01*	0.553E-01*	0.479E-01*	0.442E-01*
4P - 3D	2500.	0.253E-02	0.131E-02	0.873E-03	0.346E-03	0.854E-03	0.278E-03
11745.0A	5000.	0.271E-02	0.144E-02	0.888E-03	0.389E-03	0.863E-03	0.313E-03
C= 0.44E+20	10000.	0.312E-02	0.142E-02	0.908E-03	0.438E-03	0.875E-03	0.352E-03
	20000.	0.394E-02	0.111E-02	0.933E-03	0.492E-03	0.890E-03	0.395E-03
	30000.	0.464E-02	0.944E-03	0.952E-03	0.526E-03	0.901E-03	0.423E-03
	80000.	0.639E-02	0.673E-03	0.101E-02	0.620E-03	0.937E-03	0.498E-03
4P - 4D	2500.	0.766E-02	0.560E-02	0.199E-02	0.144E-02	0.177E-02	0.115E-02
6955.2A	5000.	0.839E-02	0.604E-02	0.215E-02	0.164E-02	0.188E-02	0.131E-02
C= 0.35E+19	10000.	0.914E-02	0.579E-02	0.232E-02	0.185E-02	0.201E-02	0.149E-02
	20000.	0.101E-01	0.457E-02	0.253E-02	0.209E-02	0.217E-02	0.167E-02
	30000.	0.109E-01	0.406E-02	0.267E-02	0.224E-02	0.227E-02	0.180E-02
	80000.	0.120E-01	0.282E-02	0.305E-02	0.264E-02	0.256E-02	0.212E-02
4P - 5D	2500.	0.166E-01	0.123E-01	0.422E-02	0.304E-02	0.372E-02	0.241E-02
5825.3A	5000.	0.181E-01	0.128E-01	0.455E-02	0.348E-02	0.397E-02	0.278E-02
C= 0.14E+19	10000.	0.197E-01	0.122E-01	0.494E-02	0.396E-02	0.425E-02	0.316E-02
	20000.	0.221E-01	0.922E-02	0.540E-02	0.448E-02	0.460E-02	0.359E-02
	30000.	0.236E-01	0.775E-02	0.570E-02	0.480E-02	0.482E-02	0.386E-02
	80000.	0.254E-01	0.453E-02	0.654E-02	0.568E-02	0.546E-02	0.456E-02
4P - 6D	2500.	0.333E-01	0.247E-01	0.831E-02	0.591E-02	0.729E-02*	0.466E-02*
5354.1A	5000.	0.364E-01	0.252E-01	0.900E-02	0.685E-02	0.780E-02	0.544E-02
C= 0.74E+18	10000.	0.398E-01	0.225E-01	0.980E-02	0.783E-02	0.839E-02	0.625E-02
	20000.	0.452E-01	0.164E-01	0.107E-01	0.890E-02	0.909E-02	0.712E-02
	30000.	0.483E-01	0.128E-01	0.113E-01	0.958E-02	0.955E-02	0.767E-02
	80000.	0.512E-01	0.581E-02	0.130E-01	0.114E-01	0.108E-01	0.911E-02

NE= 0.1E+15

TRANSITION	T(K)	ELECTRONS 2WE(A)	DE(A)	PROTONS 2WI(A)	DI(A)	IONIZED HELIUM 2WI(A)	DI(A)
4P - 7D	2500.	0.624E-01	0.466E-01	0.153E-01*	0.106E-01*	0.133E-01*	0.830E-02*
5107.2A	5000.	0.683E-01	0.441E-01	0.166E-01*	0.125E-01*	0.143E-01*	0.988E-02*
C= 0.43E+18	10000.	0.752E-01	0.384E-01	0.181E-01	0.144E-01	0.155E-01*	0.115E-01*
	20000.	0.863E-01	0.273E-01	0.199E-01	0.165E-01	0.168E-01*	0.132E-01*
	30000.	0.917E-01	0.204E-01	0.210E-01	0.178E-01	0.176E-01	0.142E-01
	80000.	0.960E-01	0.736E-02	0.242E-01	0.212E-01	0.201E-01	0.170E-01
4P - 8D	2500.	0.109	0.778E-01	0.264E-01*	0.178E-01*		
4960.2A	5000.	0.120	0.776E-01	0.287E-01*	0.213E-01*		
C= 0.28E+18	10000.	0.134	0.615E-01	0.314E-01*	0.249E-01*	0.267E-01*	0.197E-01*
	20000.	0.154	0.428E-01	0.345E-01*	0.286E-01*	0.291E-01*	0.228E-01*
	30000.	0.162	0.314E-01	0.366E-01*	0.309E-01*	0.306E-01*	0.247E-01*
	80000.	0.168	0.986E-02	0.423E-01	0.370E-01	0.349E-01*	0.296E-01*
4P - 9D	2500.	0.180	0.127				
4865.2A	5000.	0.199	0.122				
C= 0.19E+18	10000.	0.224	0.923E-01	0.515E-01*	0.403E-01*		
	20000.	0.258	0.642E-01	0.566E-01*	0.467E-01*		
	30000.	0.270	0.461E-01	0.600E-01*	0.506E-01*		
	80000.	0.277	0.134E-01	0.695E-01*	0.607E-01*	0.573E-01*	0.486E-01*
4D - 6P	2500.	0.675	0.173	0.231	0.390E-01	0.230	0.312E-01
62191.0A	5000.	0.935	0.218	0.231	0.441E-01	0.231	0.354E-01
C= 0.28E+21	10000.	1.27	0.235	0.232	0.497E-01	0.231	0.399E-01
	20000.	1.66	0.206	0.233	0.559E-01	0.231	0.449E-01
	30000.	1.89	0.184	0.233	0.599E-01	0.232	0.481E-01
	80000.	2.32	0.154	0.235	0.707E-01	0.233	0.567E-01
4D - 7P	2500.	0.369	0.213	0.124	0.541E-01	0.119	0.430E-01
27199.0A	5000.	0.451	0.231	0.127	0.618E-01	0.121	0.493E-01
C= 0.46E+20	10000.	0.561	0.225	0.131	0.701E-01	0.124	0.561E-01
	20000.	0.701	0.178	0.136	0.794E-01	0.127	0.636E-01
	30000.	0.790	0.154	0.139	0.850E-01	0.129	0.683E-01
	80000.	0.941	0.945E-01	0.150	0.101	0.136	0.807E-01
4D - 8P	2500.	0.477	0.293	0.156	0.729E-01	0.149*	0.575E-01*
20691.0A	5000.	0.569	0.315	0.161	0.842E-01	0.152*	0.669E-01*
C= 0.16E+20	10000.	0.690	0.293	0.167	0.961E-01	0.156	0.768E-01
	20000.	0.852	0.212	0.175	0.109	0.162	0.873E-01
	30000.	0.951	0.171	0.180	0.117	0.165	0.940E-01
	80000.	1.10	0.868E-01	0.196	0.139	0.176	0.112
4D - 4F	2500.	4.41	-2.62	0.802	-0.687	0.668	-0.548
136923.A	5000.	4.84	-2.76	0.889	-0.781	0.735	-0.625
C= 0.14E+22	10000.	5.27	-2.28	0.987	-0.885	0.812	-0.708
	20000.	6.17	-1.72	1.10	-0.996	0.900	-0.800
	30000.	6.70	-1.56	1.17	-1.07	0.956	-0.858
	80000.	7.37	-0.953	1.37	-1.26	1.11	-1.01

NE= 0.1E+15

TRANSITION	T(K)	ELECTRONS 2WE(A)	DE(A)	PROTONS 2WI(A)	DI(A)	IONIZED HELIUM 2WI(A)	DI(A)
4D - 5F	2500.	1.98	0.142	0.665*	0.541*	0.533*	0.419*
31162.0A	5000.	1.84	-0.352E-02	0.752*	0.642*	0.599*	0.505*
C= 0.11E+19	10000.	1.68	-0.107	0.860*	0.746*	0.674*	0.591*
	20000.	1.57	-0.963E-01	0.991	0.866	0.763*	0.681*
	30000.	1.51	-0.100	1.06	0.952	0.825*	0.736*
	80000.	1.33	-0.642E-01	1.07	1.20	1.01	0.897
5S - 5P	2500.	0.350E-01	0.127E-01	0.174E-01	0.360E-02	0.174E-01	0.288E-02
27114.0A	5000.	0.416E-01	0.120E-01	0.175E-01	0.405E-02	0.174E-01	0.325E-02
C= 0.20E+21	10000.	0.550E-01	0.767E-02	0.176E-01	0.455E-02	0.175E-01	0.366E-02
	20000.	0.767E-01	0.485E-02	0.177E-01	0.512E-02	0.175E-01	0.411E-02
	30000.	0.913E-01	0.402E-02	0.177E-01	0.548E-02	0.175E-01	0.441E-02
	80000.	0.123	0.272E-02	0.180E-01	0.646E-02	0.177E-01	0.519E-02
5S - 6P	2500.	0.302E-01	0.190E-01	0.120E-01	0.491E-02	0.117E-01	0.392E-02
12531.0A	5000.	0.352E-01	0.215E-01	0.123E-01	0.558E-02	0.119E-01	0.446E-02
C= 0.19E+20	10000.	0.420E-01	0.217E-01	0.126E-01	0.632E-02	0.120E-01	0.506E-02
	20000.	0.514E-01	0.176E-01	0.130E-01	0.711E-02	0.123E-01	0.571E-02
	30000.	0.585E-01	0.153E-01	0.133E-01	0.762E-02	0.125E-01	0.612E-02
	80000.	0.732E-01	0.116E-01	0.141E-01	0.900E-02	0.130E-01	0.723E-02
5S - 7P	2500.	0.503E-01	0.327E-01	0.184E-01	0.825E-02	0.177E-01	0.655E-02
9951.3A	5000.	0.588E-01	0.367E-01	0.189E-01	0.944E-02	0.181E-01	0.753E-02
C= 0.62E+19	10000.	0.699E-01	0.369E-01	0.195E-01	0.107E-01	0.185E-01	0.858E-02
	20000.	0.844E-01	0.299E-01	0.203E-01	0.121E-01	0.190E-01	0.973E-02
	30000.	0.946E-01	0.247E-01	0.209E-01	0.130E-01	0.193E-01	0.105E-01
	80000.	0.113	0.160E-01	0.225E-01	0.154E-01	0.204E-01	0.124E-01
5S - 8P	2500.	0.886E-01	0.584E-01	0.304E-01	0.141E-01	0.290E-01*	0.111E-01*
8924.4A	5000.	0.104	0.620E-01	0.314E-01	0.163E-01	0.298E-01*	0.129E-01*
C= 0.29E+19	10000.	0.124	0.598E-01	0.326E-01	0.186E-01	0.305E-01	0.148E-01
	20000.	0.151	0.432E-01	0.340E-01	0.211E-01	0.315E-01	0.169E-01
	30000.	0.168	0.351E-01	0.351E-01	0.227E-01	0.322E-01	0.182E-01
	80000.	0.195	0.183E-01	0.381E-01	0.269E-01	0.342E-01	0.216E-01
5S - 9P	2500.	0.153	0.997E-01	0.494E-01*	0.232E-01*		
8390.7A	5000.	0.180	0.104	0.513E-01*	0.272E-01*	0.483E-01*	0.215E-01*
C= 0.17E+19	10000.	0.216	0.905E-01	0.534E-01	0.313E-01	0.498E-01*	0.249E-01*
	20000.	0.265	0.596E-01	0.561E-01	0.356E-01	0.516E-01*	0.285E-01*
	30000.	0.292	0.505E-01	0.579E-01	0.384E-01	0.528E-01	0.307E-01
	80000.	0.332	0.210E-01	0.632E-01	0.457E-01	0.564E-01	0.367E-01
5P - 6S	2500.	0.180	0.120	0.441E-01	0.312E-01	0.395E-01	0.249E-01
36529.0A	5000.	0.209	0.142	0.473E-01	0.353E-01	0.418E-01	0.283E-01
C= 0.21E+21	10000.	0.247	0.146	0.511E-01	0.399E-01	0.445E-01	0.320E-01
	20000.	0.299	0.126	0.554E-01	0.449E-01	0.477E-01	0.361E-01
	30000.	0.344	0.110	0.583E-01	0.482E-01	0.499E-01	0.387E-01
	80000.	0.445	0.868E-01	0.664E-01	0.568E-01	0.560E-01	0.457E-01

NE= 0.1E+15

TRANSITION	T(K)	ELECTRONS 2WE(A)	DE(A)	PROTONS 2WI(A)	DI(A)	IONIZED HELIUM 2WI(A)	DI(A)
5P - 7S	2500.	0.122	0.875E-01	0.255E-01	0.223E-01	0.209E-01	0.177E-01
17979.0A	5000.	0.139	0.104	0.284E-01	0.254E-01	0.232E-01	0.203E-01
C= 0.26E+20	10000.	0.154	0.984E-01	0.317E-01	0.289E-01	0.258E-01	0.231E-01
	20000.	0.175	0.896E-01	0.355E-01	0.326E-01	0.288E-01	0.262E-01
	30000.	0.197	0.775E-01	0.378E-01	0.350E-01	0.307E-01	0.281E-01
	80000.	0.243	0.543E-01	0.444E-01	0.413E-01	0.359E-01	0.332E-01
5P - 8S	2500.	0.169	0.122	0.345E-01	0.303E-01	0.279E-01	0.239E-01
14178.0A	5000.	0.188	0.138	0.387E-01	0.349E-01	0.312E-01	0.278E-01
C= 0.93E+19	10000.	0.217	0.137	0.434E-01	0.398E-01	0.350E-01	0.318E-01
	20000.	0.242	0.107	0.487E-01	0.452E-01	0.392E-01	0.362E-01
	30000.	0.272	0.868E-01	0.521E-01	0.486E-01	0.419E-01	0.389E-01
	80000.	0.322	0.509E-01	0.613E-01	0.575E-01	0.493E-01	0.462E-01
5P - 9S	2500.	0.263	0.193	0.531E-01	0.455E-01	0.428E-01*	0.357E-01*
12600.0A	5000.	0.290	0.208	0.596E-01	0.530E-01	0.480E-01*	0.420E-01*
C= 0.46E+19	10000.	0.332	0.192	0.669E-01	0.609E-01	0.538E-01	0.485E-01
	20000.	0.389	0.133	0.751E-01	0.694E-01	0.604E-01	0.555E-01
	30000.	0.436	0.109	0.804E-01	0.747E-01	0.646E-01	0.598E-01
	80000.	0.501	0.509E-01	0.948E-01	0.887E-01	0.761E-01	0.713E-01
5P -10S	2500.	0.412	0.288	0.824E-01*	0.683E-01*	0.663E-01*	0.530E-01*
11761.0A	5000.	0.456	0.301	0.925E-01*	0.807E-01*	0.744E-01*	0.635E-01*
C= 0.27E+19	10000.	0.523	0.268	0.104	0.934E-01	0.835E-01*	0.742E-01*
	20000.	0.635	0.174	0.117	0.107	0.938E-01*	0.853E-01*
	30000.	0.706	0.141	0.125	0.115	0.100*	0.921E-01*
	80000.	0.794	0.557E-01	0.147	0.138	0.118	0.110
5P -11S	2500.	0.639	0.455	0.123*	0.982E-01*		
11253.0A	5000.	0.702	0.430	0.139*	0.118*		
C= 0.18E+19	10000.	0.817	0.362	0.156*	0.138*	0.125*	0.109*
	20000.	1.01	0.220	0.175*	0.159*	0.140*	0.126*
	30000.	1.12	0.186	0.187*	0.172*	0.150*	0.137*
	80000.	1.24	0.641E-01	0.221	0.205	0.177*	0.164*
5P - 4D	2500.	0.201	0.137	0.505E-01	0.362E-01	0.450E-01	0.289E-01
37255.0A	5000.	0.232	0.135	0.543E-01	0.411E-01	0.477E-01	0.329E-01
C= 0.10E+21	10000.	0.271	0.101	0.587E-01	0.464E-01	0.509E-01	0.373E-01
	20000.	0.341	0.787E-01	0.639E-01	0.523E-01	0.548E-01	0.420E-01
	30000.	0.379	0.673E-01	0.673E-01	0.560E-01	0.573E-01	0.450E-01
	80000.	0.446	0.391E-01	0.769E-01	0.661E-01	0.645E-01	0.532E-01
5P - 5D	2500.	0.161	0.114	0.393E-01	0.292E-01	0.343E-01	0.232E-01
18272.0A	5000.	0.176	0.121	0.426E-01	0.335E-01	0.368E-01	0.267E-01
C= 0.14E+20	10000.	0.195	0.106	0.465E-01	0.380E-01	0.397E-01	0.304E-01
	20000.	0.227	0.791E-01	0.509E-01	0.431E-01	0.430E-01	0.345E-01
	30000.	0.247	0.670E-01	0.539E-01	0.461E-01	0.453E-01	0.371E-01
	80000.	0.273	0.352E-01	0.621E-01	0.546E-01	0.515E-01	0.439E-0

NE= 0.1E+15

TRANSITION	T(K)	ELECTRONS 2WE(A)	DE(A)	PROTONS 2WI(A)	DI(A)	IONIZED HELIUM 2WI(A)	DI(A)
5P - 6D	2500.	0.238	0.169	0.581E-01	0.420E-01	0.507E-01*	0.331E-01*
14319.0A	5000.	0.260	0.171	0.631E-01	0.486E-01	0.544E-01	0.386E-01
c= 0.53E+19	10000.	0.286	0.151	0.688E-01	0.557E-01	0.587E-01	0.444E-01
	20000.	0.330	0.104	0.754E-01	0.632E-01	0.637E-01	0.506E-01
	30000.	0.354	0.838E-01	0.798E-01	0.680E-01	0.670E-01	0.545E-01
	80000.	0.380	0.366E-01	0.919E-01	0.806E-01	0.762E-01	0.647E-01
5P - 7D	2500.	0.385	0.287	0.932E-01*	0.655E-01*	0.810E-01*	0.511E-01*
12679.0A	5000.	0.422	0.268	0.101*	0.770E-01*	0.872E-01*	0.608E-01*
c= 0.27E+19	10000.	0.466	0.224	0.111	0.889E-01	0.943E-01*	0.707E-01*
	20000.	0.537	0.141	0.122	0.102	0.102*	0.811E-01*
	30000.	0.572	0.118	0.129	0.109	0.108	0.875E-01
	80000.	0.603	0.424E-01	0.149	0.130	0.123	0.105
5P - 8D	2500.	0.620	0.439	0.149*	0.101*		
11811.0A	5000.	0.682	0.438	0.162*	0.121*		
c= 0.16E+19	10000.	0.760	0.334	0.178*	0.141*	0.151*	0.112*
	20000.	0.876	0.199	0.195*	0.162*	0.164*	0.129*
	30000.	0.926	0.176	0.207*	0.175*	0.173*	0.140*
	80000.	0.962	0.540E-01	0.239	0.210	0.197*	0.168*
5P - 9D	2500.	0.968	0.661				
11286.0A	5000.	1.07	0.653				
c= 0.10E+19	10000.	1.21	0.478	0.276*	0.217*		
	20000.	1.39	0.294	0.304*	0.251*		
	30000.	1.46	0.250	0.322*	0.272*		
	80000.	1.50	0.715E-01	0.373*	0.327*	0.308*	0.261*
NE= 0.1E+16							
3D - 5P	2500.	0.573	0.330	0.210	0.843E-01	0.204	0.669E-01
31453.0A	5000.	0.655	0.396	0.214	0.964E-01	0.207	0.769E-01
c= 0.27E+21	10000.	0.770	0.404	0.220	0.110	0.211	0.877E-01
	20000.	0.942	0.363	0.227	0.124	0.215	0.994E-01
	30000.	1.07	0.311	0.232	0.133	0.218	0.107
	80000.	1.40	0.240	0.247	0.157	0.228	0.126
3D - 6P	2500.	0.352	0.225	0.131	0.551E-01	0.126*	0.432E-01*
13384.0A	5000.	0.410	0.269	0.135	0.643E-01	0.129*	0.509E-01*
c= 0.21E+20	10000.	0.480	0.262	0.139	0.740E-01	0.132	0.589E-01
	20000.	0.572	0.243	0.145	0.843E-01	0.135	0.674E-01
	30000.	0.640	0.218	0.149	0.907E-01	0.138	0.726E-01
	80000.	0.788	0.167	0.160	0.108	0.146	0.866E-01
3D - 7P	2500.	0.560	0.357	0.197*	0.822E-01*		
10482.0A	5000.	0.655	0.414	0.205*	0.986E-01*	0.194*	0.772E-01*
c= 0.68E+19	10000.	0.772	0.417	0.213*	0.115*	0.200*	0.912E-01*
	20000.	0.925	0.342	0.223*	0.133*	0.207*	0.106*
	30000.	1.03	0.297	0.229	0.143	0.211	0.114
	80000.	1.23	0.197	0.248	0.171	0.224	0.137

NE= 0.1E+16

TRANSITION	T(K)	ELECTRONS 2WE(A)	DE(A)	PROTONS 2WI(A)	DI(A)	IONIZED HELIUM 2WI(A)	DI(A)
3D - 8P	2500.	0.974	0.618				
9348.6A	5000.	1.14	0.676				
C= 0.32E+19	10000.	1.36	0.641	0.354*	0.192*		
	20000.	1.64	0.503	0.371*	0.223*		
	30000.	1.83	0.410	0.383*	0.242*	0.350*	0.193*
	80000.	2.12	0.220	0.417*	0.292*	0.374*	0.233*
3D - 9P	2500.	1.66	0.990				
8764.8A	5000.	1.96	1.07				
C= 0.18E+19	10000.	2.36	1.01				
	20000.	2.88	0.740				
	30000.	3.18	0.554	0.629*	0.402*		
	80000.	3.61	0.247	0.688*	0.488*		
3D - 4F	2500.	0.264	-0.108	0.594E-01	-0.353E-01	0.548E-01	-0.279E-01
15165.0A	5000.	0.295	-0.695E-01	0.627E-01	-0.407E-01	0.571E-01	-0.324E-01
C= 0.17E+20	10000.	0.355	-0.354E-01	0.666E-01	-0.465E-01	0.598E-01	-0.371E-01
	20000.	0.408	-0.110E-01	0.713E-01	-0.527E-01	0.631E-01	-0.422E-01
	30000.	0.439	-0.114E-01	0.745E-01	-0.567E-01	0.654E-01	-0.454E-01
	80000.	0.508	0.416E-02	0.837E-01	-0.671E-01	0.719E-01	-0.539E-01
3D - 5F	2500.	2.12	0.949E-01				
11022.3A	5000.	1.99	0.295E-01				
C= 0.14E+18	10000.	1.85	0.475E-02				
	20000.	1.72	-0.303E-01				
	30000.	1.63	-0.278E-01				
	80000.	1.43	-0.975E-02	1.36*	1.47*		
4S - 4P	2500.	0.448E-02	0.338E-02	0.277E-02	0.924E-03	0.273E-02	0.739E-03
7676.2A	5000.	0.509E-02	0.400E-02	0.280E-02	0.105E-02	0.275E-02	0.839E-03
C= 0.47E+20	10000.	0.624E-02	0.453E-02	0.284E-02	0.118E-02	0.277E-02	0.948E-03
	20000.	0.825E-02	0.461E-02	0.290E-02	0.133E-02	0.280E-02	0.107E-02
	30000.	0.973E-02	0.410E-02	0.294E-02	0.142E-02	0.283E-02	0.114E-02
	80000.	0.139E-01	0.285E-02	0.306E-02	0.168E-02	0.291E-02	0.135E-02
4S - 5P	2500.	0.964E-02	0.599E-02	0.405E-02	0.157E-02	0.395E-02	0.125E-02
4045.2A	5000.	0.110E-01	0.718E-02	0.413E-02	0.180E-02	0.401E-02	0.144E-02
C= 0.44E+19	10000.	0.126E-01	0.776E-02	0.424E-02	0.205E-02	0.407E-02	0.164E-02
	20000.	0.148E-01	0.763E-02	0.436E-02	0.232E-02	0.415E-02	0.186E-02
	30000.	0.164E-01	0.670E-02	0.445E-02	0.249E-02	0.420E-02	0.200E-02
	80000.	0.206E-01	0.492E-02	0.472E-02	0.295E-02	0.438E-02	0.237E-02
4S - 6P	2500.	0.233E-01	0.149E-01	0.913E-02	0.372E-02	0.879E-02*	0.291E-02*
3446.7A	5000.	0.271E-01	0.174E-01	0.939E-02	0.434E-02	0.901E-02*	0.344E-02*
C= 0.14E+19	10000.	0.315E-01	0.182E-01	0.968E-02	0.500E-02	0.921E-02	0.398E-02
	20000.	0.373E-01	0.171E-01	0.100E-01	0.569E-02	0.944E-02	0.455E-02
	30000.	0.414E-01	0.149E-01	0.103E-01	0.613E-02	0.960E-02	0.490E-02
	80000.	0.505E-01	0.107E-01	0.110E-01	0.728E-02	0.101E-01	0.585E-02

NE= 0.1E+16

TRANSITION	T(K)	ELECTRONS 2WE(A)	DE(A)	PROTONS 2WI(A)	DI(A)	IONIZED HELIUM 2WI(A)	DI(A)
4S - 7P	2500.	0.526E-01	0.333E-01	0.190E-01*	0.778E-02*		
3217.3A	5000.	0.615E-01	0.391E-01	0.197E-01*	0.933E-02*	0.187E-01*	0.730E-02*
C= 0.64E+18	10000.	0.723E-01	0.382E-01	0.205E-01*	0.109E-01*	0.193E-01*	0.863E-02*
	20000.	0.864E-01	0.332E-01	0.214E-01	0.125E-01	0.199E-01*	0.998E-02*
	30000.	0.961E-01	0.282E-01	0.219E-01	0.135E-01	0.203E-01	0.108E-01
	80000.	0.114	0.184E-01	0.237E-01	0.162E-01	0.215E-01	0.130E-01
4S - 8P	2500.	0.107	0.664E-01				
3101.9A	5000.	0.125	0.748E-01				
C= 0.36E+18	10000.	0.149	0.736E-01	0.393E-01*	0.211E-01*		
	20000.	0.180	0.578E-01	0.412E-01*	0.246E-01*		
	30000.	0.200	0.478E-01	0.424E-01*	0.267E-01*	0.389E-01*	0.212E-01*
	80000.	0.232	0.277E-01	0.461E-01*	0.321E-01*	0.414E-01*	0.257E-01*
4S - 9P	2500.	0.199	0.119				
3034.8A	5000.	0.235	0.129				
C= 0.22E+18	10000.	0.282	0.123				
	20000.	0.344	0.927E-01				
	30000.	0.380	0.757E-01	0.757E-01*	0.482E-01*		
	80000.	0.431	0.395E-01	0.828E-01*	0.585E-01*		
4P - 5S	2500.	0.584E-01	0.409E-01	0.136E-01	0.109E-01	0.116E-01	0.868E-02
12492.0A	5000.	0.672E-01	0.488E-01	0.149E-01	0.125E-01	0.126E-01	0.995E-02
C= 0.58E+20	10000.	0.748E-01	0.573E-01	0.165E-01	0.141E-01	0.138E-01	0.113E-01
	20000.	0.844E-01	0.566E-01	0.182E-01	0.160E-01	0.151E-01	0.128E-01
	30000.	0.900E-01	0.513E-01	0.193E-01	0.171E-01	0.160E-01	0.138E-01
	80000.	0.115	0.361E-01	0.224E-01	0.203E-01	0.184E-01	0.163E-01
4P - 6S	2500.	0.665E-01	0.477E-01	0.143E-01	0.123E-01	0.116E-01	0.962E-02
6929.5A	5000.	0.765E-01	0.566E-01	0.160E-01	0.142E-01	0.130E-01	0.113E-01
C= 0.75E+19	10000.	0.824E-01	0.623E-01	0.180E-01	0.163E-01	0.145E-01	0.130E-01
	20000.	0.916E-01	0.618E-01	0.202E-01	0.186E-01	0.163E-01	0.149E-01
	30000.	0.950E-01	0.553E-01	0.216E-01	0.200E-01	0.174E-01	0.160E-01
	80000.	0.117	0.413E-01	0.254E-01	0.237E-01	0.204E-01	0.191E-01
4P - 7S	2500.	0.126	0.907E-01	0.264E-01	0.214E-01	0.213E-01*	0.165E-01*
5795.3A	5000.	0.151	0.109	0.297E-01	0.255E-01	0.239E-01*	0.200E-01*
C= 0.27E+19	10000.	0.154	0.109	0.333E-01	0.297E-01	0.268E-01	0.235E-01
	20000.	0.170	0.103	0.374E-01	0.341E-01	0.301E-01	0.272E-01
	30000.	0.184	0.895E-01	0.400E-01	0.368E-01	0.322E-01	0.294E-01
	80000.	0.224	0.642E-01	0.471E-01	0.440E-01	0.379E-01	0.352E-01
4P - 8S	2500.	0.232	0.160	0.468E-01*	0.351E-01*		
5334.3A	5000.	0.260	0.186	0.525E-01*	0.432E-01*	0.422E-01*	0.335E-01*
C= 0.13E+19	10000.	0.298	0.188	0.590E-01*	0.512E-01*	0.474E-01*	0.403E-01*
	20000.	0.323	0.152	0.662E-01	0.594E-01	0.532E-01*	0.471E-01*
	30000.	0.360	0.127	0.708E-01	0.644E-01	0.570E-01*	0.513E-01*
	80000.	0.425	0.762E-01	0.835E-01	0.774E-01	0.671E-01	0.619E-01

NE= 0.1E+16

TRANSITION	T(K)	ELECTRONS 2WE(A)	DE(A)	PROTONS 2WI(A)	DI(A)	IONIZED HELIUM 2WI(A)	DI(A)
4P - 9S	2500.	0.431	0.299				
5094.3A	5000.	0.475	0.338				
C= 0.76E+18	10000.	0.537	0.313	0.110*	0.916E-01*		
	20000.	0.623	0.243	0.123*	0.108*		
	30000.	0.695	0.189	0.132*	0.118*	0.106*	0.932E-01*
	80000.	0.796	0.907E-01	0.155*	0.142*	0.125*	0.114*
4P -10S	2500.	0.730	0.475				
4951.4A	5000.	0.807	0.517				
C= 0.48E+18	10000.	0.924	0.491				
	20000.	1.11	0.357				
	30000.	1.23	0.259				
	80000.	1.38	0.105	0.261*	0.237*		
4P -11S	2500.	1.19	0.771				
4859.0A	5000.	1.31	0.763				
C= 0.33E+18	10000.	1.52	0.690				
	20000.	1.87	0.487				
	30000.	2.06	0.364				
	80000.	2.28	0.124				
4P -12S	2500.	1.73	1.02				
4795.7A	5000.	2.06	1.08				
C= 0.24E+18	10000.	2.38	0.885				
	20000.	2.98	0.616				
	30000.	3.27	0.465				
	80000.	3.58	0.144				
4P - 3D	2500.	0.253E-01	0.130E-01	0.872E-02	0.339E-02	0.853E-02	0.271E-02
11745.0A	5000.	0.271E-01	0.143E-01	0.888E-02	0.385E-02	0.862E-02	0.308E-02
C= 0.44E+20	10000.	0.312E-01	0.142E-01	0.908E-02	0.435E-02	0.874E-02	0.349E-02
	20000.	0.394E-01	0.111E-01	0.933E-02	0.490E-02	0.890E-02	0.393E-02
	30000.	0.464E-01	0.944E-02	0.952E-02	0.525E-02	0.901E-02	0.421E-02
	80000.	0.639E-01	0.673E-02	0.101E-01	0.619E-02	0.937E-02	0.498E-02
4P - 4D	2500.	0.766E-01	0.551E-01	0.199E-01	0.135E-01	0.176E-01	0.106E-0
6955.2A	5000.	0.839E-01	0.599E-01	0.214E-01	0.157E-01	0.188E-01	0.124E-0
C= 0.35E+19	10000.	0.914E-01	0.579E-01	0.232E-01	0.180E-01	0.201E-01	0.144E-0
	20000.	0.101	0.457E-01	0.253E-01	0.205E-01	0.217E-01	0.164E-0
	30000.	0.109	0.405E-01	0.267E-01	0.221E-01	0.227E-01	0.177E-0
	80000.	0.120	0.282E-01	0.305E-01	0.262E-01	0.256E-01	0.211E-0
4P - 5D	2500.	0.166	0.120	0.419E-01*	0.268E-01*	0.367E-01*	0.206E-
5825.3A	5000.	0.181	0.126	0.454E-01*	0.323E-01*	0.395E-01*	0.253E-
C= 0.14E+19	10000.	0.197	0.122	0.494E-01	0.378E-01	0.425E-01*	0.299E-
	20000.	0.221	0.921E-01	0.540E-01	0.435E-01	0.459E-01*	0.346E-
	30000.	0.236	0.774E-01	0.570E-01	0.470E-01	0.482E-01	0.375E-
	80000.	0.254	0.453E-01	0.654E-01	0.562E-01	0.546E-01	0.450E-

NE= 0.1E+16

TRANSITION	T(K)	ELECTRONS 2WE(A)	DE(A)	PROTONS 2WI(A)	DI(A)	IONIZED HELIUM 2WI(A)	DI(A)
4P - 6D	2500.	0.333	0.237				
5354.1A	5000.	0.364	0.247	0.896E-01*	0.607E-01*		
C= 0.74E+18	10000.	0.398	0.224	0.978E-01*	0.729E-01*		
	20000.	0.452	0.164	0.107*	0.851E-01*	0.908E-01*	0.673E-01*
	30000.	0.483	0.128	0.113	0.925E-01	0.954E-01*	0.735E-01*
	80000.	0.512	0.581E-01	0.130	0.112	0.108*	0.891E-01*
4P - 7D	2500.	0.624	0.440				
5107.2A	5000.	0.682	0.424				
C= 0.43E+18	10000.	0.752	0.378				
	20000.	0.863	0.272				
	30000.	0.917	0.204	0.210*	0.169*		
	80000.	0.960	0.736E-01	0.242*	0.206*		
4P - 8D	2500.	1.09	0.707				
4960.2A	5000.	1.20	0.737				
C= 0.28E+18	10000.	1.34	0.600				
	20000.	1.54	0.424				
	30000.	1.62	0.314				
	80000.	1.68	0.986E-01				
4P - 9D	2500.	1.80	1.11				
4865.2A	5000.	1.99	1.12				
C= 0.19E+18	10000.	2.24	0.886				
	20000.	2.58	0.640				
	30000.	2.70	0.460				
	80000.	2.77	0.134				
4D - 7P	2500.	3.69	2.08	1.22*	0.484*		
27199.0A	5000.	4.51	2.29	1.26*	0.578*	1.20*	0.453*
C= 0.46E+20	10000.	5.61	2.25	1.30*	0.673*	1.24*	0.533*
	20000.	7.01	1.78	1.36	0.772	1.27*	0.615*
	30000.	7.90	1.54	1.39	0.834	1.29*	0.666*
	80000.	9.41	0.945	1.50	0.996	1.36	0.798
4D - 8P	2500.	4.77	2.81				
20691.0A	5000.	5.69	3.12				
C= 0.16E+20	10000.	6.90	2.92	1.66*	0.901*		
	20000.	8.52	2.12	1.74*	1.05*		
	30000.	9.51	1.71	1.80*	1.14*	1.65*	0.904*
	80000.	11.0	0.868	1.96	1.37	1.76*	1.09*
5S - 5P	2500.	0.350	0.126	0.174	0.350E-01	0.173	0.278E-01
27114.0A	5000.	0.416	0.119	0.175	0.398E-01	0.174	0.318E-01
C= 0.20E+21	10000.	0.550	0.766E-01	0.176	0.451E-01	0.174	0.361E-01
	20000.	0.767	0.485E-01	0.177	0.509E-01	0.175	0.409E-01
	30000.	0.913	0.402E-01	0.177	0.545E-01	0.175	0.438E-01
	80000.	1.23	0.272E-01	0.180	0.645E-01	0.177	0.518E-01

NE= 0.1E+16

		ELECTRONS		PROTONS		IONIZED HELIUM	
TRANSITION	T(K)	2WE(A)	DE(A)	2WI(A)	DI(A)	2WI(A)	DI(A)
5S - 6P	2500.	0.302	0.186	0.119	0.458E-01	0.115*	0.359E-01*
12531.0A	5000.	0.352	0.213	0.122	0.535E-01	0.118*	0.423E-01*
C= 0.19E+20	10000.	0.420	0.217	0.126	0.614E-01	0.120	0.489E-01
	20000.	0.514	0.176	0.130	0.699E-01	0.123	0.559E-01
	30000.	0.585	0.153	0.132	0.753E-01	0.125	0.603E-01
	80000.	0.732	0.116	0.141	0.894E-01	0.130	0.719E-01
5S - 7P	2500.	0.503	0.317	0.181*	0.732E-01*		
9951.3A	5000.	0.588	0.361	0.188*	0.878E-01*	0.178*	0.688E-01*
C= 0.62E+19	10000.	0.699	0.367	0.195*	0.103*	0.184*	0.812E-01*
	20000.	0.844	0.298	0.203	0.118	0.189*	0.939E-01*
	30000.	0.946	0.247	0.208	0.127	0.193*	0.102*
	80000.	1.13	0.160	0.225	0.152	0.204	0.122
5S - 8P	2500.	0.886	0.560				
8924.4A	5000.	1.04	0.604				
C= 0.29E+19	10000.	1.24	0.592	0.324*	0.174*		
	20000.	1.51	0.430	0.340*	0.202*		
	30000.	1.68	0.350	0.350*	0.220*	0.321*	0.175*
	80000.	1.95	0.183	0.381*	0.264*	0.342*	0.211*
5S - 9P	2500.	1.53	0.940				
8390.7A	5000.	1.80	0.998				
C= 0.17E+19	10000.	2.16	0.887				
	20000.	2.65	0.591				
	30000.	2.92	0.505	0.578*	0.367*		
	80000.	3.32	0.210	0.632*	0.446*		
5P - 6S	2500.	1.80	1.19	0.441	0.294	0.394	0.231
36529.0A	5000.	2.09	1.41	0.473	0.340	0.417	0.270
C= 0.21E+21	10000.	2.47	1.46	0.510	0.390	0.445	0.311
	20000.	2.99	1.26	0.554	0.443	0.477	0.354
	30000.	3.44	1.09	0.583	0.477	0.499	0.382
	80000.	4.45	0.868	0.664	0.565	0.560	0.454
5P - 7S	2500.	1.22	0.853	0.255	0.200	0.209*	0.154*
17979.0A	5000.	1.39	1.03	0.284	0.238	0.232*	0.187*
C= 0.26E+20	10000.	1.54	0.977	0.317	0.277	0.258	0.220
	20000.	1.75	0.895	0.354	0.318	0.288	0.253
	30000.	1.97	0.775	0.378	0.343	0.307	0.274
	80000.	2.43	0.543	0.444	0.410	0.359	0.328
5P - 8S	2500.	1.69	1.17	0.345*	0.256*		
14178.0A	5000.	1.88	1.35	0.387*	0.316*	0.312*	0.244*
C= 0.93E+19	10000.	2.17	1.36	0.434*	0.375*	0.350*	0.295*
	20000.	2.42	1.07	0.487*	0.435*	0.392*	0.345*
	30000.	2.72	0.866	0.521	0.471	0.419*	0.375*
	80000.	3.22	0.509	0.613	0.566	0.493	0.453

NE= 0.1E+16

TRANSITION	T(K)	ELECTRONS 2WE(A)	DE(A)	PROTONS 2WI(A)	DI(A)	IONIZED HELIUM 2WI(A)	DI(A)
5P - 9S	2500.	2.63	1.83				
12600.0A	5000.	2.90	2.01				
C= 0.46E+19	10000.	3.32	1.89	0.669*	0.558*		
	20000.	3.89	1.33	0.751*	0.658*		
	30000.	4.36	1.09	0.803*	0.717*	0.646*	0.568*
	80000.	5.01	0.509	0.947*	0.869*	0.761*	0.693*
5P -10S	2500.	4.12	2.67				
11761.0A	5000.	4.56	2.87				
C= 0.27E+19	10000.	5.23	2.62				
	20000.	6.35	1.72				
	30000.	7.06	1.41				
	80000.	7.94	0.557	1.47*	1.34*		
5P -11S	2500.	6.39	4.14				
11253.0A	5000.	7.02	4.02				
C= 0.18E+19	10000.	8.17	3.48				
	20000.	10.1	2.15				
	30000.	11.2	1.84				
	80000.	12.4	0.641				
5P - 4D	2500.	2.01	1.35	0.504	0.340	0.448	0.267
37255.0A	5000.	2.32	1.34	0.542	0.395	0.476	0.313
C= 0.10E+21	10000.	2.71	1.01	0.587	0.453	0.509	0.361
	20000.	3.41	0.786	0.639	0.515	0.547	0.412
	30000.	3.79	0.673	0.673	0.554	0.573	0.444
	80000.	4.46	0.391	0.769	0.658	0.645	0.528
5P - 5D	2500.	1.61	1.11	0.391*	0.259*	0.339*	0.198*
18272.0A	5000.	1.76	1.19	0.425*	0.311*	0.366*	0.243*
C= 0.14E+20	10000.	1.95	1.05	0.464	0.363	0.396*	0.287*
	20000.	2.27	0.790	0.509	0.418	0.430*	0.333*
	30000.	2.47	0.670	0.539	0.452	0.452	0.360
	80000.	2.73	0.352	0.621	0.540	0.515	0.433
5P - 6D	2500.	2.38	1.61				
14319.0A	5000.	2.60	1.66	0.628*	0.432*		
C= 0.53E+19	10000.	2.86	1.48	0.687*	0.518*		
	20000.	3.30	1.04	0.754*	0.605*	0.636*	0.479*
	30000.	3.54	0.836	0.797*	0.657*	0.669*	0.522*
	80000.	3.80	0.366	0.919	0.792	0.762*	0.633*
5P - 7D	2500.	3.85	2.69				
12679.0A	5000.	4.22	2.56				
C= 0.27E+19	10000.	4.66	2.18				
	20000.	5.37	1.39				
	30000.	5.72	1.17	1.29*	1.04*		
	80000.	6.03	0.424	1.48*	1.27*		

NE= 0.1E+16							
		ELECTRONS		PROTONS		IONIZED HELIUM	
TRANSITION	T(K)	2WE(A)	DE(A)	2WI(A)	DI(A)	2WI(A)	DI(A)
5P - 8D	2500.	6.20	3.99				
11811.0A	5000.	6.81	4.11				
C= 0.16E+19	10000.	7.60	3.21				
	20000.	8.76	1.95				
	30000.	9.25	1.75				
	80000.	9.62	0.540				
5P - 9D	2500.	9.67	5.77				
11286.0A	5000.	10.7	5.96				
C= 0.10E+19	10000.	12.1	4.48				
	20000.	13.9	2.85				
	30000.	14.6	2.48				
	80000.	15.0	0.715				
NE= 0.1E+17							
3D - 5P	2500.	5.73	3.20	2.06*	0.747*	1.96*	0.573*
31453.0A	5000.	6.55	3.90	2.13	0.897	2.04*	0.702*
C= 0.27E+21	10000.	7.69	4.02	2.19	1.05	2.10*	0.829*
	20000.	9.42	3.63	2.27	1.20	2.15	0.959
	30000.	10.7	3.11	2.32	1.30	2.18	1.04
	80000.	14.0	2.40	2.47	1.56	2.28	1.25
3D - 6P	2500.	3.52	2.13				
13384.0A	5000.	4.10	2.59	1.32*	0.552*		
C= 0.21E+20	10000.	4.80	2.57	1.38*	0.675*		
	20000.	5.72	2.42	1.44*	0.797*	1.35*	0.628*
	30000.	6.40	2.18	1.48*	0.870*	1.38*	0.689*
	80000.	7.88	1.67	1.60	1.05	1.45*	0.842*
3D - 4F	2500.	2.64	-1.03	0.583*	-0.298*	0.527*	-0.224*
15165.0A	5000.	2.95	-0.658	0.623*	-0.368*	0.563*	-0.285*
C= 0.17E+20	10000.	3.55	-0.334	0.665	-0.437	0.595*	-0.344*
	20000.	4.08	-0.107	0.713	-0.507	0.630*	-0.402*
	30000.	4.39	-0.111	0.745	-0.550	0.653	-0.438
	80000.	5.08	0.416E-01	0.837	-0.661	0.719	-0.529
4S - 4P	2500.	0.448E-01	0.334E-01	0.276E-01	0.881E-02	0.270E-01*	0.696E-02*
7676.2A	5000.	0.509E-01	0.398E-01	0.280E-01	0.101E-01	0.274E-01*	0.808E-02*
C= 0.47E+20	10000.	0.624E-01	0.453E-01	0.284E-01	0.116E-01	0.277E-01*	0.925E-02*
	20000.	0.825E-01	0.461E-01	0.290E-01	0.131E-01	0.280E-01	0.105E-01
	30000.	0.973E-01	0.409E-01	0.294E-01	0.141E-01	0.283E-01	0.113E-01
	80000.	0.139	0.285E-01	0.306E-01	0.167E-01	0.291E-01	0.134E-01
4S - 5P	2500.	0.962E-01	0.580E-01	0.396E-01*	0.138E-01*	0.377E-01*	0.106E-01*
4045.2A	5000.	0.110	0.704E-01	0.410E-01	0.167E-01	0.394E-01*	0.130E-01*
C= 0.44E+19	10000.	0.126	0.768E-01	0.422E-01	0.195E-01	0.405E-01*	0.154E-01*
	20000.	0.148	0.761E-01	0.436E-01	0.225E-01	0.414E-01	0.179E-01
	30000.	0.164	0.669E-01	0.445E-01	0.243E-01	0.420E-01	0.194E-01
	80000.	0.206	0.492E-01	0.472E-01	0.292E-01	0.438E-01	0.233E-01

NE= 0.1E+17

TRANSITION	T(K)	ELECTRONS 2WE(A)	DE(A)	PROTONS 2WI(A)	DI(A)	IONIZED HELIUM 2WI(A)	DI(A)
4S - 6P	2500.	0.233	0.140				
3446.7A	5000.	0.271	0.167				
C= 0.14E+19	10000.	0.315	0.179	0.960E-01*	0.456E-01*		
	20000.	0.373	0.169	0.100*	0.538E-01*		
	30000.	0.414	0.149	0.103*	0.587E-01*	0.957E-01*	0.465E-01*
	80000.	0.505	0.107	0.110	0.712E-01	0.101*	0.569E-01*
4S - 7P	2500.	0.525	0.301				
3217.3A	5000.	0.614	0.369				
C= 0.64E+18	10000.	0.723	0.367				
	20000.	0.864	0.326				
	30000.	0.961	0.279				
	80000.	1.14	0.184	0.237*	0.156*		
4S - 8P	2500.	1.07	0.571				
3101.9A	5000.	1.25	0.681				
C= 0.36E+18	10000.	1.49	0.694				
	20000.	1.80	0.559				
	30000.	2.00	0.468				
	80000.	2.32	0.277				
4S - 9P	2500.	1.98*	0.945*				
3034.8A	5000.	2.34*	1.12*				
C= 0.22E+18	10000.	2.82	1.12				
	20000.	3.44	0.874				
	30000.	3.80	0.732				
	80000.	4.31	0.395				
4P - 5S	2500.	0.583	0.397	0.136	0.980E-01	0.115	0.756E-01
12492.0A	5000.	0.672	0.481	0.149	0.117	0.126	0.916E-01
C= 0.58E+20	10000.	0.748	0.572	0.165	0.136	0.138	0.108
	20000.	0.844	0.566	0.182	0.156	0.151	0.124
	30000.	0.900	0.513	0.193	0.168	0.160	0.134
	80000.	1.15	0.361	0.224	0.201	0.184	0.161
4P - 6S	2500.	0.665	0.452	0.143*	0.969E-01*	0.115*	0.706E-01*
6929.5A	5000.	0.765	0.548	0.160*	0.124*	0.129*	0.948E-01*
C= 0.75E+19	10000.	0.823	0.612	0.180*	0.151*	0.145*	0.117*
	20000.	0.916	0.615	0.202	0.177	0.163*	0.140*
	30000.	0.950	0.552	0.216	0.193	0.174*	0.153*
	80000.	1.17	0.413	0.254	0.233	0.204	0.186
4P - 7S	2500.	1.26	0.828				
5795.3A	5000.	1.51	1.03				
C= 0.27E+19	10000.	1.54	1.05	0.333*	0.258*		
	20000.	1.70	1.02	0.374*	0.313*		
	30000.	1.84	0.888	0.400*	0.346*		
	80000.	2.24	0.642	0.471*	0.425*	0.379*	0.338*

NE= 0.1E+17

TRANSITION	T(K)	ELECTRONS 2WE(A)	DE(A)	PROTONS 2WI(A)	DI(A)	IONIZED HELIUM 2WI(A)	DI(A)
4P - 8S	2500.	2.32	1.40				
5334.3A	5000.	2.60	1.72				
C= 0.13E+19	10000.	2.98	1.79				
	20000.	3.23	1.49				
	30000.	3.60	1.25				
	80000.	4.25	0.761	0.835*	0.738*		
4P - 9S	2500.	4.30*	2.45*				
5094.3A	5000.	4.75	3.00				
C= 0.76E+18	10000.	5.37	2.88				
	20000.	6.23	2.31				
	30000.	6.95	1.83				
	80000.	7.96	0.903				
4P -10S	2500.	7.21*	3.49*				
4951.4A	5000.	8.03*	4.29*				
C= 0.48E+18	10000.	9.21	4.32				
	20000.	11.1	3.37				
	30000.	12.3	2.45				
	80000.	13.8	1.04				
4P - 3D	2500.	0.253	0.128	0.867E-01	0.319E-01	0.843E-01	0.251E-01
11745.0A	5000.	0.271	0.142	0.886E-01	0.370E-01	0.859E-01	0.294E-01
C= 0.44E+20	10000.	0.312	0.142	0.907E-01	0.424E-01	0.873E-01	0.338E-01
	20000.	0.394	0.111	0.933E-01	0.483E-01	0.890E-01	0.386E-01
	30000.	0.464	0.943E-01	0.952E-01	0.519E-01	0.901E-01	0.416E-01
	80000.	0.639	0.673E-01	0.101	0.616E-01	0.937E-01	0.495E-01
4P - 4D	2500.	0.766	0.522	0.195*	0.105*		
6955.2A	5000.	0.839	0.578	0.213*	0.136*	0.185*	0.103*
C= 0.35E+19	10000.	0.914	0.567	0.232*	0.165*	0.200*	0.129*
	20000.	1.01	0.453	0.253*	0.195*	0.216*	0.154*
	30000.	1.09	0.403	0.267	0.212	0.227*	0.168*
	80000.	1.20	0.282	0.305	0.257	0.256	0.205
4P - 5D	2500.	1.66	1.09				
5825.3A	5000.	1.81	1.18				
C= 0.14E+19	10000.	1.97	1.17				
	20000.	2.21	0.903				
	30000.	2.36	0.763	0.569*	0.437*		
	80000.	2.54	0.452	0.653*	0.542*		
4P - 6D	2500.	3.33	2.02				
5354.1A	5000.	3.63	2.22				
C= 0.74E+18	10000.	3.98	2.07				
	20000.	4.52	1.58				
	30000.	4.83	1.25				
	80000.	5.12	0.578				

NE= 0.1E+17

		ELECTRONS		PROTONS		IONIZED HELIUM	
TRANSITION	T(K)	2WE(A)	DE(A)	2WI(A)	DI(A)	2WI(A)	DI(A)
4P - 7D	2500.	6.16	3.41				
5107.2A	5000.	6.78	3.54				
C= 0.43E+18	10000.	7.49	3.32				
	20000.	8.61	2.55				
	30000.	9.15	1.93				
	80000.	9.59	0.725				
5S - 5P	2500.	3.50	1.23	1.70*	0.320*	1.65*	0.249*
27114.0A	5000.	4.16	1.17	1.73	0.377	1.71*	0.298*
C= 0.20E+21	10000.	5.50	0.756	1.75	0.436	1.73*	0.347*
	20000.	7.67	0.480	1.76	0.498	1.75	0.398
	30000.	9.13	0.401	1.77	0.537	1.75	0.429
	80000.	12.3	0.271	1.80	0.641	1.77	0.513
5S - 6P	2500.	3.02	1.76				
12531.0A	5000.	3.52	2.06				
C= 0.19E+20	10000.	4.20	2.12	1.24*	0.562*		
	20000.	5.14	1.74	1.29*	0.663*	1.22*	0.522*
	30000.	5.85	1.52	1.32*	0.723*	1.24*	0.572*
	80000.	7.32	1.16	1.41	0.876	1.30*	0.699*
5S - 7P	2500.	5.02	2.87				
9951.3A	5000.	5.88	3.40				
C= 0.62E+19	10000.	6.99	3.55				
	20000.	8.44	2.93				
	30000.	9.46	2.43				
	80000.	11.3	1.59	2.25*	1.47*		
NE= 0.1E+18							
4S - 4P	2500.	0.448	0.320	0.263*	0.745E-01*	0.246*	0.560E-01*
7676.2A	5000.	0.509	0.388	0.275	0.919E-01	0.265*	0.711E-01*
C= 0.47E+20	10000.	0.624	0.447	0.282	0.109	0.274*	0.857E-01*
	20000.	0.825	0.459	0.289	0.126	0.279	0.100
	30000.	0.973	0.409	0.293	0.137	0.282	0.109
	80000.	1.39	0.285	0.306	0.165	0.290	0.132
4S - 5P	2500.	0.960	0.519				
4045.2A	5000.	1.10	0.661				
C= 0.44E+19	10000.	1.26	0.738				
	20000.	1.48	0.743	0.432*	0.204*		
	30000.	1.64	0.655	0.443*	0.226*		
	80000.	2.06	0.491	0.472*	0.281*	0.437*	0.223*
4S - 6P	2500.	2.31	1.12				
3446.7A	5000.	2.70	1.48				
C= 0.14E+19	10000.	3.15	1.64				
	20000.	3.73	1.60				
	30000.	4.14	1.42				
	80000.	5.04	1.06				

NE= 0.1E+18

TRANSITION	T(K)	ELECTRONS 2WE(A)	DE(A)	PROTONS 2WI(A)	DI(A)	IONIZED HELIUM 2WI(A)	DI(A)
4S - 7P	2500.	5.09*	1.97*				
3217.3A	5000.	6.08*	2.95*				
C= 0.64E+18	10000.	7.20	3.15				
	20000.	8.62	2.96				
	30000.	9.60	2.55				
	80000.	11.4	1.81				
4P - 5S	2500.	5.83	3.62	1.31*	0.627*		
12492.0A	5000.	6.72	4.57	1.48*	0.918*	1.23*	0.667*
C= 0.58E+20	10000.	7.48	5.56	1.64*	1.18*	1.37*	0.900*
	20000.	8.44	5.59	1.82*	1.43*	1.51*	1.12*
	30000.	9.00	5.08	1.93	1.58	1.60*	1.24*
	80000.	11.5	3.60	2.24	1.95	1.84*	1.55*
4P - 6S	2500.	6.64	3.70				
6929.5A	5000.	7.65	4.90				
C= 0.75E+19	10000.	8.23	5.72				
	20000.	9.16	5.91				
	30000.	9.50	5.40				
	80000.	11.7	4.11	2.54*	2.18*		
4P - 3D	2500.	2.53	1.22	0.814*	0.256*	0.742*	0.188*
11745.0A	5000.	2.71	1.38	0.867*	0.326*	0.823*	0.249*
C= 0.44E+20	10000.	3.12	1.41	0.900	0.393	0.860*	0.307*
	20000.	3.94	1.11	0.931	0.460	0.885*	0.364*
	30000.	4.64	0.940	0.950	0.501	0.899	0.397
	80000.	6.39	0.673	1.01	0.605	0.936	0.483
4P - 4D	2500.	7.63	4.25				
6955.2A	5000.	8.38	5.10				
C= 0.35E+19	10000.	9.13	5.19				
	20000.	10.1	4.25				
	30000.	10.9	3.89				
	80000.	12.0	2.80	3.05*	2.40*		
NE= 0.1E+19							
4S - 4P	2500.	4.44	2.76				
7676.2A	5000.	5.08	3.57				
C= 0.47E+20	10000.	6.24	4.25	2.66*	0.874*		
	20000.	8.25	4.45	2.83*	1.11*		
	30000.	9.72	4.01	2.90*	1.25*		
	80000.	13.9	2.84	3.06*	1.57*	2.89*	1.24*

ШТАРКОВО ШИРЕЊЕ ЛИНИЈА K I

Милан С. Димитријевић[1] **и Sylvie Sahal–Bréchot**[2]

[1] *Астрономска опсерваторија, Волгина 7, 11050 Београд, Југославија*
[2] *Departement „Atomes et molecules en astrophysique", Unité associée au C. N. R. S. No 812, Observatoire de Paris Meudon, France*

УДК 52–355.3
Претходно саопштење

Користећи семикласичан прилаз, у раду су израчунате ширине и помаци за 51 мултиплет неутралног калијума, проузроковане сударима са електронима, протонима и јонизованим хелијумом. Резултати су дати у функцији електронске температуре и густине.

Bull. Obs. Astron. Belgrade N° 142 (1990), 59–77

UDC 52–355.3
Preliminary report

TABLES FOR NA I LINES STARK BROADENING PARAMETERS

Milan S. Dimitrijević[1] and Sylvie Sahal–Bréchot[2]

[1]*Astronomical Observatory, Volgina 7, 11050 Beograd, Yugoslavie*
[2]*Department „Atomes et molecules en astrophysique", Unité associée au C. N. R. S. No 812, Observatoire de Paris, 92195 Meudon, France*

(Received: August 4, 1989)

SUMMARY: A semiclassical approach has been used to evaluate electron–, proton–, and ionized–helium–impact line widths and shifts for 61 neutral sodium multiplets as a function of electron temperature and electron density.

Reliable Stark broadening parameters for Na I lines are useful for a number of problems in astrophysics (e. g. Caccin, Gomez and Roberti, 1980; Vince, Dimitrijević and Kršljanin, 1985), plasma diagnostics (Griem, 1974), technology of high pressure discharge lamps (Stormberg, 1980; Wharmby, 1980) etc. Using a semiclassical–perturbational approach (Sahal–Bréchot, 1969, a,b) we have calculated recently (Dimitrijević and Sahal-Bréchot, 1989) electron–, proton–, and ionized helium-impact broadening parameters for 46 neutral sodium multiplets with the principal quantum number (n) of the upper state between 6 and 10, at perturber density $N = \cdot 10^{13}$ cm^{-3} and electron impact broadening parameters at $N = 10^{16}$ cm^{-3}. For higher densities the departure from the linear density law due to Debye screening influences on the accuracy of the method (this is especially serious in the case of the shift) making that extrapolation to higher densities is sometimes difficult and inaccurate.

In order to enable such extrapolation, we calculated Stark broadening data for 61 Na I multiplets for perturber densities 10^{13} – 10^{19} cm^{-3}, when validity conditions of the theory are satysfied. Data at 10^{13} and 10^{16} cm^{-3} for $n \geqslant 6$, can be found in Dimitrijević and Sahal–Bréchot (1989), where all details of the calculations are given. For the discussion and the comparison with experimental data see also Dimitrijević and Sahal–Bréchot (1985). Energy level data were taken from Bashkin and Stoner (1975).

The calculated values are presented in Table 1. We checked that for each value given in the Table, the collision volume (V) multiplied by the perturber density (NE) is much less than one. In such a case the impact approximation is valid (Sahal–Bréchot, 1969). The values for which $NE \cdot V > 0.5$ are not given in the Table, while values where $0.1 < NE \cdot V \leqslant 0.5$ are denoted with an asterisk and are given in order to enable interpolation to lower densities. In the case when the impact approximation is not valid, the ion broadening contribution may be estimated by the quasistatic ion-broadening parameter (Griem, 1974).

Table 1. This table lists electron–, proton– and ionized helium–impact broadening parameters for Na I lines for perturber densities from 10^{13} to 10^{18} cm^{-3} and temperatures from 2500 to 80,000 K. Transitions and averaged wavelengths for the multiplet (in Å) are also given. Under 2W are given full halfwidths, while D denotes corresponding shifts. Using c (sce Eq. (4) in the preceeding article), we obtain an estimate for maximum perturber density for which the line may be treated as isolated and the tabulated values may be used. Asterisk denotes cases when the colision volume multipled by the electron denisity (condition for the validity of the impact approximation) lies between 0.1 and 0.5.

NE= 0.1E+14

TRANSITION	T(K)	ELECTRONS 2WE(A)	DE(A)	PROTONS 2WI(A)	DI(A)	IONIZED HELIUM 2WI(A)	DI(A)
3S - 3P	2500.	0.191E-04	0.132E-04	0.126E-04	0.372E-05	0.125E-04	0.301E-05
5891.8A	5000.	0.211E-04	0.155E-04	0.127E-04	0.417E-05	0.126E-04	0.338E-05
C= 0.30E+20	10000.	0.249E-04	0.178E-04	0.129E-04	0.469E-05	0.127E-04	0.380E-05
	20000.	0.322E-04	0.182E-04	0.130E-04	0.526E-05	0.128E-04	0.426E-05
	30000.	0.381E-04	0.183E-04	0.132E-04	0.563E-05	0.128E-04	0.456E-05
	80000.	0.551E-04	0.129E-04	0.136E-04	0.663E-05	0.131E-04	0.537E-05
3S - 4P	2500.	0.649E-04	-0.241E-04	0.224E-04	-0.797E-05	0.220E-04	-0.645E-05
3302.6A	5000.	0.725E-04	-0.148E-04	0.227E-04	-0.896E-05	0.222E-04	-0.725E-05
C= 0.12E+19	10000.	0.864E-04	-0.448E-05	0.231E-04	-0.101E-04	0.224E-04	-0.815E-05
	20000.	0.100E-03	0.232E-05	0.236E-04	-0.113E-04	0.227E-04	-0.915E-05
	30000.	0.108E-03	0.579E-05	0.239E-04	-0.121E-04	0.230E-04	-0.979E-05
	80000.	0.126E-03	0.634E-05	0.251E-04	-0.142E-04	0.237E-04	-0.115E-04
3S - 5P	2500.	0.202E-03	-0.114E-03	0.599E-04	-0.341E-04	0.565E-04	-0.276E-04
2852.8A	5000.	0.221E-03	-0.100E-03	0.624E-04	-0.384E-04	0.582E-04	-0.310E-04
C= 0.40E+18	10000.	0.254E-03	-0.668E-04	0.656E-04	-0.432E-04	0.603E-04	-0.349E-04
	20000.	0.295E-03	-0.465E-04	0.695E-04	-0.485E-04	0.630E-04	-0.393E-04
	30000.	0.313E-03	-0.344E-04	0.721E-04	-0.520E-04	0.648E-04	-0.421E-04
	80000.	0.347E-03	-0.115E-04	0.799E-04	-0.609E-04	0.703E-04	-0.496E-04
3P - 4S	2500.	0.367E-03	0.262E-03	0.857E-04	0.708E-04	0.737E-04	0.573E-04
11397.0A	5000.	0.420E-03	0.301E-03	0.938E-04	0.795E-04	0.799E-04	0.644E-04
C= 0.59E+20	10000.	0.466E-03	0.356E-03	0.103E-03	0.893E-04	0.871E-04	0.724E-04
	20000.	0.515E-03	0.334E-03	0.114E-03	0.100E-03	0.954E-04	0.812E-04
	30000.	0.552E-03	0.329E-03	0.121E-03	0.107E-03	0.101E-03	0.869E-04
	80000.	0.702E-03	0.228E-03	0.140E-03	0.126E-03	0.116E-03	0.102E-03
3P - 5S	2500.	0.405E-03	0.294E-03	0.867E-04	0.807E-04	0.706E-04	0.653E-04
6158.6A	5000.	0.468E-03	0.351E-03	0.971E-04	0.908E-04	0.790E-04	0.735E-04
C= 0.70E+19	10000.	0.508E-03	0.383E-03	0.109E-03	0.102E-03	0.885E-04	0.827E-04
	20000.	0.563E-03	0.366E-03	0.122E-03	0.115E-03	0.991E-04	0.929E-04
	30000.	0.589E-03	0.339E-03	0.130E-03	0.123E-03	0.106E-03	0.995E-04
	80000.	0.732E-03	0.254E-03	0.154E-03	0.145E-03	0.125E-03	0.117E-03
3P - 3D	2500.	0.312E-03	0.228E-03	0.814E-04	0.617E-04	0.721E-04	0.500E-04
8191.1A	5000.	0.355E-03	0.247E-03	0.879E-04	0.694E-04	0.769E-04	0.562E-04
C= 0.74E+19	10000.	0.385E-03	0.247E-03	0.955E-04	0.780E-04	0.825E-04	0.632E-04
	20000.	0.413E-03	0.227E-03	0.104E-03	0.876E-04	0.892E-04	0.710E-04
	30000.	0.428E-03	0.201E-03	0.110E-03	0.937E-04	0.936E-04	0.759E-04
	80000.	0.474E-03	0.137E-03	0.126E-03	0.110E-03	0.106E-03	0.894E-04
3P - 4D	2500.	0.255E-02	0.126E-02	0.699E-03	0.638E-03	0.569E-03	0.514E-03
5686.4A	5000.	0.243E-02	0.107E-02	0.784E-03	0.723E-03	0.637E-03	0.584E-03
C= 0.13E+18	10000.	0.226E-02	0.836E-03	0.883E-03	0.816E-03	0.713E-03	0.661E-03
	20000.	0.208E-02	0.598E-03	0.100E-02	0.919E-03	0.800E-03	0.743E-03
	30000.	0.197E-02	0.479E-03	0.109E-02	0.986E-03	0.858E-03	0.797E-03
	80000.	0.170E-02	0.262E-03	0.130E-02	0.120E-02	0.103E-02	0.941E-03
3P - 5D	2500.	0.672E-02	0.321E-02	0.189E-02	0.170E-02	0.154E-02	0.136E-02
4981.4A	5000.	0.633E-02	0.249E-02	0.212E-02	0.194E-02	0.172E-02	0.156E-02
C= 0.52E+17	10000.	0.585E-02	0.189E-02	0.239E-02	0.220E-02	0.193E-02	0.177E-02
	20000.	0.532E-02	0.121E-02	0.272E-02	0.249E-02	0.217E-02	0.201E-02
	30000.	0.500E-02	0.945E-03	0.295E-02	0.267E-02	0.233E-02	0.216E-02
	80000.	0.419E-02	0.426E-03	0.354E-02	0.325E-02	0.279E-02	0.255E-02

NE= 0.1E+14

TRANSITION	T(K)	ELECTRONS 2WE(A)	DE(A)	PROTONS 2WI(A)	DI(A)	IONIZED HELIUM 2WI(A)	DI(A)
3D - 4P	2500.	0.734E-01	-0.424E-01	0.169E-01	-0.110E-01	0.156E-01	-0.892E-02
91050.0A	5000.	0.814E-01	-0.428E-01	0.179E-01	-0.124E-01	0.162E-01	-0.100E-01
c= 0.91E+21	10000.	0.901E-01	-0.336E-01	0.191E-01	-0.139E-01	0.171E-01	-0.113E-01
	20000.	0.105	-0.252E-01	0.205E-01	-0.156E-01	0.181E-01	-0.127E-01
	30000.	0.114	-0.221E-01	0.214E-01	-0.167E-01	0.188E-01	-0.136E-01
	80000.	0.131	-0.129E-01	0.241E-01	-0.197E-01	0.207E-01	-0.160E-01
3D - 5P	2500.	0.785E-02	-0.463E-02	0.208E-02	-0.130E-02	0.193E-02	-0.105E-02
17038.7A	5000.	0.874E-02	-0.441E-02	0.219E-02	-0.146E-02	0.200E-02	-0.118E-02
c= 0.14E+20	10000.	0.986E-02	-0.328E-02	0.232E-02	-0.165E-02	0.209E-02	-0.133E-02
	20000.	0.115E-01	-0.260E-02	0.248E-02	-0.185E-02	0.221E-02	-0.150E-02
	30000.	0.123E-01	-0.226E-02	0.259E-02	-0.198E-02	0.229E-02	-0.160E-02
	80000.	0.136E-01	-0.104E-02	0.290E-02	-0.233E-02	0.251E-02	-0.189E-02
3D - 4F	2500.	0.188E-01	-0.586E-02	0.552E-02	-0.508E-02	0.448E-02	-0.410E-02
18465.3A	5000.	0.177E-01	-0.359E-02	0.621E-02	-0.576E-02	0.502E-02	-0.465E-02
c= 0.14E+19	10000.	0.164E-01	-0.180E-02	0.701E-02	-0.648E-02	0.564E-02	-0.525E-02
	20000.	0.149E-01	-0.785E-03	0.801E-02	-0.730E-02	0.634E-02	-0.591E-02
	30000.	0.142E-01	-0.445E-03	0.870E-02	-0.787E-02	0.681E-02	-0.633E-02
	80000.	0.126E-01	0.221E-03	0.103E-01	-0.974E-02	0.821E-02	-0.748E-02
4S - 4P	2500.	0.356E-02	-0.189E-02	0.105E-02	-0.504E-03	0.102E-02	-0.408E-03
22070.0A	5000.	0.385E-02	-0.189E-02	0.108E-02	-0.567E-03	0.103E-02	-0.459E-03
c= 0.53E+20	10000.	0.440E-02	-0.165E-02	0.112E-02	-0.637E-03	0.106E-02	-0.516E-03
	20000.	0.529E-02	-0.124E-02	0.117E-02	-0.715E-03	0.109E-02	-0.579E-03
	30000.	0.589E-02	-0.105E-02	0.120E-02	-0.765E-03	0.111E-02	-0.620E-03
	80000.	0.723E-02	-0.658E-03	0.130E-02	-0.901E-03	0.118E-02	-0.730E-03
4S - 5P	2500.	0.298E-02	-0.171E-02	0.859E-03	-0.499E-03	0.808E-03	-0.404E-03
10747.0A	5000.	0.325E-02	-0.162E-02	0.898E-03	-0.562E-03	0.833E-03	-0.455E-03
c= 0.57E+19	10000.	0.372E-02	-0.124E-02	0.945E-03	-0.633E-03	0.866E-03	-0.512E-03
	20000.	0.438E-02	-0.103E-02	0.100E-02	-0.711E-03	0.906E-03	-0.576E-03
	30000.	0.470E-02	-0.800E-03	0.104E-02	-0.762E-03	0.933E-03	-0.617E-03
	80000.	0.531E-02	-0.387E-03	0.116E-02	-0.897E-03	0.101E-02	-0.727E-03
4P - 4D	2500.	0.451E-01	0.216E-01	0.118E-01	0.108E-01	0.961E-02	0.872E-02
23370.0A	5000.	0.433E-01	0.187E-01	0.133E-01	0.123E-01	0.108E-01	0.991E-02
c= 0.22E+19	10000.	0.408E-01	0.148E-01	0.149E-01	0.138E-01	0.121E-01	0.112E-01
	20000.	0.381E-01	0.105E-01	0.170E-01	0.156E-01	0.136E-01	0.126E-01
	30000.	0.367E-01	0.824E-02	0.184E-01	0.167E-01	0.145E-01	0.135E-01
	80000.	0.329E-01	0.432E-02	0.221E-01	0.203E-01	0.174E-01	0.160E-01
4P - 5D	2500.	0.599E-01	0.282E-01	0.166E-01	0.149E-01	0.135E-01	0.120E-01
14776.0A	5000.	0.566E-01	0.229E-01	0.187E-01	0.171E-01	0.151E-01	0.137E-01
c= 0.45E+18	10000.	0.525E-01	0.174E-01	0.211E-01	0.194E-01	0.170E-01	0.156E-01
	20000.	0.481E-01	0.116E-01	0.239E-01	0.219E-01	0.191E-01	0.177E-01
	30000.	0.453E-01	0.893E-02	0.259E-01	0.235E-01	0.205E-01	0.190E-01
	80000.	0.385E-01	0.408E-02	0.311E-01	0.286E-01	0.245E-01	0.225E-01
5S - 5P	2500.	0.948E-01	-0.576E-01	0.235E-01	-0.152E-01	0.217E-01	-0.123E-01
54318.3A	5000.	0.106	-0.610E-01	0.249E-01	-0.171E-01	0.226E-01	-0.138E-01
c= 0.15E+21	10000.	0.120	-0.572E-01	0.265E-01	-0.192E-01	0.237E-01	-0.156E-01
	20000.	0.139	-0.463E-01	0.284E-01	-0.216E-01	0.251E-01	-0.175E-01
	30000.	0.152	-0.389E-01	0.297E-01	-0.232E-01	0.261E-01	-0.188E-01
	80000.	0.176	-0.255E-01	0.334E-01	-0.273E-01	0.288E-01	-0.221E-01

NE= 0.1E+15

3S - 3P	2500.	0.191E-03	0.132E-03	0.126E-03	0.371E-04	0.125E-03	0.300E-04
5891.8A	5000.	0.211E-03	0.155E-03	0.127E-03	0.417E-04	0.126E-03	0.338E-04
c= 0.30E+20	10000.	0.249E-03	0.178E-03	0.129E-03	0.468E-04	0.127E-03	0.379E-04
	20000.	0.322E-03	0.182E-03	0.130E-03	0.526E-04	0.128E-03	0.426E-04
	30000.	0.381E-03	0.183E-03	0.132E-03	0.563E-04	0.128E-03	0.456E-04
	80000.	0.551E-03	0.129E-03	0.136E-03	0.663E-04	0.131E-03	0.537E-04

NE= 0.1E+15

TRANSITION	T(K)	ELECTRONS 2WE(A)	DE(A)	PROTONS 2WI(A)	DI(A)	IONIZED HELIUM 2WI(A)	DI(A)
3S - 4P	2500.	0.649E-03	-0.241E-03	0.224E-03	-0.790E-04	0.220E-03	-0.637E-04
3302.6A	5000.	0.725E-03	-0.148E-03	0.227E-03	-0.890E-04	0.222E-03	-0.721E-04
c= 0.12E+19	10000.	0.864E-03	-0.448E-04	0.231E-03	-0.100E-03	0.224E-03	-0.811E-04
	20000.	0.100E-02	0.232E-04	0.236E-03	-0.113E-03	0.227E-03	-0.913E-04
	30000.	0.108E-02	0.579E-04	0.239E-03	-0.121E-03	0.230E-03	-0.978E-04
	80000.	0.126E-02	0.634E-04	0.251E-03	-0.142E-03	0.237E-03	-0.115E-03
3S - 5P	2500.	0.202E-02	-0.113E-02	0.598E-03	-0.332E-03	0.564E-03	-0.267E-03
2852.8A	5000.	0.221E-02	-0.998E-03	0.624E-03	-0.378E-03	0.581E-03	-0.305E-03
c= 0.40E+18	10000.	0.254E-02	-0.668E-03	0.656E-03	-0.428E-03	0.603E-03	-0.346E-03
	20000.	0.295E-02	-0.465E-03	0.695E-03	-0.483E-03	0.630E-03	-0.391E-03
	30000.	0.313E-02	-0.344E-03	0.721E-03	-0.517E-03	0.648E-03	-0.419E-03
	80000.	0.347E-02	-0.115E-03	0.799E-03	-0.608E-03	0.703E-03	-0.495E-03
3S - 6P	2500.	0.528E-02	-0.337E-02	0.143E-02	-0.909E-03	0.131E-02	-0.726E-03
2680.4A	5000.	0.573E-02	-0.286E-02	0.152E-02	-0.105E-02	0.137E-02	-0.839E-03
c= 0.19E+18	10000.	0.653E-02	-0.206E-02	0.163E-02	-0.119E-02	0.145E-02	-0.959E-03
	20000.	0.749E-02	-0.145E-02	0.176E-02	-0.135E-02	0.154E-02	-0.109E-02
	30000.	0.785E-02	-0.110E-02	0.184E-02	-0.145E-02	0.160E-02	-0.117E-02
	80000.	0.843E-02	-0.366E-03	0.208E-02	-0.172E-02	0.178E-02	-0.139E-02
3S - 7P	2500.	0.118E-01	-0.732E-02	0.304E-02*	-0.202E-02*	0.272E-02*	-0.160E-02*
2593.9A	5000.	0.127E-01	-0.662E-02	0.327E-02	-0.236E-02	0.289E-02*	-0.188E-02*
c= 0.10E+18	10000.	0.145E-01	-0.470E-02	0.354E-02	-0.271E-02	0.308E-02*	-0.218E-02*
	20000.	0.164E-01	-0.334E-02	0.385E-02	-0.309E-02	0.332E-02	-0.249E-02
	30000.	0.170E-01	-0.247E-02	0.406E-02	-0.332E-02	0.347E-02	-0.268E-02
	80000.	0.178E-01	-0.749E-03	0.464E-02	-0.395E-02	0.391E-02	-0.320E-02
3S - 8P	2500.	0.235E-01	-0.153E-01	0.588E-02*	-0.393E-02*		
2543.8A	5000.	0.252E-01	-0.125E-01	0.638E-02*	-0.468E-02*	0.554E-02*	-0.371E-02*
c= 0.63E+17	10000.	0.288E-01	-0.913E-02	0.695E-02*	-0.544E-02*	0.598E-02*	-0.435E-02*
	20000.	0.321E-01	-0.675E-02	0.761E-02*	-0.624E-02*	0.648E-02*	-0.501E-02*
	30000.	0.331E-01	-0.455E-02	0.805E-02	-0.673E-02	0.681E-02*	-0.542E-02*
	80000.	0.340E-01	-0.126E-02	0.929E-02	-0.804E-02	0.775E-02*	-0.649E-02*
3S - 9P	2500.	0.431E-01	-0.262E-01				
2512.1A	5000.	0.461E-01	-0.227E-01				
c= 0.42E+17	10000.	0.526E-01	-0.144E-01	0.126E-01*	-0.991E-02*		
	20000.	0.578E-01	-0.104E-01	0.139E-01*	-0.115E-01*		
	30000.	0.593E-01	-0.743E-02	0.147E-01*	-0.124E-01*	0.124E-01*	-0.997E-02*
	80000.	0.600E-01	-0.234E-02	0.171E-01*	-0.149E-01*	0.141E-01*	-0.120E-01*
3S -10P	2500.	0.739E-01	-0.445E-01				
2490.7A	5000.	0.789E-01	-0.372E-01				
c= 0.29E+17	10000.	0.898E-01	-0.257E-01				
	20000.	0.974E-01	-0.161E-01				
	30000.	0.994E-01	-0.113E-01				
	80000.	0.990E-01	-0.270E-02	0.294E-01*	-0.257E-01*		
3P - 4S	2500.	0.367E-02	0.262E-02	0.857E-03	0.703E-03	0.737E-03	0.567E-03
11397.0A	5000.	0.420E-02	0.301E-02	0.938E-03	0.791E-03	0.799E-03	0.640E-03
c= 0.59E+20	10000.	0.466E-02	0.356E-02	0.103E-02	0.891E-03	0.871E-03	0.721E-03
	20000.	0.515E-02	0.334E-02	0.114E-02	0.100E-02	0.954E-03	0.811E-03
	30000.	0.552E-02	0.329E-02	0.121E-02	0.107E-02	0.101E-02	0.868E-03
	80000.	0.702E-02	0.228E-02	0.140E-02	0.126E-02	0.116E-02	0.102E-02
3P - 5S	2500.	0.405E-02	0.293E-02	0.867E-03	0.793E-03	0.706E-03	0.639E-03
6158.6A	5000.	0.468E-02	0.350E-02	0.971E-03	0.899E-03	0.790E-03	0.726E-03
c= 0.70E+19	10000.	0.508E-02	0.383E-02	0.109E-02	0.101E-02	0.885E-03	0.822E-03
	20000.	0.563E-02	0.366E-02	0.122E-02	0.114E-02	0.991E-03	0.925E-03
	30000.	0.589E-02	0.339E-02	0.130E-02	0.122E-02	0.106E-02	0.991E-03
	80000.	0.732E-02	0.254E-02	0.154E-02	0.145E-02	0.125E-02	0.117E-02

NE= 0.1E+15

TRANSITION	T(K)	ELECTRONS 2WE(A)	DE(A)	PROTONS 2WI(A)	DI(A)	IONIZED HELIUM 2WI(A)	DI(A)
3P - 6S	2500.	0.780E-02	0.571E-02	0.162E-02	0.147E-02	0.131E-02	0.118E-02
5151.9A	5000.	0.892E-02	0.648E-02	0.182E-02	0.168E-02	0.147E-02	0.135E-02
c= 0.25E+19	10000.	0.974E-02	0.676E-02	0.204E-02	0.190E-02	0.165E-02	0.153E-02
	20000.	0.110E-01	0.640E-02	0.229E-02	0.215E-02	0.186E-02	0.174E-02
	30000.	0.119E-01	0.546E-02	0.245E-02	0.230E-02	0.199E-02	0.186E-02
	80000.	0.146E-01	0.375E-02	0.289E-02	0.272E-02	0.234E-02	0.220E-02
3P - 7S	2500.	0.152E-01	0.107E-01	0.302E-02	0.269E-02	0.245E-02	0.215E-02
4750.6A	5000.	0.173E-01	0.122E-01	0.339E-02	0.309E-02	0.275E-02	0.248E-02
c= 0.12E+19	10000.	0.190E-01	0.118E-01	0.381E-02	0.352E-02	0.309E-02	0.284E-02
	20000.	0.219E-01	0.101E-01	0.428E-02	0.399E-02	0.347E-02	0.322E-02
	30000.	0.245E-01	0.844E-02	0.458E-02	0.429E-02	0.371E-02	0.347E-02
	80000.	0.293E-01	0.528E-02	0.540E-02	0.507E-02	0.437E-02	0.410E-02
3P - 8S	2500.	0.271E-01	0.189E-01	0.533E-02	0.464E-02	0.432E-02	0.368E-02
4544.2A	5000.	0.307E-01	0.206E-01	0.599E-02	0.538E-02	0.485E-02	0.430E-02
c= 0.68E+18	10000.	0.361E-01	0.198E-01	0.672E-02	0.616E-02	0.544E-02	0.495E-02
	20000.	0.423E-01	0.151E-01	0.755E-02	0.700E-02	0.611E-02	0.564E-02
	30000.	0.475E-01	0.126E-01	0.808E-02	0.753E-02	0.654E-02	0.608E-02
	80000.	0.555E-01	0.692E-02	0.952E-02	0.893E-02	0.771E-02	0.723E-02
3P - 9S	2500.	0.460E-01	0.310E-01	0.886E-02*	0.748E-02*	0.718E-02*	0.589E-02*
4423.5A	5000.	0.526E-01	0.325E-01	0.995E-02	0.878E-02	0.806E-02*	0.699E-02*
c= 0.43E+18	10000.	0.627E-01	0.299E-01	0.112E-01	0.101E-01	0.905E-02*	0.811E-02*
	20000.	0.770E-01	0.218E-01	0.125E-01	0.115E-01	0.102E-01	0.930E-02
	30000.	0.861E-01	0.178E-01	0.134E-01	0.124E-01	0.109E-01	0.100E-01
	80000.	0.986E-01	0.694E-02	0.158E-01	0.148E-01	0.128E-01	0.120E-01
3P - 3D	2500.	0.312E-02	0.228E-02	0.814E-03	0.611E-03	0.721E-03	0.493E-03
8191.1A	5000.	0.355E-02	0.247E-02	0.879E-03	0.691E-03	0.768E-03	0.558E-03
c= 0.74E+19	10000.	0.385E-02	0.247E-02	0.955E-03	0.777E-03	0.825E-03	0.629E-03
	20000.	0.413E-02	0.227E-02	0.104E-02	0.874E-03	0.892E-03	0.708E-03
	30000.	0.428E-02	0.201E-02	0.110E-02	0.936E-03	0.936E-03	0.758E-03
	80000.	0.474E-02	0.137E-02	0.126E-02	0.110E-02	0.106E-02	0.894E-03
3P - 4D	2500.	0.255E-01	0.123E-01	0.698E-02	0.605E-02	0.569E-02	0.481E-02
5686.4A	5000.	0.243E-01	0.106E-01	0.784E-02	0.699E-02	0.636E-02	0.560E-02
c= 0.13E+18	10000.	0.226E-01	0.833E-02	0.882E-02	0.799E-02	0.713E-02	0.643E-02
	20000.	0.208E-01	0.597E-02	0.100E-01	0.907E-02	0.800E-02	0.732E-02
	30000.	0.197E-01	0.479E-02	0.109E-01	0.978E-02	0.858E-02	0.788E-02
	80000.	0.170E-01	0.262E-02	0.130E-01	0.119E-01	0.103E-01	0.936E-02
3P - 5D	2500.	0.672E-01	0.304E-01	0.189E-01*	0.153E-01*		
4981.4A	5000.	0.633E-01	0.243E-01	0.212E-01*	0.182E-01*	0.172E-01*	0.144E-01*
c= 0.52E+17	10000.	0.585E-01	0.187E-01	0.239E-01*	0.211E-01*	0.193E-01*	0.169E-01*
	20000.	0.532E-01	0.120E-01	0.272E-01	0.242E-01	0.217E-01*	0.195E-01*
	30000.	0.500E-01	0.942E-02	0.295E-01	0.262E-01	0.232E-01*	0.210E-01*
	80000.	0.419E-01	0.426E-02	0.354E-01	0.322E-01	0.279E-01	0.252E-01
3P - 6D	2500.	0.144	0.601E-01				
4667.5A	5000.	0.135	0.472E-01				
c= 0.28E+17	10000.	0.124	0.316E-01				
	20000.	0.113	0.213E-01	0.598E-01*	0.521E-01*		
	30000.	0.106	0.166E-01	0.648E-01*	0.566E-01*		
	80000.	0.875E-01	0.630E-02	0.776E-01*	0.703E-01*	0.612E-01*	0.547E-01*
3P - 7D	2500.	0.272	0.999E-01				
4496.6A	5000.	0.255	0.812E-01				
c= 0.17E+17	10000.	0.236	0.455E-01				
	20000.	0.213	0.347E-01				
	30000.	0.199	0.265E-01				
	80000.	0.164	0.851E-02				

NE= 0.1E+15

TRANSITION	T(K)	ELECTRONS 2WE(A)	DE(A)	PROTONS 2WI(A)	DI(A)	IONIZED HELIUM 2WI(A)	DI(A)
3P - 8D	2500.	0.477	0.160				
4392.3A	5000.	0.448	0.125				
c= 0.96E+16	10000.	0.414	0.789E-01				
	20000.	0.374	0.428E-01				
	30000.	0.348	0.395E-01				
	80000.	0.284	0.108E-01				
3P - 9D	2500.	0.739	0.230				
4323.5A	5000.	0.705	0.176				
c= 0.67E+16	10000.	0.658	0.116				
	20000.	0.596	0.651E-01				
	30000.	0.555	0.454E-01				
	80000.	0.454	0.138E-01				
3D - 4P	2500.	0.734	-0.423	0.169	-0.109	0.156	-0.877E-01
91050.0A	5000.	0.814	-0.428	0.179	-0.123	0.162	-0.994E-01
c= 0.91E+21	10000.	0.901	-0.336	0.191	-0.139	0.171	-0.112
	20000.	1.05	-0.252	0.205	-0.156	0.181	-0.126
	30000.	1.14	-0.221	0.214	-0.167	0.188	-0.135
	80000.	1.31	-0.129	0.241	-0.197	0.207	-0.160
3D - 5P	2500.	0.785E-01	-0.462E-01	0.207E-01	-0.127E-01	0.192E-01	-0.102E-01
17038.7A	5000.	0.874E-01	-0.441E-01	0.219E-01	-0.144E-01	0.200E-01	-0.116E-01
c= 0.14E+20	10000.	0.986E-01	-0.328E-01	0.232E-01	-0.163E-01	0.209E-01	-0.132E-01
	20000.	0.115	-0.260E-01	0.248E-01	-0.184E-01	0.221E-01	-0.149E-01
	30000.	0.123	-0.226E-01	0.259E-01	-0.197E-01	0.229E-01	-0.160E-01
	80000.	0.136	-0.104E-01	0.290E-01	-0.233E-01	0.251E-01	-0.189E-01
3D - 6P	2500.	0.114	-0.696E-01	0.299E-01	-0.194E-01	0.271E-01	-0.155E-01
12309.2A	5000.	0.125	-0.638E-01	0.318E-01	-0.223E-01	0.285E-01	-0.179E-01
c= 0.39E+19	10000.	0.142	-0.447E-01	0.341E-01	-0.254E-01	0.302E-01	-0.205E-01
	20000.	0.163	-0.309E-01	0.369E-01	-0.288E-01	0.322E-01	-0.233E-01
	30000.	0.171	-0.229E-01	0.387E-01	-0.310E-01	0.336E-01	-0.250E-01
	80000.	0.184	-0.564E-02	0.439E-01	-0.366E-01	0.374E-01	-0.296E-01
3D - 7P	2500.	0.201	-0.125	0.512E-01*	-0.344E-01*	0.456E-01*	-0.271E-01*
10674.6A	5000.	0.218	-0.112	0.552E-01	-0.401E-01	0.486E-01*	-0.320E-01*
c= 0.18E+19	10000.	0.248	-0.752E-01	0.597E-01	-0.461E-01	0.520E-01*	-0.370E-01*
	20000.	0.281	-0.471E-01	0.650E-01	-0.525E-01	0.560E-01	-0.423E-01
	30000.	0.292	-0.359E-01	0.686E-01	-0.565E-01	0.586E-01	-0.455E-01
	80000.	0.307	-0.537E-02	0.786E-01	-0.669E-01	0.661E-01	-0.543E-01
3D - 8P	2500.	0.356	-0.232	0.883E-01*	-0.593E-01*		
9875.6A	5000.	0.382	-0.193	0.959E-01*	-0.706E-01*	0.833E-01*	-0.559E-01*
c= 0.96E+18	10000.	0.436	-0.127	0.105*	-0.820E-01*	0.899E-01*	-0.656E-01*
	20000.	0.487	-0.762E-01	0.115*	-0.941E-01*	0.975E-01*	-0.756E-01*
	30000.	0.503	-0.592E-01	0.121	-0.102	0.103*	-0.817E-01*
	80000.	0.517	-0.881E-02	0.140	-0.121	0.117*	-0.979E-01*
3D - 9P	2500.	0.607	-0.363				
9414.4A	5000.	0.649	-0.322				
c= 0.58E+18	10000.	0.741	-0.218	0.177*	-0.139*		
	20000.	0.815	-0.125	0.195*	-0.161*		
	30000.	0.836	-0.975E-01	0.207*	-0.174*	0.173*	-0.140*
	80000.	0.846	-0.175E-01	0.240*	-0.209*	0.198*	-0.169*
3D -10P	2500.	0.992	-0.627				
9120.8A	5000.	1.06	-0.480				
c= 0.39E+18	10000.	1.21	-0.355				
	20000.	1.31	-0.200				
	30000.	1.34	-0.155				
	80000.	1.33	-0.332E-01	0.394*	-0.344*		

NE= 0.1E+15

		ELECTRONS		PROTONS		IONIZED HELIUM	
TRANSITION	T(K)	2WE(A)	DE(A)	2WI(A)	DI(A)	2WI(A)	DI(A)
3D - 4F	2500.	0.188	-0.571E-01	0.552E-01	-0.485E-01	0.448E-01	-0.387E-01
18465.3A	5000.	0.177	-0.355E-01	0.620E-01	-0.558E-01	0.502E-01	-0.448E-01
c= 0.14E+19	10000.	0.164	-0.180E-01	0.701E-01	-0.636E-01	0.563E-01	-0.513E-01
	20000.	0.149	-0.785E-02	0.801E-01	-0.723E-01	0.634E-01	-0.583E-01
	30000.	0.142	-0.445E-02	0.870E-01	-0.783E-01	0.681E-01	-0.627E-01
	80000.	0.126	0.221E-02	0.103	-0.971E-01	0.821E-01	-0.744E-01
4S - 4P	2500.	0.356E-01	-0.188E-01	0.105E-01	-0.498E-02	0.101E-01	-0.402E-02
22070.0A	5000.	0.385E-01	-0.189E-01	0.108E-01	-0.563E-02	0.103E-01	-0.455E-02
c= 0.53E+20	10000.	0.440E-01	-0.165E-01	0.112E-01	-0.634E-02	0.106E-01	-0.513E-02
	20000.	0.529E-01	-0.124E-01	0.117E-01	-0.713E-02	0.109E-01	-0.577E-02
	30000.	0.589E-01	-0.105E-01	0.120E-01	-0.764E-02	0.111E-01	-0.619E-02
	80000.	0.723E-01	-0.658E-02	0.130E-01	-0.901E-02	0.118E-01	-0.730E-02
4S - 5P	2500.	0.298E-01	-0.170E-01	0.859E-02	-0.487E-02	0.807E-02	-0.391E-02
10747.0A	5000.	0.325E-01	-0.161E-01	0.898E-02	-0.554E-02	0.833E-02	-0.446E-02
c= 0.57E+19	10000.	0.372E-01	-0.124E-01	0.945E-02	-0.628E-02	0.865E-02	-0.507E-02
	20000.	0.438E-01	-0.103E-01	0.100E-01	-0.707E-02	0.906E-02	-0.573E-02
	30000.	0.470E-01	-0.800E-02	0.104E-01	-0.758E-02	0.933E-02	-0.614E-02
	80000.	0.531E-01	-0.387E-02	0.116E-01	-0.896E-02	0.101E-01	-0.725E-02
4S - 6P	2500.	0.556E-01	-0.353E-01	0.150E-01	-0.952E-02	0.137E-01	-0.760E-02
8650.3A	5000.	0.604E-01	-0.310E-01	0.159E-01	-0.109E-01	0.143E-01	-0.879E-02
c= 0.19E+19	10000.	0.687E-01	-0.217E-01	0.170E-01	-0.125E-01	0.151E-01	-0.100E-01
	20000.	0.793E-01	-0.156E-01	0.184E-01	-0.141E-01	0.161E-01	-0.114E-01
	30000.	0.834E-01	-0.116E-01	0.192E-01	-0.152E-01	0.168E-01	-0.123E-01
	80000.	0.902E-01	-0.292E-02	0.218E-01	-0.180E-01	0.186E-01	-0.145E-01
4S - 7P	2500.	0.107	-0.664E-01	0.276E-01*	-0.184E-01*	0.246E-01*	-0.145E-01*
7810.0A	5000.	0.116	-0.598E-01	0.297E-01	-0.214E-01	0.262E-01*	-0.171E-01*
c= 0.94E+18	10000.	0.132	-0.423E-01	0.321E-01	-0.246E-01	0.280E-01*	-0.198E-01*
	20000.	0.150	-0.301E-01	0.349E-01	-0.280E-01	0.301E-01	-0.226E-01
	30000.	0.156	-0.197E-01	0.368E-01	-0.302E-01	0.315E-01	-0.243E-01
	80000.	0.164	-0.312E-02	0.421E-01	-0.358E-01	0.355E-01	-0.290E-01
4S - 8P	2500.	0.198	-0.129	0.494E-01*	-0.330E-01*		
7373.3A	5000.	0.213	-0.110	0.536E-01*	-0.393E-01*	0.466E-01*	-0.311E-01*
c= 0.53E+18	10000.	0.242	-0.781E-01	0.584E-01*	-0.457E-01*	0.502E-01*	-0.365E-01*
	20000.	0.271	-0.523E-01	0.640E-01*	-0.524E-01*	0.545E-01*	-0.421E-01*
	30000.	0.280	-0.340E-01	0.677E-01	-0.566E-01	0.573E-01*	-0.455E-01*
	80000.	0.288	-0.523E-02	0.781E-01	-0.676E-01	0.651E-01*	-0.545E-01*
4S - 9P	2500.	0.346	-0.210				
7113.0A	5000.	0.370	-0.177				
c= 0.33E+18	10000.	0.422	-0.132	0.101*	-0.794E-01*		
	20000.	0.465	-0.853E-01	0.111*	-0.919E-01*		
	30000.	0.477	-0.548E-01	0.118*	-0.995E-01*	0.990E-01*	-0.779E-01*
	80000.	0.483	-0.103E-01	0.137*	-0.119*	0.113*	-0.963E-01*
4S -10P	2500.	0.575	-0.364				
6944.0A	5000.	0.614	-0.290				
c= 0.22E+18	10000.	0.698	-0.202				
	20000.	0.758	-0.130				
	30000.	0.774	-0.918E-01				
	80000.	0.771	-0.197E-01	0.229*	-0.200*		
4P - 6S	2500.	0.890E-01	0.582E-01	0.175E-01	0.153E-01	0.145E-01	0.123E-01
16384.0A	5000.	0.103	0.672E-01	0.195E-01	0.175E-01	0.160E-01	0.141E-01
c= 0.25E+20	10000.	0.114	0.691E-01	0.218E-01	0.198E-01	0.179E-01	0.160E-01
	20000.	0.129	0.634E-01	0.243E-01	0.224E-01	0.199E-01	0.181E-01
	30000.	0.142	0.544E-01	0.260E-01	0.240E-01	0.212E-01	0.194E-01
	80000.	0.174	0.382E-01	0.305E-01	0.284E-01	0.248E-01	0.230E-01

NE= 0.1E+15

		ELECTRONS		PROTONS		IONIZED HELIUM	
TRANSITION	T(K)	2WE(A)	DE(A)	2WI(A)	DI(A)	2WI(A)	DI(A)
4P - 7S	2500.	0.117	0.801E-01	0.227E-01	0.201E-01	0.185E-01	0.160E-01
12915.0A	5000.	0.133	0.935E-01	0.255E-01	0.231E-01	0.207E-01	0.185E-01
c= 0.88E+19	10000.	0.151	0.877E-01	0.286E-01	0.263E-01	0.232E-01	0.212E-01
	20000.	0.174	0.751E-01	0.321E-01	0.298E-01	0.260E-01	0.240E-01
	30000.	0.195	0.629E-01	0.343E-01	0.320E-01	0.278E-01	0.259E-01
	80000.	0.233	0.394E-01	0.404E-01	0.379E-01	0.327E-01	0.306E-01
4P - 8S	2500.	0.178	0.121	0.343E-01	0.298E-01	0.278E-01*	0.236E-01*
11495.0A	5000.	0.203	0.133	0.385E-01	0.345E-01	0.312E-01	0.276E-01
c= 0.44E+19	10000.	0.235	0.129	0.432E-01	0.395E-01	0.350E-01	0.318E-01
	20000.	0.281	0.100	0.485E-01	0.449E-01	0.393E-01	0.362E-01
	30000.	0.315	0.825E-01	0.519E-01	0.484E-01	0.421E-01	0.390E-01
	80000.	0.368	0.465E-01	0.612E-01	0.573E-01	0.495E-01	0.464E-01
4P - 9S	2500.	0.277	0.185	0.528E-01*	0.445E-01*	0.428E-01*	0.351E-01*
10745.0A	5000.	0.317	0.195	0.593E-01	0.523E-01	0.481E-01*	0.416E-01*
c= 0.25E+19	10000.	0.379	0.181	0.666E-01	0.603E-01	0.539E-01*	0.483E-01*
	20000.	0.464	0.136	0.747E-01	0.688E-01	0.605E-01	0.554E-01
	30000.	0.519	0.111	0.800E-01	0.741E-01	0.648E-01	0.597E-01
	80000.	0.594	0.572E-01	0.944E-01	0.882E-01	0.763E-01	0.714E-01
4P - 4D	2500.	0.451	0.213	0.118	0.103	0.961E-01	0.816E-01
23370.0A	5000.	0.433	0.185	0.133	0.119	0.108	0.950E-01
c= 0.22E+19	10000.	0.408	0.147	0.149	0.136	0.121	0.109
	20000.	0.381	0.105	0.170	0.154	0.136	0.124
	30000.	0.367	0.824E-01	0.184	0.166	0.145	0.134
	80000.	0.329	0.432E-01	0.221	0.202	0.174	0.159
4P - 5D	2500.	0.599	0.269	0.166*	0.134*		
14776.0A	5000.	0.566	0.224	0.187*	0.160*	0.151*	0.127*
c= 0.45E+18	10000.	0.525	0.171	0.210*	0.186*	0.170*	0.149*
	20000.	0.481	0.115	0.239	0.213	0.191*	0.171*
	30000.	0.453	0.891E-01	0.259	0.231	0.204*	0.185*
	80000.	0.385	0.408E-01	0.311	0.283	0.245	0.222
4P - 6D	2500.	0.998	0.423				
12318.0A	5000.	0.939	0.341				
c= 0.20E+18	10000.	0.869	0.236				
	20000.	0.791	0.144	0.410*	0.358*		
	30000.	0.742	0.111	0.444*	0.389*		
	80000.	0.618	0.414E-01	0.533*	0.482*	0.420*	0.376*
4P - 7D	2500.	1.69	0.654				
11195.0A	5000.	1.59	0.522				
c= 0.10E+18	10000.	1.47	0.349				
	20000.	1.33	0.220				
	30000.	1.24	0.158				
	80000.	1.02	0.493E-01				
4P - 8D	2500.	2.76	0.938				
10570.0A	5000.	2.60	0.743				
c= 0.56E+17	10000.	2.40	0.437				
	20000.	2.17	0.301				
	30000.	2.02	0.185				
	80000.	1.65	0.587E-01				
4D - 6P	2500.	1.95	-0.997	0.410	-0.327	0.345*	-0.259*
36390.1A	5000.	1.99	-0.921	0.454	-0.380	0.379	-0.304
c= 0.52E+19	10000.	2.03	-0.673	0.504	-0.436	0.418	-0.350
	20000.	2.14	-0.443	0.564	-0.496	0.462	-0.400
	30000.	2.17	-0.347	0.604	-0.534	0.492	-0.431
	80000.	2.15	-0.129	0.718	-0.641	0.575	-0.513

NE= 0.1E+15

TRANSITION	T(K)	ELECTRONS 2WE(A)	DE(A)	PROTONS 2WI(A)	DI(A)	IONIZED HELIUM 2WI(A)	DI(A)
4D - 7P	2500.	1.55	-0.861	0.330*	-0.241*	0.284*	-0.190*
25050.1A	5000.	1.62	-0.758	0.361*	-0.283*	0.308*	-0.225*
c= 0.25E+19	10000.	1.74	-0.507	0.396	-0.326	0.335*	-0.261*
	20000.	1.88	-0.287	0.438	-0.372	0.367	-0.300
	30000.	1.93	-0.217	0.465	-0.401	0.388	-0.323
	80000.	1.95	-0.626E-01	0.544	-0.479	0.446	-0.386
4D - 8P	2500.	1.93	-1.05	0.425*	-0.294*		
21052.6A	5000.	2.03	-0.854	0.464*	-0.351*		
c= 0.18E+19	10000.	2.24	-0.471	0.509*	-0.409*	0.433*	-0.326*
	20000.	2.45	-0.294	0.560*	-0.469*	0.472*	-0.377*
	30000.	2.51	-0.206	0.594	-0.506	0.498*	-0.408*
	80000.	2.53	-0.297E-01	0.691	-0.606	0.571*	-0.488*
4D - 9P	2500.	2.74	-1.50				
19062.1A	5000.	2.90	-1.24				
c= 0.14E+19	10000.	3.25	-0.693	0.746*	-0.591*		
	20000.	3.54	-0.320	0.823*	-0.685*		
	30000.	3.61	-0.204	0.873*	-0.741*	0.730*	-0.595*
	80000.	3.62	-0.853E-02	1.02*	-0.890*	0.838*	-0.717*
4D -10P	2500.	4.04	-2.43				
17895.5A	5000.	4.29	-1.84				
c= 0.13E+19	10000.	4.83	-0.981				
	20000.	5.21	-0.375				
	30000.	5.30	-0.279				
	80000.	5.25	-0.136	1.54*	-1.35*		
5S - 5P	2500.	0.948	-0.573	0.235	-0.148	0.217	-0.118
54318.3A	5000.	1.06	-0.608	0.249	-0.168	0.226	-0.135
c= 0.15E+21	10000.	1.20	-0.572	0.265	-0.191	0.237	-0.154
	20000.	1.39	-0.463	0.284	-0.215	0.251	-0.174
	30000.	1.52	-0.389	0.297	-0.230	0.261	-0.186
	80000.	1.76	-0.255	0.334	-0.272	0.288	-0.220
5S - 6P	2500.	0.470	-0.301	0.121	-0.785E-01	0.110	-0.626E-01
24414.1A	5000.	0.515	-0.291	0.129	-0.903E-01	0.116	-0.725E-01
c= 0.15E+20	10000.	0.584	-0.223	0.139	-0.103	0.123	-0.829E-01
	20000.	0.680	-0.162	0.150	-0.117	0.131	-0.941E-01
	30000.	0.725	-0.128	0.157	-0.125	0.136	-0.101
	80000.	0.796	-0.560E-01	0.178	-0.148	0.152	-0.120
5S - 7P	2500.	0.628	-0.406	0.160*	-0.107*	0.142*	-0.842E-01*
18726.6A	5000.	0.681	-0.349	0.172	-0.124	0.151*	-0.992E-01*
c= 0.54E+19	10000.	0.776	-0.228	0.186	-0.143	0.162*	-0.115*
	20000.	0.887	-0.158	0.202	-0.163	0.174	-0.131
	30000.	0.929	-0.102	0.213	-0.175	0.182	-0.141
	80000.	0.986	-0.329E-01	0.244	-0.208	0.206	-0.169
5S - 8P	2500.	0.987	-0.642	0.245*	-0.164*		
16398.8A	5000.	1.06	-0.534	0.266*	-0.195*	0.231*	-0.155*
c= 0.26E+19	10000.	1.21	-0.348	0.290*	-0.227*	0.249*	-0.181*
	20000.	1.36	-0.220	0.317*	-0.260*	0.270*	-0.209*
	30000.	1.41	-0.102	0.335	-0.281	0.284*	-0.226*
	80000.	1.46	-0.369E-01	0.387	-0.336	0.323*	-0.271*
5S - 9P	2500.	1.58	-0.956				
15165.3A	5000.	1.69	-0.821				
c= 0.15E+19	10000.	1.93	-0.546	0.460*	-0.361*		
	20000.	2.13	-0.335	0.507*	-0.418*		
	30000.	2.19	-0.124	0.537*	-0.453*	0.451*	-0.364*
	80000.	2.22	-0.587E-01	0.623*	-0.543*	0.516*	-0.438*

NE= 0.1E+15

TRANSITION	T(K)	ELECTRONS 2WE(A)	DE(A)	PROTONS 2WI(A)	DI(A)	IONIZED HELIUM 2WI(A)	DI(A)
5S -10P	2500.	2.48	-1.57				
14417.5A	5000.	2.65	-1.26				
c= 0.97E+18	10000.	3.02	-0.850				
	20000.	3.28	-0.515				
	30000.	3.36	-0.348				
	80000.	3.35	-0.986E-01	0.986*	-0.861*		
5P - 6S	2500.	2.80	1.73	0.574	0.430	0.502	0.345
75075.1A	5000.	3.24	1.95	0.623	0.492	0.539	0.396
c= 0.28E+21	10000.	3.67	1.96	0.680	0.558	0.582	0.450
	20000.	4.17	1.67	0.745	0.632	0.632	0.511
	30000.	4.58	1.42	0.788	0.677	0.665	0.548
	80000.	5.38	0.986	0.908	0.801	0.758	0.648
5P - 7S	2500.	0.969	0.605	0.182	0.152	0.152	0.121
33658.7A	5000.	1.13	0.694	0.202	0.174	0.168	0.140
c= 0.56E+20	10000.	1.29	0.702	0.224	0.199	0.186	0.160
	20000.	1.48	0.569	0.250	0.225	0.206	0.182
	30000.	1.64	0.467	0.266	0.242	0.219	0.196
	80000.	1.93	0.288	0.311	0.286	0.255	0.232
5D - 7P	2500.	11.5	-3.51	3.37*	-2.62*		
66489.4A	5000.	11.0	-2.39	3.76*	-3.11*	3.10*	-2.4*
c= 0.91E+19	10000.	10.3	-1.41	4.21*	-3.61*	3.44*	-2.8*
	20000.	9.47	-0.584	4.76	-4.14	3.83*	-3.3*
	30000.	8.92	-0.267	5.15	-4.48	4.09*	-3.6*
	80000.	7.56	0.174	6.14	-5.53	4.88	-4.31
5D - 8P	2500.	12.1	-5.79				
44208.7A	5000.	12.5	-4.35	2.78*	-2.21*		
c= 0.40E+19	10000.	13.0	-2.23	3.09*	-2.59*		
	20000.	13.6	-1.63	3.45*	-2.99*	2.83*	-2.40*
	30000.	13.7	-1.01	3.69*	-3.23*	3.01*	-2.60*
	80000.	13.2	-0.113	4.39*	-3.91*	3.52*	-3.12*
5D - 9P	2500.	12.4	-6.45				
36258.2A	5000.	12.8	-4.36				
c= 0.27E+19	10000.	13.8	-2.31				
	20000.	14.7	-1.20	3.48*	-2.96*		
	30000.	14.8	-0.914	3.71*	-3.20*		
	80000.	14.5	-0.299E-01	4.37*	-3.86*	3.55*	-3.10*
3S - 3P	2500.	0.191E-02	0.132E-02	0.126E-02	0.366E-03	0.125E-02	0.296E-03
5891.8A	5000.	0.211E-02	0.155E-02	0.127E-02	0.414E-03	0.126E-02	0.335E-03
c= 0.30E+20	10000.	0.249E-02	0.178E-02	0.129E-02	0.466E-03	0.127E-02	0.377E-03
	20000.	0.322E-02	0.182E-02	0.130E-02	0.525E-03	0.128E-02	0.425E-03
	30000.	0.381E-02	0.183E-02	0.132E-02	0.562E-03	0.128E-02	0.455E-03
	80000.	0.551E-02	0.129E-02	0.136E-02	0.663E-03	0.131E-02	0.537E-03
3S - 4P	2500.	0.649E-02	-0.239E-02	0.223E-02	-0.764E-03	0.219E-02	-0.612E-03
3302.6A	5000.	0.725E-02	-0.146E-02	0.226E-02	-0.873E-03	0.222E-02	-0.702E-03
c= 0.12E+19	10000.	0.864E-02	-0.442E-03	0.230E-02	-0.991E-03	0.224E-02	-0.799E-03
	20000.	0.100E-01	0.234E-03	0.236E-02	-0.112E-02	0.227E-02	-0.906E-03
	30000.	0.108E-01	0.579E-03	0.239E-02	-0.120E-02	0.230E-02	-0.972E-03
	80000.	0.126E-01	0.634E-03	0.251E-02	-0.142E-02	0.237E-02	-0.115E-02
3S - 5P	2500.	0.202E-01	-0.110E-01	0.595E-02	-0.307E-02	0.558E-02*	-0.242E-02
2852.8A	5000.	0.221E-01	-0.983E-02	0.623E-02	-0.360E-02	0.579E-02*	-0.287E-02
c= 0.40E+18	10000.	0.254E-01	-0.662E-02	0.655E-02	-0.415E-02	0.602E-02	-0.333E-02
	20000.	0.295E-01	-0.464E-02	0.695E-02	-0.474E-02	0.629E-02	-0.381E-02
	30000.	0.313E-01	-0.344E-02	0.721E-02	-0.510E-02	0.648E-02	-0.411E-02
	80000.	0.347E-01	-0.115E-02	0.799E-02	-0.605E-02	0.703E-02	-0.491E-02

NE= 0.1E+16

TRANSITION	T(K)	ELECTRONS 2WE(A)	ELECTRONS DE(A)	PROTONS 2WI(A)	PROTONS DI(A)	IONIZED HELIUM 2WI(A)	IONIZED HELIUM DI(A)
3S - 6P	2500.	0.528E-01	-0.325E-01	0.141E-01*	-0.782E-02*		
2680.4A	5000.	0.573E-01	-0.281E-01	0.152E-01*	-0.955E-02*		
c= 0.19E+18	10000.	0.653E-01	-0.202E-01	0.163E-01*	-0.113E-01*	0.145E-01*	-0.895E-02*
	20000.	0.749E-01	-0.145E-01	0.175E-01*	-0.130E-01*	0.154E-01*	-0.104E-01*
	30000.	0.785E-01	-0.109E-01	0.184E-01	-0.141E-01	0.160E-01*	-0.113E-01*
	80000.	0.843E-01	-0.365E-02	0.208E-01	-0.169E-01	0.178E-01*	-0.137E-01*
3S - 7P	2500.	0.118	-0.687E-01				
2593.9A	5000.	0.127	-0.634E-01				
c= 0.10E+18	10000.	0.145	-0.458E-01				
	20000.	0.164	-0.332E-01	0.384E-01*	-0.292E-01*		
	30000.	0.170	-0.245E-01	0.405E-01*	-0.319E-01*		
	80000.	0.178	-0.749E-02	0.464E-01*	-0.387E-01*	0.391E-01*	-0.311E-01*
3S - 8P	2500.	0.235	-0.141				
2543.8A	5000.	0.252	-0.119				
c= 0.63E+17	10000.	0.288	-0.877E-01				
	20000.	0.321	-0.656E-01				
	30000.	0.331	-0.450E-01				
	80000.	0.340	-0.126E-01				
3S - 9P	2500.	0.430	-0.225				
2512.1A	5000.	0.460	-0.205				
c= 0.42E+17	10000.	0.525	-0.142				
	20000.	0.578	-0.103				
	30000.	0.593	-0.730E-01				
	80000.	0.600	-0.230E-01				
3S -10P	2500.	0.730*	-0.388*				
2490.7A	5000.	0.783	-0.320				
c= 0.29E+17	10000.	0.894	-0.235				
	20000.	0.971	-0.158				
	30000.	0.992	-0.110				
	80000.	0.989	-0.270E-01				
3P - 4S	2500.	0.367E-01	0.262E-01	0.856E-02	0.683E-02	0.736E-02	0.548E-02
11397.0A	5000.	0.420E-01	0.300E-01	0.938E-02	0.778E-02	0.798E-02	0.626E-02
c= 0.59E+20	10000.	0.466E-01	0.356E-01	0.103E-01	0.882E-02	0.871E-02	0.712E-02
	20000.	0.515E-01	0.334E-01	0.114E-01	0.995E-02	0.954E-02	0.806E-02
	30000.	0.552E-01	0.329E-01	0.121E-01	0.107E-01	0.101E-01	0.863E-02
	80000.	0.702E-01	0.228E-01	0.140E-01	0.126E-01	0.116E-01	0.102E-01
3P - 5S	2500.	0.405E-01	0.289E-01	0.866E-02	0.750E-02	0.705E-02	0.596E-02
6158.6A	5000.	0.468E-01	0.349E-01	0.971E-02	0.868E-02	0.790E-02	0.695E-02
c= 0.70E+19	10000.	0.508E-01	0.382E-01	0.109E-01	0.993E-02	0.884E-02	0.799E-02
	20000.	0.563E-01	0.365E-01	0.122E-01	0.113E-01	0.991E-02	0.910E-02
	30000.	0.589E-01	0.339E-01	0.130E-01	0.121E-01	0.106E-01	0.979E-02
	80000.	0.732E-01	0.254E-01	0.154E-01	0.144E-01	0.125E-01	0.116E-01
3P - 6S	2500.	0.780E-01	0.562E-01	0.162E-01	0.134E-01	0.131E-01*	0.105E-01*
5151.9A	5000.	0.892E-01	0.640E-01	0.182E-01	0.158E-01	0.147E-01	0.126E-01
c= 0.25E+19	10000.	0.974E-01	0.673E-01	0.204E-01	0.183E-01	0.165E-01	0.147E-01
	20000.	0.110	0.640E-01	0.229E-01	0.210E-01	0.186E-01	0.169E-01
	30000.	0.119	0.545E-01	0.245E-01	0.226E-01	0.199E-01	0.182E-01
	80000.	0.146	0.375E-01	0.289E-01	0.270E-01	0.234E-01	0.218E-01
3P - 7S	2500.	0.152	0.104	0.302E-01*	0.233E-01*	0.245E-01*	0.178E-01*
4750.6A	5000.	0.173	0.121	0.339E-01*	0.284E-01*	0.275E-01*	0.223E-01*
c= 0.12E+19	10000.	0.190	0.117	0.381E-01	0.334E-01	0.309E-01*	0.266E-01*
	20000.	0.219	0.101	0.428E-01	0.386E-01	0.347E-01*	0.309E-01*
	30000.	0.245	0.843E-01	0.458E-01	0.418E-01	0.371E-01*	0.336E-01*
	80000.	0.293	0.528E-01	0.540E-01	0.501E-01	0.437E-01	0.404E-01

NE= 0.1E+16

TRANSITION	T(K)	ELECTRONS 2WE(A)	DE(A)	PROTONS 2WI(A)	DI(A)	IONIZED HELIUM 2WI(A)	DI(A)
3P - 8S	2500.	0.271	0.180				
4544.2A	5000.	0.307	0.202	0.598E-01*	0.474E-01*		
c= 0.68E+18	10000.	0.361	0.198	0.672E-01*	0.571E-01*	0.544E-01*	0.450E-01*
	20000.	0.423	0.151	0.754E-01*	0.668E-01*	0.611E-01*	0.532E-01*
	30000.	0.475	0.125	0.807E-01*	0.726E-01*	0.654E-01*	0.581E-01*
	80000.	0.555	0.692E-01	0.952E-01	0.877E-01	0.770E-01*	0.706E-01*
3P - 9S	2500.	0.460	0.291				
4423.5A	5000.	0.526	0.315				
c= 0.43E+18	10000.	0.627	0.298				
	20000.	0.770	0.217	0.125*	0.108*		
	30000.	0.861	0.177	0.134*	0.119*		
	80000.	0.986	0.694E-01	0.158*	0.144*	0.128*	0.116*
3P - 3D	2500.	0.312E-01	0.226E-01	0.814E-02	0.589E-02	0.720E-02	0.472E-02
8191.1A	5000.	0.355E-01	0.246E-01	0.879E-02	0.674E-02	0.768E-02	0.542E-02
c= 0.74E+19	10000.	0.385E-01	0.246E-01	0.955E-02	0.766E-02	0.825E-02	0.618E-02
	20000.	0.413E-01	0.227E-01	0.104E-01	0.868E-02	0.892E-02	0.701E-02
	30000.	0.428E-01	0.201E-01	0.110E-01	0.930E-02	0.936E-02	0.753E-02
	80000.	0.474E-01	0.137E-01	0.126E-01	0.110E-01	0.106E-01	0.891E-02
3P - 4D	2500.	0.253	0.112	0.697E-01*	0.499E-01*		
5686.4A	5000.	0.242	0.993E-01	0.783E-01*	0.624E-01*		
c= 0.13E+18	10000.	0.225	0.804E-01	0.882E-01*	0.746E-01*	0.713E-01*	0.590E-01*
	20000.	0.207	0.593E-01	0.100*	0.869E-01*	0.800E-01*	0.694E-01*
	30000.	0.196	0.475E-01	0.108*	0.945E-01*	0.857E-01*	0.757E-01*
	80000.	0.170	0.262E-01	0.130	0.117	0.103*	0.916E-01*
3P - 5D	2500.	0.644	0.246				
4981.4A	5000.	0.613	0.221				
c= 0.52E+17	10000.	0.571	0.171				
	20000.	0.523	0.117				
	30000.	0.492	0.922E-01				
	80000.	0.414	0.426E-01				
3P - 6D	2500.	1.27	0.434				
4667.5A	5000.	1.23	0.387				
c= 0.28E+17	10000.	1.16	0.302				
	20000.	1.07	0.204				
	30000.	1.01	0.158				
	80000.	0.846	0.630E-01				
3P - 7D	2500.	2.15	0.670				
4496.6A	5000.	2.15	0.602				
c= 0.17E+17	10000.	2.07	0.455				
	20000.	1.93	0.319				
	30000.	1.83	0.242				
	80000.	1.54	0.851E-01				
3P - 8D	2500.	3.20	0.910				
4392.3A	5000.	3.39	0.833				
c= 0.96E+16	10000.	3.37	0.663				
	20000.	3.19	0.428				
	30000.	3.03	0.336				
	80000.	2.57	0.108				
3P - 9D	2500.	4.30*	1.21*				
4323.5A	5000.	4.89	1.14				
c= 0.67E+16	10000.	5.05	0.901				
	20000.	4.88	0.624				
	30000.	4.67	0.454				
	80000.	4.00	0.138				

NE= 0.1E+16

		ELECTRONS		PROTONS		IONIZED HELIUM	
TRANSITION	T(K)	2WE(A)	DE(A)	2WI(A)	DI(A)	2WI(A)	DI(A)
3D - 4P	2500.	7.34	-4.19	1.69	-1.04	1.55	-0.831
91050.0A	5000.	8.14	-4.26	1.79	-1.20	1.62	-0.960
c= 0.91E+21	10000.	9.01	-3.35	1.91	-1.36	1.71	-1.10
	20000.	10.5	-2.52	2.05	-1.55	1.81	-1.25
	30000.	11.4	-2.21	2.14	-1.66	1.88	-1.34
	80000.	13.1	-1.29	2.41	-1.96	2.07	-1.59
3D - 5P	2500.	0.785	-0.457	0.206	-0.117	0.190*	-0.917E-01*
17038.7A	5000.	0.874	-0.440	0.218	-0.137	0.199*	-0.109*
c= 0.14E+20	10000.	0.986	-0.327	0.232	-0.158	0.209	-0.127
	20000.	1.15	-0.260	0.248	-0.180	0.221	-0.145
	30000.	1.23	-0.226	0.259	-0.194	0.229	-0.157
	80000.	1.36	-0.104	0.290	-0.231	0.251	-0.187
3D - 6P	2500.	1.14	-0.670	0.295*	-0.167*		
12309.2A	5000.	1.25	-0.627	0.317*	-0.204*		
c= 0.39E+19	10000.	1.42	-0.446	0.341*	-0.240*	0.301*	-0.191*
	20000.	1.63	-0.309	0.369*	-0.278*	0.322*	-0.223*
	30000.	1.71	-0.229	0.387	-0.301	0.336*	-0.242*
	80000.	1.84	-0.564E-01	0.439	-0.361	0.374	-0.291
3D - 7P	2500.	2.01	-1.17				
10674.6A	5000.	2.18	-1.09				
c= 0.18E+19	10000.	2.48	-0.747				
	20000.	2.81	-0.467	0.650*	-0.497*		
	30000.	2.92	-0.356	0.685*	-0.542*		
	80000.	3.07	-0.537E-01	0.786*	-0.656*	0.661*	-0.528*
3D - 8P	2500.	3.56	-2.12				
9875.6A	5000.	3.82	-1.82				
c= 0.96E+18	10000.	4.36	-1.26				
	20000.	4.87	-0.752				
	30000.	5.03	-0.584				
	80000.	5.17	-0.881E-01				
3D - 9P	2500.	6.05	-3.16				
9414.4A	5000.	6.48	-2.89				
c= 0.58E+18	10000.	7.40	-2.05				
	20000.	8.15	-1.23				
	30000.	8.36	-0.957				
	80000.	8.46	-0.175				
3D -10P	2500.	9.80*	-5.10*				
9120.8A	5000.	10.5	-4.27				
c= 0.39E+18	10000.	12.0	-3.21				
	20000.	13.0	-1.95				
	30000.	13.3	-1.51				
	80000.	13.3	-0.332				
3D - 4F	2500.	1.86	-0.496	0.551*	-0.412*	0.447*	-0.314*
18465.3A	5000.	1.77	-0.317	0.620*	-0.507*	0.502*	-0.397*
c= 0.14E+19	10000.	1.64	-0.176	0.701*	-0.600*	0.563*	-0.476*
	20000.	1.49	-0.755E-01	0.800	-0.701	0.634*	-0.557*
	30000.	1.41	-0.425E-01	0.870	-0.759	0.681*	-0.605*
	80000.	1.26	0.221E-01	1.03	-0.960	0.821	-0.731
4S - 4P	2500.	0.356	-0.186	0.105	-0.479E-01	0.101	-0.383E-01
22070.0A	5000.	0.385	-0.188	0.108	-0.549E-01	0.103	-0.441E-01
c= 0.53E+20	10000.	0.440	-0.165	0.112	-0.625E-01	0.106	-0.504E-01
	20000.	0.529	-0.124	0.117	-0.708E-01	0.109	-0.571E-01
	30000.	0.589	-0.105	0.120	-0.760E-01	0.111	-0.614E-01
	80000.	0.723	-0.658E-01	0.130	-0.898E-01	0.118	-0.727E-01

NE= 0.1E+16

TRANSITION	T(K)	ELECTRONS 2WE(A)	DE(A)	PROTONS 2WI(A)	DI(A)	IONIZED HELIUM 2WI(A)	DI(A)
4S - 5P	2500.	0.298	-0.167	0.854E-01	-0.449E-01	0.798E-01*	-0.353E-01*
10747.0A	5000.	0.325	-0.160	0.896E-01	-0.527E-01	0.830E-01*	-0.420E-01*
c= 0.57E+19	10000.	0.372	-0.124	0.944E-01	-0.608E-01	0.864E-01	-0.487E-01
	20000.	0.438	-0.103	0.100	-0.694E-01	0.905E-01	-0.558E-01
	30000.	0.470	-0.800E-01	0.104	-0.747E-01	0.933E-01	-0.602E-01
	80000.	0.531	-0.387E-01	0.116	-0.890E-01	0.101	-0.720E-01
4S - 6P	2500.	0.556	-0.340	0.148*	-0.818E-01*		
8650.3A	5000.	0.604	-0.303	0.158*	-0.100*		
c= 0.19E+19	10000.	0.687	-0.217	0.170*	-0.118*	0.151*	-0.938E-01*
	20000.	0.793	-0.155	0.183*	-0.137*	0.161*	-0.109*
	30000.	0.834	-0.116	0.192	-0.148	0.167*	-0.119*
	80000.	0.902	-0.292E-01	0.218	-0.177	0.186	-0.143
4S - 7P	2500.	1.07	-0.623				
7810.0A	5000.	1.16	-0.576				
c= 0.94E+18	10000.	1.32	-0.420				
	20000.	1.50	-0.299	0.349*	-0.265*		
	30000.	1.56	-0.195	0.368*	-0.289*		
	80000.	1.64	-0.312E-01	0.421*	-0.351*	0.355*	-0.282*
4S - 8P	2500.	1.98	-1.18				
7373.3A	5000.	2.12	-1.02				
c= 0.53E+18	10000.	2.42	-0.751				
	20000.	2.71	-0.517				
	30000.	2.80	-0.336				
	80000.	2.88	-0.523E-01				
4S - 9P	2500.	3.45	-1.81				
7113.0A	5000.	3.70	-1.64				
c= 0.33E+18	10000.	4.22	-1.23				
	20000.	4.64	-0.840				
	30000.	4.77	-0.548				
	80000.	4.82	-0.103				
4S -10P	2500.	5.68*	-2.96*				
6944.0A	5000.	6.09	-2.48				
c= 0.22E+18	10000.	6.95	-1.88				
	20000.	7.56	-1.30				
	30000.	7.72	-0.894				
	80000.	7.70	-0.197				
4P - 6S	2500.	0.890	0.568	0.175	0.139	0.144*	0.109*
16384.0A	5000.	1.03	0.663	0.195	0.165	0.160	0.131
c= 0.25E+20	10000.	1.14	0.686	0.218	0.191	0.179	0.153
	20000.	1.29	0.634	0.243	0.219	0.199	0.176
	30000.	1.42	0.543	0.260	0.236	0.212	0.190
	80000.	1.74	0.382	0.305	0.282	0.248	0.227
4P - 7S	2500.	1.17	0.773	0.227*	0.173*	0.185*	0.133*
12915.0A	5000.	1.33	0.922	0.255*	0.211*	0.207*	0.166*
c= 0.88E+19	10000.	1.51	0.868	0.286*	0.249*	0.232*	0.198*
	20000.	1.74	0.750	0.320	0.288	0.260*	0.231*
	30000.	1.95	0.628	0.343	0.312	0.278*	0.250*
	80000.	2.33	0.394	0.404	0.374	0.327	0.301
4P - 8S	2500.	1.78	1.15				
11495.0A	5000.	2.03	1.29	0.385*	0.304*		
c= 0.44E+19	10000.	2.35	1.28	0.432*	0.366*		
	20000.	2.81	0.997	0.485*	0.429*	0.393*	0.342*
	30000.	3.15	0.823	0.519*	0.466*	0.421*	0.373*
	80000.	3.68	0.465	0.612	0.563	0.495*	0.453*

		ELECTRONS		PROTONS		IONIZED HELIUM	
TRANSITION	T(K)	2WE(A)	DE(A)	2WI(A)	DI(A)	2WI(A)	DI(A)
NE= 0.1E+16							
4P - 9S	2500.	2.77	1.73				
10745.0A	5000.	3.17	1.88				
c= 0.25E+19	10000.	3.79	1.78				
	20000.	4.64	1.35	0.747*	0.646*		
	30000.	5.19	1.11	0.800*	0.707*		
	80000.	5.94	0.572	0.943*	0.860*	0.763*	0.691*
4P - 4D	2500.	4.49	1.95	1.18*	0.847*		
23370.0A	5000.	4.32	1.74	1.33*	1.06*		
c= 0.22E+19	10000.	4.07	1.42	1.49*	1.27*	1.21*	1.00*
	20000.	3.80	1.04	1.70*	1.48*	1.35*	1.18*
	30000.	3.66	0.824	1.84*	1.60*	1.45*	1.28*
	80000.	3.29	0.432	2.21	1.99	1.74*	1.56*
4P - 5D	2500.	5.75	2.18				
14776.0A	5000.	5.49	1.93				
c= 0.45E+18	10000.	5.13	1.55				
	20000.	4.72	1.13				
	30000.	4.46	0.873				
	80000.	3.80	0.408				
4P - 6D	2500.	8.88	3.04				
12318.0A	5000.	8.62	2.71				
c= 0.20E+18	10000.	8.14	2.18				
	20000.	7.52	1.44				
	30000.	7.10	1.06				
	80000.	5.99	0.414				
5S - 5P	2500.	9.48	-5.62	2.34	-1.35	2.14*	-1.06*
54318.3A	5000.	10.6	-6.04	2.48	-1.59	2.25*	-1.27*
c= 0.15E+21	10000.	12.0	-5.71	2.65	-1.84	2.37	-1.47
	20000.	13.9	-4.63	2.84	-2.10	2.51	-1.69
	30000.	15.2	-3.88	2.97	-2.27	2.61	-1.83
	80000.	17.6	-2.55	3.34	-2.71	2.88	-2.19
5S - 6P	2500.	4.70	-2.96	1.20*	-0.672*		
24414.1A	5000.	5.15	-2.90	1.29*	-0.823*		
c= 0.15E+20	10000.	5.84	-2.23	1.38*	-0.973*	1.22*	-0.772*
	20000.	6.80	-1.62	1.50*	-1.13*	1.31*	-0.901*
	30000.	7.25	-1.28	1.57	-1.22	1.36*	-0.979*
	80000.	7.96	-0.560	1.78	-1.46	1.52	-1.18
5S - 7P	2500.	6.28	-3.85				
18726.6A	5000.	6.81	-3.42				
c= 0.54E+19	10000.	7.75	-2.26				
	20000.	8.87	-1.58	2.02*	-1.54*		
	30000.	9.29	-1.02	2.13*	-1.68*		
	80000.	9.86	-0.329	2.44*	-2.04*	2.05*	-1.64*
5S - 8P	2500.	9.87	-5.87				
16398.8A	5000.	10.6	-5.06				
c= 0.26E+19	10000.	12.1	-3.45				
	20000.	13.6	-2.17				
	30000.	14.1	-1.02				
	80000.	14.6	-0.369				
NE= 0.1E+17							
3S - 3P	2500.	0.191E-01	0.130E-01	0.126E-01	0.352E-02	0.124E-01	0.282E-02
5891.8A	5000.	0.211E-01	0.154E-01	0.127E-01	0.404E-02	0.126E-01	0.325E-02
c= 0.30E+20	10000.	0.249E-01	0.177E-01	0.129E-01	0.459E-02	0.127E-01	0.370E-02
	20000.	0.322E-01	0.181E-01	0.130E-01	0.521E-02	0.128E-01	0.420E-02
	30000.	0.381E-01	0.183E-01	0.132E-01	0.559E-02	0.128E-01	0.452E-02
	80000.	0.551E-01	0.129E-01	0.136E-01	0.660E-02	0.131E-01	0.534E-02

NE= 0.1E+17

TRANSITION	T(K)	ELECTRONS 2WE(A)	DE(A)	PROTONS 2WI(A)	DI(A)	IONIZED HELIUM 2WI(A)	DI(A)
3S - 4P	2500.	0.649E-01	-0.231E-01	0.219E-01*	-0.686E-02*	0.211E-01*	-0.535E-02*
3302.6A	5000.	0.725E-01	-0.141E-01	0.225E-01	-0.818E-02	0.219E-01*	-0.647E-02*
c= 0.12E+19	10000.	0.864E-01	-0.422E-02	0.230E-01	-0.951E-02	0.223E-01*	-0.760E-02*
	20000.	0.100	0.248E-02	0.235E-01	-0.109E-01	0.227E-01	-0.877E-02
	30000.	0.108	0.582E-02	0.239E-01	-0.118E-01	0.229E-01	-0.948E-02
	80000.	0.126	0.635E-02	0.251E-01	-0.141E-01	0.237E-01	-0.114E-01
3S - 5P	2500.	0.202	-0.102				
2852.8A	5000.	0.221	-0.928E-01	0.611E-01*	-0.303E-01*		
c= 0.40E+18	10000.	0.254	-0.631E-01	0.651E-01*	-0.375E-01*		
	20000.	0.295	-0.460E-01	0.693E-01*	-0.445E-01*	0.626E-01*	-0.353E-01*
	30000.	0.313	-0.340E-01	0.720E-01*	-0.487E-01*	0.646E-01*	-0.388E-01*
	80000.	0.347	-0.114E-01	0.798E-01	-0.590E-01	0.702E-01*	-0.476E-01*
3S - 6P	2500.	0.527	-0.283				
2680.4A	5000.	0.573	-0.257				
c= 0.19E+18	10000.	0.653	-0.186				
	20000.	0.749	-0.143				
	30000.	0.785	-0.108				
	80000.	0.842	-0.356E-01	0.208*	-0.162*		
3P - 4S	2500.	0.367	0.258	0.855E-01	0.623E-01	0.733E-01	0.488E-01
11397.0A	5000.	0.420	0.296	0.937E-01	0.735E-01	0.797E-01	0.584E-01
c= 0.59E+20	10000.	0.466	0.355	0.103	0.851E-01	0.870E-01	0.681E-01
	20000.	0.515	0.333	0.114	0.974E-01	0.953E-01	0.783E-01
	30000.	0.552	0.329	0.121	0.105	0.101	0.846E-01
	80000.	0.702	0.228	0.140	0.125	0.116	0.101
3P - 5S	2500.	0.405	0.276	0.865E-01*	0.615E-01*	0.702E-01*	0.461E-01*
6158.6A	5000.	0.468	0.339	0.970E-01	0.773E-01	0.789E-01*	0.600E-01*
c= 0.70E+19	10000.	0.508	0.376	0.109	0.925E-01	0.884E-01*	0.731E-01*
	20000.	0.563	0.363	0.122	0.108	0.991E-01	0.862E-01
	30000.	0.589	0.339	0.130	0.117	0.106	0.940E-01
	80000.	0.732	0.254	0.154	0.141	0.125	0.114
3P - 6S	2500.	0.780	0.519				
5151.9A	5000.	0.891	0.611	0.181*	0.129*		
c= 0.25E+19	10000.	0.974	0.654	0.204*	0.162*		
	20000.	1.10	0.634	0.229*	0.195*	0.186*	0.154*
	30000.	1.19	0.542	0.245*	0.214*	0.198*	0.170*
	80000.	1.46	0.374	0.289*	0.262*	0.234*	0.210*
3P - 7S	2500.	1.52	0.920				
4750.6A	5000.	1.73	1.12				
c= 0.12E+19	10000.	1.90	1.12				
	20000.	2.19	0.986				
	30000.	2.45	0.832				
	80000.	2.93	0.528	0.539*	0.480*		
3P - 3D	2500.	0.312	0.219	0.809E-01	0.521E-01	0.711E-01*	0.404E-01*
8191.1A	5000.	0.355	0.241	0.877E-01	0.626E-01	0.765E-01	0.494E-01
c= 0.74E+19	10000.	0.385	0.244	0.954E-01	0.732E-01	0.824E-01	0.584E-01
	20000.	0.413	0.227	0.104	0.843E-01	0.891E-01	0.676E-01
	30000.	0.428	0.200	0.110	0.910E-01	0.936E-01	0.732E-01
	80000.	0.474	0.136	0.126	0.109	0.106	0.879E-01
3P - 4D	2500.	2.25	0.809				
5686.4A	5000.	2.22	0.772				
c= 0.13E+18	10000.	2.11	0.669				
	20000.	1.97	0.550				
	30000.	1.88	0.450				
	80000.	1.65	0.254				

NE= 0.1E+17

TRANSITION	T(K)	ELECTRONS 2WE(A)	DE(A)	PROTONS 2WI(A)	DI(A)	IONIZED HELIUM 2WI(A)	DI(A)
3P - 5D	2500.	4.62	1.43				
4981.4A	5000.	4.86	1.45				
c= 0.52E+17	10000.	4.81	1.24				
	20000.	4.59	0.993				
	30000.	4.40	0.808				
	80000.	3.82	0.426				
3D - 5P	2500.	7.85	-4.29				
17038.7A	5000.	8.74	-4.29	2.14*	-1.14*		
c= 0.14E+20	10000.	9.86	-3.25	2.31*	-1.42*		
	20000.	11.5	-2.58	2.48*	-1.69*	2.20*	-1.34*
	30000.	12.3	-2.26	2.59*	-1.85*	2.28*	-1.47*
	80000.	13.6	-1.04	2.90	-2.26	2.51*	-1.81*
3D - 6P	2500.	11.4	-5.81				
12309.2A	5000.	12.5	-5.67				
c= 0.39E+19	10000.	14.2	-4.25				
	20000.	16.3	-3.01				
	30000.	17.1	-2.25				
	80000.	18.4	-0.564	4.39*	-3.46*		
4S - 4P	2500.	3.56	-1.81	1.03*	-0.421*	0.974*	-0.325*
22070.0A	5000.	3.86	-1.84	1.07	-0.508	1.02*	-0.400*
c= 0.53E+20	10000.	4.40	-1.62	1.12	-0.595	1.05*	-0.474*
	20000.	5.29	-1.23	1.16	-0.686	1.09	-0.550
	30000.	5.89	-1.05	1.20	-0.742	1.11	-0.596
	80000.	7.23	-0.658	1.30	-0.888	1.18	-0.716
4S - 5P	2500.	2.98	-1.55				
10747.0A	5000.	3.25	-1.52				
c= 0.57E+19	10000.	3.72	-1.21	0.938*	-0.548*		
	20000.	4.38	-1.02	1.00*	-0.651*	0.901*	-0.516*
	30000.	4.70	-0.797	1.04*	-0.713*	0.931*	-0.568*
	80000.	5.31	-0.387	1.16	-0.868	1.01*	-0.697*
4S - 6P	2500.	5.55	-2.97				
8650.3A	5000.	6.04	-2.74				
c= 0.19E+19	10000.	6.87	-2.00				
	20000.	7.92	-1.49				
	30000.	8.34	-1.15				
	80000.	9.02	-0.292	2.17*	-1.70*		

NE= 0.1E+18

TRANSITION	T(K)	ELECTRONS 2WE(A)	DE(A)	PROTONS 2WI(A)	DI(A)	IONIZED HELIUM 2WI(A)	DI(A)
3S - 3P	2500.	0.191	0.126	0.121	0.308E-01	0.116*	0.238E-01*
5891.8A	5000.	0.211	0.150	0.126	0.373E-01	0.123*	0.294E-01*
c= 0.30E+20	10000.	0.249	0.176	0.128	0.437E-01	0.125	0.348E-01
	20000.	0.322	0.180	0.130	0.504E-01	0.127	0.404E-01
	30000.	0.381	0.182	0.132	0.545E-01	0.128	0.438E-01
	80000.	0.551	0.129	0.136	0.653E-01	0.131	0.527E-01
3S - 4P	2500.	0.648	-0.206				
3302.6A	5000.	0.724	-0.124				
c= 0.12E+19	10000.	0.863	-0.359E-01	0.224*	-0.828E-01*		
	20000.	1.00	0.293E-01	0.233*	-0.100*		
	30000.	1.08	0.591E-01	0.238*	-0.111*	0.227*	-0.877E-01*
	80000.	1.26	0.641E-01	0.251*	-0.136*	0.236*	-0.109*
3S - 5P	2500.	1.98	-0.749				
2852.8A	5000.	2.19	-0.734				
c= 0.40E+18	10000.	2.53	-0.494				
	20000.	2.95	-0.378				
	30000.	3.12	-0.281				
	80000.	3.47	-0.108				

NE= 0.1E+18

TRANSITION	T(K)	ELECTRONS 2WE(A)	DE(A)	PROTONS 2WI(A)	DI(A)	IONIZED HELIUM 2WI(A)	DI(A)
3S - 6P	2500.	4.39*	-1.41*				
2680.4A	5000.	5.24*	-1.55*				
c= 0.19E+18	10000.	6.21	-1.14				
	20000.	7.28	-0.921				
	30000.	7.68	-0.748				
	80000.	8.32	-0.326				
3P - 4S	2500.	3.67	2.37	0.831*	0.434*	0.689*	0.300*
11397.0A	5000.	4.20	2.83	0.930*	0.602*	0.784*	0.451*
c= 0.59E+20	10000.	4.66	3.45	1.03*	0.757*	0.865*	0.587*
	20000.	5.15	3.28	1.14	0.907	0.952*	0.716*
	30000.	5.52	3.26	1.21	0.995	1.01*	0.791*
	80000.	7.02	2.27	1.40	1.22	1.16	0.977
3P - 5S	2500.	4.04	2.33				
6158.6A	5000.	4.68	3.09				
c= 0.70E+19	10000.	5.08	3.55				
	20000.	5.63	3.50	1.22*	0.929*		
	30000.	5.89	3.32	1.30*	1.05*		
	80000.	7.32	2.54	1.53*	1.34*	1.24*	1.06*
3P - 6S	2500.	7.76*	3.84*				
5151.9A	5000.	8.90	5.15				
c= 0.25E+19	10000.	9.74	5.87				
	20000.	11.0	5.92				
	30000.	11.9	5.12				
	80000.	14.6	3.71				
3P - 3D	2500.	3.12	1.97	0.749*	0.308*		
8191.1A	5000.	3.55	2.26	0.859*	0.475*		
c= 0.74E+19	10000.	3.85	2.34	0.948*	0.625*	0.812*	0.477*
	20000.	4.13	2.20	1.04*	0.767*	0.887*	0.600*
	30000.	4.28	1.97	1.10*	0.848*	0.934*	0.670*
	80000.	4.74	1.36	1.26	1.05	1.06*	0.841*
3P - 4D	2500.	12.8	4.00				
5686.4A	5000.	15.3	4.81				
c= 0.13E+18	10000.	16.3	4.63				
	20000.	16.3	4.08				
	30000.	16.0	3.50				
	80000.	14.8	2.32				

NE= 0.1E+19

TRANSITION	T(K)	ELECTRONS 2WE(A)	DE(A)	PROTONS 2WI(A)	DI(A)	IONIZED HELIUM 2WI(A)	DI(A)
3S - 3P	2500.	1.90	1.12	0.796*	0.170*		
5891.8A	5000.	2.11	1.41	1.09*	0.275*		
c= 0.30E+20	10000.	2.49	1.70	1.22*	0.368*		
	20000.	3.22	1.78	1.28*	0.455*	1.23*	0.355*
	30000.	3.81	1.82	1.31*	0.505*	1.26*	0.398*
	80000.	5.51	1.29	1.36	0.628	1.30*	0.502*
3S - 4P	2500.	5.62	-1.15				
3302.6A	5000.	6.89	-0.586				
c= 0.12E+19	10000.	8.45	0.146				
	20000.	9.91	0.593				
	30000.	10.7	0.739				
	80000.	12.5	0.659				

ACKNOWLEDGEMENTS

This work, supported by C. N. R. S., is a part of French–Yugoslav collaboration through the project „L'élargissement Stark des raies spectrales des plasmas astrophysiques et de la laboratoire". Also this is a part of the project „Atomic, molecular and plasma spectroscopy" supported by SKNTI and RZN of Serbia.

REFERENCES

Bashkin, S. and Stoner, Jr. J. O.: 1975, *Atomic Energy Levels and Grotrian Diagrams*, Vol. 1, North Holand, Amsterdam.

Caccin, B., Gomez, M. T., and Roberti, G.: 1980, *Astron. Astrophys.* **92**, 63.

Dimitrijević, M. S. and Sahal–Bréchot, S.: 1985, *JQSRT* **34**, 149.

Dimitrijević, M. S. and Sahal–Bréchot, S.: 1990, *JQSRT*, in press.

Griem, H.R.: 1974, *Spectral Line Broadening by Plasmas*, Academic Press, New York.

Sahal–Bréchot, S.: 1969a, *Astron. Astrophys.* **1**, 91.

Sahal–Bréchot, S.: 1969b, *Astron. Astrophys.* **2**, 322.

Stromberg, H. P.: 1980, *J. Appl. Phys.* **51**, 1963.

Vince, I., Dimitrijević, M. S. and Kršljanin, V,: 1985, in *Spectral Line Shapes III*, ed. F. Rostas, W. de Gruyter, Berlin, p. 649.

Whannby, D. O.: 1980, *Proc. IEEE*, **127**, 165.

ТАБЛИЦЕ ЗА ПАРАМЕТРЕ ШТАРКОВОГ ШИРЕЊА ЛИНИЈА NaI

Милан С. Димитријевић[1] и **Sylvie Sahal – Bréchot**[2]

[1] *Астрономска опсерваторија, Волгина 7, 11050 Београд, Југославија*
[2] *Departement „Atomes et molecules en astrophysique", Unité associée au C. N. R. S. No 812, Observatoire de Paris, 92195 Meudon, France*

УДК 52–355,3
Претходно саопштење

У оквиру семикласичне теорије израчунате су ширине и помаци услед судара са електронима, протонима и јонизованим хелијумом за спектралне линије у оквиру 61 мултиплета неутралног натријума. Резултати су дати у функцији електронске температуре и густине.

Bull. Obs. Astron. Belgrade N° 142 (1990), 79–81

UDC 528,541
Preliminary report

BEHAVIOUR OF LEVELS IN THE CONDITIONS OF ASYMMETRICAL HEATING

S. Sadžakov

Astronomical Observatory, Volgina 7, 11050 Beograd, Yugoslavia

(Received: August 1, 1989)

SUMMARY: The subject of the paper is the earlier and present importance of second level examinations. The data of a general analysis are presented. They indicate not only some problems of second levels, but also give informations on level triers whose properties are weakly known at present.

For levels it is very important that the temperature difference at some parts of the tube is not large. According to Drodofski (Drodofski, 1956) in the case of a tube 150 mm long a temperature difference greater than 0.009 C already causes a measurable effect in the position of the bubble. It is difficult to satisfy this requirement. Sardy (Sardy, 1965) measured temperature differences, equal to 0.25 C on the average, on the outer sides of levels in the field conditions and for the levels examined by him a change of 2" in the geographic latitude determined by use of Talcot's method due to a temperature difference of 1 C at the level ends was found. Drodofski's datum concerns the hydrostatic influences only, whereas Sardy's effect corresponds to a sum of influences both of hydrostatic and mechanical character. The thermomechanical influence is a function of properties of the level–tube housing. The housing can produce a change in the tube's curvature already at a uniform temperature distribution. In the case of a nonuniform temperature distribution its influence is significantly larger and more complicated (Tarczy–Hornoch, A., 1964).

The hydrostatic effects may have a more general character, whereas the mechanical influences are practically different for different levels. This means that one should carefully examine the level behaviour within an inhomogeneous temperature field. This behaviour is usually not taken into account because it is thought that the tube is well isolated from outer influences, but unfortunately this statement is not true.

a) At the geodetico-geophysical Institute in Sopron, in 1964, two levels (in further text level A and level B) were examined with a photo-automatical trier. One level was put on a trier (Tarczy–Hornoch, 1959) and then its ends were heated by lamps. Between the lamps and the levels was a glass wall 10 mm thick. A lamp was at the distance of 1 m from the level's body (position I), i. e. shifted by 40° with respect to position I (position II). The heating was carried out with an infralamp (power 250 W), or with a normal lamp (power 300 W). The beam was directed to the part of the level's end containing the correction screws (←→), i. e. to the opposite end (← →). The level was read every minute. The cooling interval between two successive groups of measurements was 4 minutes. When the position of the bubble's middle was determined (expressed in parts of the level constant), a significant difference in heating, between the two kinds of lamps, as well as a prominent influence caused by the heating of the level's ends containing the correction screws, were established. Practically, there was no difference in the effects for positions I and II. After the heating was finished the bubble would come back to its rest position along a logarithmic spiral trajectory. Since the major part of the normal lamp effects was absorbed by the glass, the shifting of the bubble was in this case about three times smaller.

On the basis of these examinations one can conclude that it is desirable to put a level within a protective shell in such a way that the correction screws should be covered and a glass slab situated in front of the level in order to protect it from the direct influence of observer who radiates like a normal lamp whose power is 100 W (Teleki, 1965).

b) Level A was heated along its length with electric heaters. The heaters (each one having 0.5 kW power) were at the distance of 170 cm from level B. A 0.5 kw heater changed the position of the bubble's middle by a very small amount (0.2 level constants) and the bubble came back to its rest position within 5 minutes. A heater of 1 kW shifted the bubble by 1 level constant and to come back to the rest position the bubble needed 25 minutes.

Level A was permanently under heating and the change in the bubble's position was observed from the moment of turning the heating source off. The time interval necessary to the middle of the bubble to come back to its original position was one hour. Later on, during the cooling process, the level ends were two times, the first time for 5 minutes, the second time for 10 minutes, heated with infralamps. This caused an uncertainty in the bubble's position and a long time interval was necessary for the bubble to come back in the state of equilibrium.

The levels A and B were heated under the conditions mentioned above with electric heaters of 1 kW power. After the bubble had reached its rest position, the positions of the levels were changed by 180°. The position of the bubble of level A had a change of 1.8 level constants after rotation and to reach the state of rest it needed 24 minutes. In the case of level B the rest state of its bubble was already reached after 16 minutes and the change in the bubble's middle position was 1.8 level constants.

The results of these measurements also indicate the different character of the levels on the one side and the necessity of level protection on the other side; in the case of existence of temperature gradients the position of the bubble had significant and long–lasting changes. This fact is especially important for those observations where instruments are rotated and there is no time enough to wait for the bubble to reach its rest state again.

c) The determinations of the constants for level A and level B in the presence of a temperature gradient were performed on a classical level trier of the type „Bamberg" No 5023 which belongs to the Geodetical Institute of Faculty of Civil Engineering of Belgrade University. The levels were heated along their lengths from the distance of 170 cm with an electric heater whose power was 1 kW. The trier was covered so that it suffered no direct radiation. The bubble length for both levels was 25 level constants and the mean external temperature was + 18 C. Wanach's method was used. The examinations began only after the bubble had reached its state of rest.

The levels were examined by two observers in two positions (of the levels). In the first position (I) the screws were opposite the heater and in the second one (II) they were closer to the heater.

Table 1

level	I			II		
	N	M	F	N	M	F
A	1.12136	0.050	0.056	1.12123	0.060	0.067
	1.12276	0.065	0.073	1.11410	0.060	0.068
B	0.80636	0.057	0.046	0.81505	0.096	0.079
	0.80949	0.116	0.096	0.81160	0.109	0.087

It is seen from Table 1 that there is a systematic difference in the level constant value depending on the rectification screw position. For level A from the mean values of the data concerning both observers one obtains a difference of $0\overset{''}{.}00438$; for level B the difference is $-0\overset{''}{.}01040$.

All our examinations concerning the asymmetrical level heating point out that the problem is serious. Since it is very difficult, or perhaps impossible, to satisfy completely Drodofski's condition concerning the temperature difference at the tube's ends (Drodofski, 1956), a better level isolation becomes necessary. If we carry out the isolation, and especially if we do not, it is necessary for any level to know also the characteristics in the case that the level is within a variable temperature field. The results of these examinations indicate that the level constant at almost the same mean temepirature has different values. According to Drodofski as level characteristics in addition to the constant one should also assume the durations of oscillations and damping and the highest possible accuracy of measurements with a given level. These data in Drodafski's opinion sufficiently characterise a level in the course of its using.

It is true that our instruments, including the levels as well, are seldom within a homogeneous temperature field. Knowing this and also that mentioned above one concludes that Drodofski's characteristics give no real picture of a level. Drodofski's opinion should be, certainly, taken into account, however the data proposed by him neither characterise a level sufficiently, nor give a real picture of it and therefore as a level characteristic one should assume the datum concerning its behaviour within an inhomogeneous temperature field. In astrometrical and astrogeodetical praxis these data are necessary, whereas the data concerning the durations of oscillations and damping are of no practical importance because there is time enough for the bubble to reach its rest state.

On the basis of the results obtained from the examinations of levels A and B and of other ones (Sadzakov, 1989) one can point out the following.

i) Any level is a problem for itself requiring thus a special examination.

ii) Levels are not sufficiently isolated from temperature influences. The correction screws are the main source of trouble. For this reason it is necessary to put a level within a protective shell and to separate it from the observer with a glass slab.

iii) For every level one should specify the datum describing its behaviour within an inhomogeneous temperature field. This characteristic is necessary to any astrometric and astrogeodetic measurement.

iv) Levels should be thoroughly examined at all temperatures at which they are used. A special attention should be paid to the level behaviour at low temperatures.

v) One should verify the constant of the disc belonging to the trier serving for the purpose of level examining. The trier should be well isolated from external effects.

All the examinations and analyses indicate that the levels are very large sources of errors of different kinds. For this reason levels should be examined in detail, comprehensively and with a special care, so that a prior knowledge of them is required.

ПОНАШАЊЕ ЛИБЕЛА ПРИ АСИМЕТРИЧНОМ ГРЕЈАЊУ

С. Саџаков

Астрономска опсерваторија, Београд, Волгина 7, Југославија

УДК 528.541
Претходно саопштење

Говори се о значају испитивања секундних либела пре и сада. Дати су подаци анализе општег карактера, који указују не само на неке проблеме секундних либела, него дају информацију и о испитивању либела, чије су особине за сада мало познате.

Bull. Obs. Astron. Belgrade N^{o} 142 (1990), 83–97

UDC 521.936/.938
Preliminary report

VALUES OF BELGRADE LATITUDE OBTAINED IN THE PERIOD 1969.0–1975.0

R. Grujić, M. Djokić, V. Milovanović, L. Djurović

Astronomical Observatory, Volgina 7, 11050 Belgrade, Yugoslavia

(Received: March 5, 1990)

SUMMARY: The values of Belgrade latitude obtained in the period 1969.0–1975.0 are presented here.

The latitude values presented here (Table 1) are subject of the analysis of the variations in the latitude of Belgrade given in the paper by Grujić, Djokić and Jovanović (1989). The observations comprehend a period within which the conditions of deriving the latitude values were the most favourable with regard to the programme characteristics and the number of observations. For this reason the mentioned period has been chosen for the purpose of examining the fine change of the Belgrade latitude and the other nonpolar changes (Z term). The six–year period has been taken in order to obtain the value of the Belgrade mean latitude and its change by applying Orlov's formula which eliminates the Chandlerian annual and semi-annual periods. The latitudes are reduced to the FK4 system. No explanations of the designations appearing in the title are given because they are usual.

REFERENCES

Grujić, R., Djokić, M., Jovanović, B.,: 1989, Bull. Astr. Obs., Beograd, **141**, in press.

ВРЕДНОСТИ ШИРИНА БЕОГРАДА ДОБИЈЕНИХ ИЗ ПОСМАТРАЧКОГ ПЕРИОДА 1969.0–1975.0

Р. Грујић, М. Ђокић, В. Миловановић, Л. Ђуровић

Астрономска опсерваторија, Волгина 7, 11050 Београд

УДК 521.936/938
Претходно саопштење

Дате су вредности ширина коришћене код анализе промена ширине Београда у раду Грујић, Ђокић и Јовановић /1989/.

Prilog I

Date		Julian days	Observer	Group	Subgroup φ_a	φ_b
1969		2440000+				
I	7	229.250	MD	I	–	10.194
	7	229.395	MD	II	10.176	10.316
	10	232.220	MD	I	10.008	10.290
	10	232.385	MD	II	10.411	10.493
	14	236.350	RG	II	10.411	–
	21	243.355	RG	II	10.250	10.390
	22	244.355	MD	II	10.241	10.279
	27	249.360	MD	II	–	10.177
	27	249.480	MD	III	10.283	–
	31	253.325	MD	II	10.018	10.214
II	8	261.305	RG	II	10.155	10.234
	14	267.285	MD	II	10.310	10.324
	15	268.310	RG	II	–	10.313
	18	271.300	RG	II	–	10.191
	18	271.420	RG	III	10.312	–
III	9	290.250	RG	II	–	10.370
	9	290.395	RG	III	10.368	10.160
	9	290.565	RG	IV	10.290	10.302
	22	303.355	RG	III	10.470	10.151
IV	5	317.325	RG	III	10.474	10.242
	5	317.490	RG	IV	10.315	10.259
	7	319.340	MD	III	–	10.308
	8	320.315	RG	III	10.518	10.274
	9	321.310	MD	III	10.590	10.238
	10	322.315	RG	III	10.558	10.293
	10	322.450	RG	IV	10.182	–
	11	323.315	MD	III	10.674	10.570
	11	323.450	MD	IV	10.272	–
	12	324.305	RG	III	10.482	10.303
	12	324.450	RG	IV	10.236	–
	25	337.435	MD	IV	10.268	10.311
	26	338.435	RG	IV	10.305	10.262
	27	339.400	RG	IV	10.274	–
	28	340.425	MD	IV	10.345	10.295
	29	341.590	RG	V	10.304	10.247
V	3	345.390	RG	IV	10.321	–
	12	354.385	MD	IV	10.355	10.419
	14	356.385	MD	IV	10.317	10.409
	15	357.385	RG	IV	10.309	10.543
	15	357.545	VM	V	10.588	10.519
	16	358.375	MD	IV	10.443	10.216
	16	358.545	VM	V	10.436	10.467
	22	364.360	RG	IV	10.316	10.411
	22	364.525	RG	V	10.283	10.398
	23	365.380	MD	IV	–	10.55[illegible]
	24	366.355	RG	IV	10.401	10.341
	24	366.520	VM	V	10.519	10.474
	29	371.480	RG	V	10.479	–
VI	5	378.350	RG	IV	–	10.369
	10	383.475	RG	V	10.380	10.318
	12	385.330	RG	IV	–	10.462
	12	385.470	RG	V	10.4[illegible]0	10.447
	16	389.460	MD	V	10.496	10.33[illegible]
	18	391.455	MD	V	10.481	10.301
	23	396.440	RG	V	10.355	10.377
	28	401.425	RG	V	10.375	10.471

VII	2	405.515	VM	V	10.551	10.461
	2	405.560	VM	VI	10.421	–
	3	406.415	RG	V	10.357	10.359
	3	406.550	RG	VI	10.491	–
	4	407.410	VM	V	10.538	10.448
	4	407.550	VM	VI	10.560	–
	5	408.405	RG	V	10.509	10.487
	7	410.400	VM	V	10.458	10.474
	7	410.550	VM	VI	10.361	–
	15	418.380	RG	V	10.515	10.488
	15	418.545	RG	VI	10.535	10.595
	16	419.380	VM	V	10.558	10.494
	16	419.545	VM	VI	10.499	10.491
	17	420.375	RG	V	10.458	10.518
	17	420.535	RG	VI	10.347	10.378
	20	423.390	RG	V	–	10.529
	22	425.340	RG	V	10.534	–
	23	426.340	VM	V	10.551	–
	23	426.525	VM	VI	10.571	10.320
	24	427.355	RG	V	10.497	10.619
	24	427.520	RG	VI	10.461	10.459
	25	428.380	VM	V	–	10.474
	25	428.515	VM	VI	10.542	10.520
VIII	1	435.360	MD	V	–	10.581
	2	436.330	VM	V	10.464	10.544
	2	436.470	VM	VI	10.599	–
	3	437.350	MD	V	–	10.658
	3	437.470	MD	VI	10.503	–
	5	439.325	MD	V	10.423	10.359
	7	441.340	MD	V	–	10.419
	11	445.305	MD	V	10.469	10.387
	11	445.450	MD	VI	10.521	–
	13	447.340	MD	V	–	10.637
	20	454.445	MD	VI	10.494	10.529
	29	463.450	MD	VI	–	10.526
	30	464.400	VM	VI	10.541	–
IX	1	466.415	MD	VI	10.625	10.484
	1	466.550	MD	I	10.666	–
	2	467.390	VM	VI	10.513	–
	2	467.520	VM	I	–	10.542
	8	473.395	MD	VI	10.414	10.532
	9	474.395	VM	VI	10.479	10.439
	9	474.555	VM	I	10.580	10.455
	10	475.360	RG	VI	10.663	–
	16	481.350	VM	VI	10.589	–
	21	486.355	VM	VI	10.562	10.626
	21	486.525	VM	I	10.518	10.589
	23	488.355	VM	VI	10.490	10.576
	23	488.515	VM	I	10.589	10.564
	24	489.355	RG	VI	10.650	10.696
	24	489.515	RG	I	10.431	10.429
	25	490.355	MD	VI	10.438	10.489
	25	490.515	MD	I	10.429	10.605
	27	492.345	RG	VI	10.596	10.599
	27	492.505	RG	I	10.551	10.539
	29	494.335	MD	VI	10.575	10.502
	29	494.530	MD	I	–	10.681
X	1	496.310	RG	VI	10.642	–
	3	498.300	VM	VI	10.579	–
	4	499.325	RG	VI	10.462	10.614
	4	499.485	RG	I	10.595	10.430
	4	499.630	RG	II	10.464	–

X	6	501.315	MD	VI	10.424	10.411
	6	501.490	MD	I	10.437	-
	6	501.620	MD	II	10.428	-
	9	504.475	MD	I	10.415	10.446
	11	506.465	RG	I	10.713	10.465
	11	506.635	RG	II	10.425	10.451
	13	508.440	MD	I	-	10.418
	13	508.490	MD	II	10.614	-
	16	511.455	MD	I	10.499	10.607
	16	511.620	MD	II	10.587	10.544
	17	512.455	VM	I	10.560	10.588
	17	512.515	VM	II	10.480	10.555
	20	515.445	MD	I	10.265	10.387
	21	516.445	VM	I	10.513	10.503
	21	516.605	VM	II	10.529	10.438
	22	517.410	RG	I	10.548	-
	23	518.435	MD	I	10.575	10.464
	28	523.425	VM	I	10.387	10.315
	28	523.585	VM	II	10.551	10.445
	29	524.390	RG	I	10.500	-
XI	1	527.415	RG	I	10.444	10.402
	2	528.410	VM	I	10.435	10.512
	2	528.600	VM	II	-	10.392
	3	529.405	MD	I	10.462	10.505
	4	530.405	RG	I	10.451	10.375
	4	530.565	RG	II	10.441	10.397
	7	533.395	VM	I	10.430	10.347
	11	537.410	VM	I	-	10.459
	11	537.545	VM	II	10.591	10.479
	16	542.560	MD	II	-	10.404
	17	543.340	VM	I	10.369	-
	19	545.365	RG	I	10.342	10.422
	20	546.365	VM	I	10.386	10.393
	28	554.335	VM	I	10.303	10.321
	28	554.505	VM	II	10.199	10.440
1970						
I	3	590.270	RG	I	10.217	-
	8	595.285	RG	I	10.122	10.166
	8	595.445	MD	II	10.166	10.097
	8	595.615	MD	III	10.269	10.325
	21	608.440	RG	II	-	10.095
	21	608.560	RG	III	10.316	-
	24	611.405	VM	II	10.212	10.244
	29	616.395	MD	II	10.144	10.348
	30	617.385	VM	II	10.426	10.271
II	2	620.520	MD	III	10.306	-
	12	630.380	MD	II	-	10.260
	17	635.335	VM	II	10.036	10.258
	17	635.480	VM	III	10.163	-
III	2	648.330	MD	II	-	10.321
	6	652.440	VM	III	10.248	-
	7	653.625	RG	IV	10.175	10.127
	8	654.310	VM	II	-	10.218
	8	654.455	VM	III	10.226	10.177
	9	655.310	MD	II	-	10.281
	18	664.400	RG	III	10.325	-
	20	666.425	VM	III	10.098	10.235
	20	666.590	VM	IV	10.229	10.091
	21	667.450	RG	III	-	10.301
	24	670.415	VM	III	[illegible]	[illegible]
	24	670.575	VM	IV	10.205	10.302
	29	675.370	MD	III	10.247	-

	29	675.565	MD	IV	10.347	10.255
	30	676.420	RG	III	–	10.244
	30	676.555	RG	IV	10.089	10.219
IV	4	681.385	RG	III	10.181	10.137
	4	681.545	RG	IV	10.202	10.050
	5	682.375	VM	III	10.256	10.114
	6	683.545	MD	IV	10.287	10.235
	9	686.535	RG	IV	10.078	10.213
	10	687.535	MD	IV	10.168	10.262
	12	689.525	RG	IV	10.150	10.037
	15	692.380	RG	III	–	10.167
	15	692.515	RG	IV	10.084	10.177
	17	694.345	MD	III	10.178	10.254
	19	696.335	VM	III	10.156	10.133
	19	696.505	VM	IV	10.300	10.281
	20	697.360	MD	III	–	10.237
	22	699.500	RG	IV	10.171	10.174
	23	700.495	MD	IV	10.091	10.126
	29	706.475	RG	IV	10.265	10.236
V	6	713.465	RG	IV	10.164	10.185
	8	715.430	VM	IV	10.239	–
	10	717.455	MD	IV	10.146	10.217
	14	721 .445	MD	IV	10.141	10.299
	15	722.420	RG	IV	9.905	–
	16	723.470	RG	IV	–	10.280
	25	732.430	MD	IV	–	10.268
	25	732.575	MD	V	10.424	10.247
	26	733.405	VM	IV	10.202	10.274
	26	733.550	VM	V	10.308	–
	29	736.395	VM	IV	10.302	10.256
	29	736.565	VM	V	10.244	10.254
VI	5	743.400	MD	IV	–	10.436
	6	744.400	RG	IV	–	10.270
	6	744.545	RG	V	10.297	10.261
	15	753.520	MD	V	10.391	10.305
	17	755.490	RG	V	10.463	–
	20	758.480	RG	V	10.378	–
	21	759.505	MD	V	10.385	10.433
	25	763.520	MD	V	–	10.327
	27	765.485	RG	V	10.361	10.323
	27	765.630	RG	VI	10.402	–
	28	766.485	VM	V	10.309	10.453
VII	1	769.450	RG	V	10.398	–
	8	776.455	RG	V	10.361	10.405
	8	776.625	RG	VI	10.360	10.378
	9	777.455	MD	V	10.463	10.552
	9	777.650	MD	VI	–	10.365
	10	778.445	VM	V	10.453	10.329
	10	778.615	VM	VI	10.405	10.409
	11	779.435	RG	V	10.484	10.536
	11	779.615	RG	VI	10.416	10.378
	12	780.435	MD	V	10.453	10.364
	12	780.605	MD	VI	10.481	10.304
	15	783.450	RG	V	–	10.375
	19	787.415	VM	V	10.462	10.419
	19	787.585	VM	VI	10.474	10.465
	20	788.585	MD	VI	10.414	10.533
	21	789.415	VM	V	10.390	10.474
	21	789.565	VM	VI	10.515	10.418
	22	790.415	RG	V	10.429	10.474
	22	790.585	RG	VI	10.464	[illegible]

	23	791.415	MD	V	10.537	10.561
	23	791.585	MD	VI	10.544	[illegible]
	24	792.415	VM	V	10.555	10.497
	24	792.575	VM	VI	10.577	10.594
	26	794.405	MD	V	10.441	10.440
	26	794.575	MD	VI	10.402	10.461
	27	795.405	VM	V	10.470	10.463
	27	795.575	VM	VI	10.586	10.443
	29	797.395	MD	V	10.559	10.518
	29	797.565	MD	VI	10.575	10.551
VIII	3	802.400	MD	V	-	10.504
	4	803.400	VM	V	-	10.488
	6	805.365	MD	V	10.551	10.491
	7	806.365	VM	V	10.528	10.531
	18	817.505	RG	VI	10.564	10.627
	20	819.530	RG	VI	-	10.654
	26	825.510	MD	VI	-	10.625
	27	826.485	RG	VI	10.511	10.540
	27	826.645	RG	I	10.517	10.610
IX	2	832.465	MD	VI	10.626	10.647
	2	832.600	MD	I	10.796	-
	3	833.465	RG	VI	10.558	10.567
	7	837.370	VM	VI	10.578	-
	8	838.395	RG	VI	10.581	10.541
	9	839.395	VM	VI	10.507	10.524
	9	839.555	VM	I	10.622	10.562
	11	841.385	VM	VI	10.675	10.554
	11	841.530	VM	I	10.511	-
	15	845.400	LD	VI	-	10.595
	21	851.340	RG	VI	10.525	-
	23	853.355	VM	VI	10.508	10.599
	23	853.515	VM	I	10.701	10.604
	29	859.335	LD	VI	10.637	10.733
	29	859.480	LD	I	10.729	-
	30	860.335	LD	VI	10.579	10.694
	30	860.480	LD	I	10.695	-
X	6	866.320	VM	VI	10.632	10.566
	6	866.485	VM	I	10.542	10.598
	8	868.315	VM	VI	10.627	10.497
	8	868.480	VM	I	10.549	10.746
	9	869.315	MD	VI	10.598	10.686
	9	869.480	MD	I	10.673	10.432
	11	871.475	MD	I	10.641	10.830
	12	872.315	RG	VI	10.655	10.588
	13	873.315	VM	VI	10.590	10.617
	13	873.465	VM	I	10.695	10.659
	19	879.260	MD	VI	10.685	-
	26	886.290	MD	VI	-	10.511
	26	886.425	MD	I	10.618	10.583
	28	888.415	RG	I	10.673	10.593
	28	888.575	RG	II	10.529	10.513
	30	890.255	LD	VI	10.538	10.577
	30	890.415	VM	I	10.653	10.588
	30	890.575	VM	II	10.611	10.532
	31	891.220	RG	VI	10.516	-
XI	1	892.405	RG	I	10.592	10.580
	1	892.590	RG	II	-	10.512
	3	894.405	VM	I	10.550	10.459
	3	894.565	VM	II	10.577	10.584
	4	895.395	RG	I	10.527	10.509
	4	895.565	RG	II	10.491	10.503
	5	896.235	LD	VI	10.580	10.520

[illegible]	7	898.[illegible]	RG	[illegible]	10.500	10.4[illegible]
	7	898.395	[illegible]	I	10.605	10.505
	11	902.375	RG	I	10.581	10.403
	12	903.365	MD	I	10.551	10.732
	12	903.525	MD	II	10.524	10.509
	13	904.365	VM	I	10.510	10.652
	19	910.355	MD	I	10.482	10.578
	25	916.345	VM	I	10.538	10.414
	25	916.515	RG	II	10.614	10.415
	29	920.335	VM	I	10.447	10.547
	29	920.480	VM	II	10.485	-
1971						
I	19	971.340	RG	II	10.166	-
	20	972.355	VM	II	10.314	10.332
	23	975.355	RG	II	10.282	10.403
	23	975.515	RG	III	10.316	10.237
	30	982.505	RG	III	10.446	10.350
II	10	993.510	RG	III	-	10.177
	11	994.295	MD	II	10.375	10.221
	11	994.485	MD	III	10.483	10.249
	12	995.285	VM	II	10.144	10.299
	12	995.475	VM	III	10.269	10.140
	13	996.285	RG	II	10.214	10.187
	13	996.470	RG	III	10.345	10.172
	16	999.260	LD	II	10.341	-
		2441000+				
III	10	021.560	RG	IV	10.016	10.186
	12	023.530	LD	IV	10.275	-
	13	024.385	RG	III	10.423	10.049
	13	024.555	RG	IV	10.093	10.211
	15	026.400	MD	III	-	10.218
	18	029.365	MD	III	10.225	10.126
	18	029.535	MD	IV	10.137	10.184
	20	031.365	RG	III	10.132	10.012
	20	031.535	RG	IV	9.970	10.172
	22	033.365	MD	III	10.236	10.108
	24	035.525	LD	IV	10.346	10.176
	25	036.380	MD	III	-	10.306
	25	036.520	MD	IV	10.229	10.388
	26	037.350	LD	III	10.321	10.194
	26	037.515	LD	IV	10.104	10.197
	31	042.32[illegible]	RG	III	10.113	10.027
IV	2	044.480	LD	IV	10.350	-
	7	049.340	RG	III	-	10.082
	8	050.315	MD	III	10.282	10.229
	8	050.485	MD	IV	10.103	10.240
	9	051.315	LD	III	10.053	10.048
	9	051.485	LD	IV	9.972	10.268
	14	056.320	MD	III	-	10.089
	14	056.465	MD	IV	10.272	10.357
	15	057.465	VM	IV	10.129	10.059
	16	058.465	LD	IV	10.118	10.191
	18	060.455	MD	IV	10.180	10.172
	20	062.310	LD	III	-	10.159
	20	062.445	LD	IV	10.044	10.180
	21	063.445	MD	IV	10.099	10.304
	21	063.590	MD	V	10.246	-
V	7	079.430	LD	IV	-	10.213
	9	081.395	MD	IV	10.161	10.189
	10	082.370	VM	IV	10.108	-
	11	083.385	LD	IV	10.0[illegible]	10.088
	11	083.570	LD	V	-	10.139

V	12	084.38	VM	IV	10.201	–
	12	084.54[illegible]	VM	V	10.15[illegible]	10.[illegible]
	13	085.3[illegible]	MD	IV	10.207	10.1[illegible]
	13	085.535	MD	V	10.184	10.1[illegible]
	14	086.375	LD	IV	10.310	10.[illegible]
	14	086.560	LD	V	–	10.187
	17	089.335	MD	V	10.225	10.22[illegible]
	18	090.535	LD	V	10.276	10.317
	25	097.330	LD	IV	10.082	–
VI	3	106.500	MD	V	10.334	10.335
	11	114.330	LD	IV	–	10.153
	11	114.475	LD	V	10.367	10.364
	14	117.465	MD	V	10.423	10.308
	15	118.440	LD	V	10.329	–
	24	127.420	MD	V	10.284	–
	28	131.425	MD	V	10.327	10.312
VII	8	141.400	MD	V	10.453	10.395
	9	142.395	LD	V	10.359	10.307
	10	143.395	MD	V	10.308	10.425
	12	145.395	MD	V	10.338	10.404
	12	145.555	MD	VI	10.390	10.470
	16	149.360	LD	V	10.262	–
	17	150.520	VM	VI	10.298	–
	22	155.500	LD	VI	10.293	–
	25	158.355	LD	V	10.325	10.277
	27	160.345	LD	V	10.488	10.391
	27	160.490	LD	VI	10.458	–
VIII	19	183.455	MD	VI	10.505	10.502
	20	184.285	VM	V	10.487	10.493
	20	184.470	VM	VI	–	10.427
	21	185.445	MD	VI	10.525	10.492
	26	190.290	MD	V	–	10.364
	26	190.435	MD	VI	10.550	10.489
	28	192.400	VM	VI	10.384	–
	29	193.280	MD	V	–	10.557
	30	194.280	VM	V	–	10.497
	30	194.425	VM	VI	10.506	10.501
IX	3	198.405	LD	VI	10.550	10.623
	3	198.575	LD	I	10.585	10.621
	4	199.405	MD	VI	10.564	10.599
	4	199.575	MD	I	10.653	10.699
	9	204.420	MD	VI	–	10.559
	9	204.530	MD	I	10.753	–
	12	207.395	VM	VI	10.620	10.598
	21	216.360	LD	VI	10.737	10.589
	21	216.525	LD	I	10.552	10.787
	22	217.355	VM	VI	10.588	10.624
	22	217.525	VM	I	10.540	10.708
	23	218.355	MD	VI	10.755	10.712
	23	218.515	MD	I	10.626	10.614
	24	219.355	LD	VI	10.688	10.556
	24	219.515	LD	I	10.612	10.703
	26	221.515	MD	I	10.650	10.650
	27	222.320	VM	VI	10.629	–
	27	222.505	VM	I	10.547	10.692
X	2	227.335	MD	VI	10.735	10.695
	4	229.300	MD	VI	10.713	1 –
	5	230.300	LD	VI	10.628	–
	5	230.485	LD	I	10.632	10.753
	8	233.315	LD	VI	10.[illegible]	10.[illegible]
	8	233.475	LD	I	10.[illegible]	10.708
	10	235.305	MD	VI	10.54[illegible]	10.527
	10	235.475	MD	I	10.[illegible]	10.777

	11	236.305	VM	VI	10.661	10.726
	11	236.475	VM	I	10.768	10.763
	12	237.305	LD	VI	10.699	10.666
	12	237.465	LD	I	10.654	10.675
	13	238.305	MD	VI	10.531	10.610
	14	239.295	MD	VI	10.700	10.634
	14	239.465	MD	I	10.568	10.581
	19	244.285	LD	VI	10.547	10.567
	19	244.470	LD	I	–	10.756
	20	245.285	VM	VI	10.610	10.644
	20	245.445	VM	I	10.664	10.587
	22	247.275	LD	VI	10.661	10.505
	22	247.445	LD	I	10.729	10.778
	23	248.275	VM	VI	10.642	10.637
	23	248.435	VM	I	10.606	10.736
	24	249.275	MD	VI	10.605	10.484
	24	249.435	MD	I	10.615	10.654
	26	251.240	LD	VI	10.568	–
	28	253.425	MD	I	10.627	10.724
	29	254.425	LD	I	10.565	10.648
XI	5	261.405	LD	I	10.500	10.490
	5	261.565	LD	II	10.561	10.545
	6	262.400	VM	I	10.560	10.553
	6	262.565	VM	II	10.677	10.647
	8	264.395	MD	I	10.532	10.551
	8	264.580	MD	II	–	10.624
	11	267.385	MD	I	10.749	10.618
	11	267.520	MD	II	10.549	–
	15	271.680	MD	III	10.617	–
	27	283.345	VM	I	10.612	10.499
	27	283.505	VM	II	10.437	10.559
XII	7	293.340	LD	I	–	10.488
	7	293.500	LD	II	–	10.574
	10	296.305	LD	I	10.625	10.692
	15	301.295	VM	I	10.550	10.629
	15	301.455	VM	II	10.625	10.592
	22	308.275	VM	I	10.464	10.495
	22	308.440	VM	II	–	10.572
	23	309.275	MD	I	10.448	10.466
	23	309.410	MD	II	10.315	–
1972						
II	2	350.350	RG	II	–	10.476
	3	351.325	MD	II	10.512	10.526
	5	353.315	RG	II	10.267	10.442
	17	365.285	MD	II	10.444	10.449
	17	365.455	MD	III	10.358	10.502
	18	366.280	LD	II	10.438	10.382
	20	368.250	RG	II	10.316	–
	26	374.255	RG	II	10.272	10.290
	26	374.410	RG	III	10.358	–
III	1	378.270	RG	II	–	10.283
	1	378.425	RG	III	10.356	10.281
	4	381.415	RG	III	10.243	10.184
	13	390.385	LD	III	10.228	10.250
	13	390.555	MD	IV	10.269	10.541

	14	391.385	RG	III	[illegible]	10.345
	14	391.555	RG	IV	10.452	10.288
	15	392.375	MD	III	10.263	10.429
	15	392.545	MD	IV	10.397	10.376
	17	394.375	MD	III	10.299	10.325
	19	396.365	RG	III	10.246	10.348
	20	397.330	LD	III	10.372	–
	20	397.525	LD	IV	10.132	10.335
	21	398.550	MD	IV	–	10.385
	25	402.345	RG	III	10.215	10.210
	30	407.335	LD	III	10.211	10.155
	31	408.310	MD	III	10.321	–
IV	2	410.470	RG	IV	10.224	–
	3	411.325	LD	III	10.092	10.082
	4	412.510	MD	IV	–	10.247
	5	413.325	RG	III	10.291	10.114
	7	415.460	MD	IV	10.175	–
	8	416.290	RG	III	10.223	–
	8	416.480	RG	IV	10.208	10.236
	10	418.305	LD	III	10.263	10.037
	22	430.445	RG	IV	10.277	10.209
	29	437.400	RG	IV	10.139	–
V	6	444.405	RG	IV	10.199	10.148
	6	444.570	RG	V	10.129	10.187
	7	445.420	MD	IV	–	10.211
	8	446.395	LD	IV	10.099	10.164
	8	446.565	LD	V	10.122	10.129
	17	455.350	RG	IV	10.233	–
	22	460.365	LD	IV	10.243	10.258
	22	460.535	LD	V	10.225	10.296
	23	461.355	MD	IV	10.164	10.392
	23	461.525	MD	V	10.201	10.214
	24	462.355	RG	IV	10.306	10.229
	24	462.525	RG	V	10.112	10.097
	25	463.320	LD	IV	10.118	–
	26	464.320	MD	IV	10.102	–
	29	467.360	LD	IV	–	10.065
	29	467.530	LD	V	–	10.074
	30	468.325	MD	IV	10.244	10.218
	30	468.495	MD	V	10.262	10.267
	31	469.350	RG	IV	–	10.183
	31	469.495	RG	V	10.257	10.159
VI	5	474.485	LD	V	10.195	10.225
	6	475.315	MD	IV	10.124	10.156
	6	475.460	MD	V	10.241	–
	7	476.315	RG	IV	10.190	10.206
	7	476.485	RG	V	10.163	10.080
	8	477.340	LD	IV	–	10.153
	8	477.500	LD	V	–	10.124
	9	478.330	MD	IV	–	10.169
	9	478.475	MD	V	10.268	10.259
	15	484.480	LD	V	–	10.132
	17	486.455	RG	V	10.110	10.192
	21	490.450	RG	V	10.188	10.165
	25	494.435	RG	V	10.176	10.177
	26	495.435	LD	V	10.209	10.233
	28	497.450	RG	V	–	10.225
	28	497.570	RG	VI	10.305	–
	29	498.425	LD	V	10.158	10.050
VII	2	501.415	RG	V	10.311	10.267
	5	504.405	RG	V	[illegible]	10.193
	6	507.370	RG	V	[illegible]	–
	10	509.395	RG	V	[illegible]	10.329

	16	515.350	RG	V	10.392	–
	18	517.340	MD	V	–	10.280
	18	517.510	MD	VI	10.117	–
	19	518.340	RG	V	10.193	–
	20	519.510	MD	VI	10.130	–
	30	529.360	MD	V	–	10.165
VIII	9	539.315	MD	V	10.173	10.259
	9	539.450	MD	VI	10.276	–
	11	541.305	MD	V	10.196	10.179
	11	541.450	MD	VI	10.295	–
	14	544.490	MD	VI	–	10.245
	27	557.280	MD	V	–	10.292
	27	557.400	MD	VI	10.350	–
IX	1	562.415	MD	VI	10.338	10.290
	6	567.400	RG	VI	10.430	10.415
	7	568.395	LD	VI	10.508	10.537
	14	575.375	RG	VI	10.471	10.399
	14	575.520	RG	I	10.532	–
	18	579.340	RG	VI	10.442	–
	22	583.355	LD	VI	10.467	10.514
	22	583.550	LD	I	–	10.521
	25	586.355	RG	VI	10.530	10.391
	28	589.345	RG	VI	10.485	10.474
X	15	606.455	MD	I	10.354	10.357
	17	608.310	MD	VI	–	10.468
	24	615.460	MD	I	–	10.436
	25	616.260	RG	VI	10.453	10.455
	25	616.430	RG	I	10.500	10.510
	26	617.265	LD	VI	10.670	10.678
	26	617.425	LD	I	10.619	10.595
	27	618.260	MD	VI	10.390	10.499
	27	618.425	MD	I	10.592	10.363
	31	622.245	MD	VI	10.455	10.376
	31	622.415	MD	I	10.575	10.354
XI	1	623.245	RG	VI	10.521	10.656
	1	623.415	RG	I	10.534	10.467
	4	626.405	RG	I	10.632	10.511
	7	629.370	MD	I	10.521	–
	8	630.395	RG	I	10.695	10.651
	9	631.420	LD	I	–	10.707
	12	634.385	RG	I	10.610	10.527
	28	650.360	MD	I	–	10.476
	28	650.480	MD	II	10.483	–
XII	3	655.325	RG	I	10.568	10.606
	4	656.325	LD	I	10.520	10.482
	20	672.275	RG	I	10.464	10.526
	20	672.445	RG	II	10.514	10.633
	21	673.275	LD	I	10.522	10.493
	23	675.240	RG	I	10.461	–
	28	680.255	RG	I	10.562	10.514
	29	681.270	MD	I	–	10.511
1973						
I	13	696.240	RG	I	–	10.431
	14	697.375	MD	II	10.460	10.443
	20	703.330	RG	II	10.499	–
	25	708.370	LD	II	–	10.545
	26	709.345	MD	II	10.254	10.543
II	6	720.475	RG	III	10.469	10.431
	8	722.450	LD	III	10.198	–
	12	726.395	LD	II	10.488	10.560
	12	726.465	RG	III	10.329	10.338
	19	733.250	LD	II	10.421	–

	19	733.445	RG	III	10.467	10.292
III	17	759.375	RG	III	10.340	10.340
	17	759.540	RG	IV	10.270	10.382
	22	764.355	LD	III	10.394	10.266
	22	764.525	LD	IV	10.350	10.346
	23	765.355	MD	III	10.392	10.186
	23	765.525	MD	IV	10.229	10.264
	31	773.335	RG	III	10.231	10.295
	31	773.505	RG	IV	10.336	10.336
IV	2	775.325	LD	III	10.400	10.266
	2	775.490	LD	IV	10.309	10.318
	7	780.315	RG	III	10.312	10.365
	7	780.460	RG	IV	10.185	-
	17	790.430	MD	IV	10.250	-
	18	791.285	RG	III	10.298	10.254
	22	795.445	RG	IV	10.180	10.194
	27	800.435	MD	IV	10.202	10.314
V	13	816.410	RG	IV	-	10.192
	13	816.530	RG	V	10.195	-
	14	817.385	MD	IV	10.103	10.138
	15	818.400	RG	IV	-	10.257
	17	820.375	RG	IV	10.112	10.215
	21	824.365	MD	IV	10.084	10.162
	22	825.360	RG	IV	10.208	10.135
	24	827.330	RG	IV	10.130	-
	29	832.345	RG	IV	10.098	10.286
	29	832.505	RG	V	10.239	10.166
	30	833.360	MD	IV	[illegible]	10.165
VI	1	835.335	MD	IV	9.996	10.026
	1	835.500	MD	V	10.238	10.121
	12	846.470	RG	V	10.132	10.289
	13	847.320	MD	IV	-	10.193
	13	847.465	MD	V	10.092	10.176
	16	850.440	RG	V	10.155	-
	22	856.445	MD	V	10.234	10.074
VII	5	869.405	RG	V	10.092	10.176
	6	870.405	MD	V	10.020	10.156
	10	874.400	RG	V	10.183	10.204
	12	876.385	RG	V	10.210	10.105
	16	880.375	RG	V	10.200	10.184
	19	883.340	RG	V	10.238	-
	21	885.365	RG	V	10.106	10.185
	31	895.335	RG	V	10.271	10.335
VIII	1	896.480	RG	VI	10.257	-
	21	916.445	MD	VI	10.292	10.168
IX	2	928.415	RG	VI	10.334	10.254
	4	930.405	RG	VI	10.367	10.371
	7	933.370	MD	VI	10.172	-
	9	935.395	MD	VI	10.264	10.252
	11	937.380	RG	VI	10.463	10.437
	12	938.350	MD	VI	10.325	-
	15	941.340	RG	VI	10.380	-
	16	942.365	MD	VI	10.211	10.297
	20	946.365	RG	VI	10.347	10.367
	20	946.550	RG	I	-	10.331
	25	951.370	RG	VI	-	10.212
	29	955.335	RG	VI	10.306	10.278
	29	955.505	RG	I	10.385	10.207
X	5	961.325	MD	VI	10.266	10.285
	5	961.480	MD	I	10.317	10.282
	10	966.330	MD	VI	-	10.377
	11	967.305	RG	VI	10.249	10.249
	11	967.460	RG	I	10.231	10.449

	19	975.470	MD	I	–	10.286
	23	979.250	RG	VI	10.353	–
	26	982.265	MD	VI	10.438	10.445
	27	983.260	RG	VI	10.314	10.371
	27	983.425	RG	I	10.421	10.538
XI	1	988.415	RG	I	10.400	10.522
	10	997.385	RG	I	10.443	10.324
	18	005.365	RG	I	10.476	10.388
	19	006.365	MD	I	10.317	10.430
	19	006.550	MD	II	–	10.267
	20	007.355	RG	I	10.383	10.342
	23	010.330	MD	I	10.501	–
XII	6	023.290	RG	I	10.276	–
	10	027.305	MD	I	10.470	10.420
	10	027.470	RG	II	10.401	10.332
	16	033.260	RG	I	10.538	–
	20	037.250	RG	I	10.438	–
	20	037.445	MD	II	10.423	10.522
	23	040.435	RG	II	10.397	10.344
1974						
I	9	057.385	MD	II	10.315	10.379
	9	057.555	RG	III	10.303	10.356
	13	061.375	RG	II	10.351	10.363
	13	061.545	MD	III	10.455	10.222
	15	063.400	RG	II	–	10.351
	22	070.380	RG	II	–	10.469
	22	070.500	MD	III	10.492	–
	24	072.515	RG	III	10.385	10.199
	26	074.345	RG	II	10.283	10.401
	26	074.510	MD	III	10.325	10.375
	29	077.335	RG	II	10.392	10.327
	29	077.505	MD	III	10.284	10.138
II	5	084.315	MD	II	10.430	10.412
	5	084.485	RG	III	10.417	10.339
	10	089.300	RG	II	10.366	10.426
	10	089.465	MD	III	10.362	10.242
	12	091.320	MD	II	–	10.292
	12	091.440	RG	III	10.425	–
	16	095.285	RG	II	10.410	10.421
	16	095.455	MD	III	10.408	10.220
	27	106.255	MD	II	10.397	10.355
	27	106.425	RG	III	10.345	10.309
	28	107.255	RG	II	10.408	10.396
	28	107.400	MD	III	10.425	–
III	3	110.245	RG	II	10.429	10.368
	3	110.415	MD	III	10.346	10.219
	12	119.385	MD	III	10.284	10.147
	12	119.555	RG	IV	10.268	10.384
	14	121.385	RG	III	10.326	10.264
	14	121.530	MD	IV	10.397	–
	19	125.370	RG	III	10.360	10.312
	19	125.535	MD	IV	10.324	10.419
	21	127.365	RG	III	10.402	10.252
	21	127.525	MD	IV	10.206	10.297
	26	133.345	MD	III	10.373	10.322
	26	133.515	RG	IV	10.248	10.361
	28	135.370	MD	III	–	10.165
	28	135.515	RG	IV	10.289	10.410
IV	3	141.325	MD	III	10.270	10.176
	3	141.495	RG	IV	10.267	10.362
	6	144.290	RG	III	10.375	–

	9	147.315	RG	III	10.392	10.194
	9	147.460	RG	IV	10.[illegible]26	-
	10	148.280	MD	III	10.357	-
	20	158.4[illegible]0	RG	IV	10.309	-
	29	167.430	RG	IV	-	10.335
V	11	179.395	RG	IV	10.181	10.214
	11	179.555	RG	V	10.309	10.238
	19	187.365	RG	IV	10.290	10.357
	19	187.535	RG	V	10.235	10.306
	26	194.345	RG	IV	10.274	10.229
	26	194.515	MD	V	10.153	10.190
	30	198.340	RG	IV	10.224	10.259
	30	198.505	MD	V	10.239	10.268
VI	4	203.350	MD	IV	-	10.256
	4	203.495	RG	V	10.199	10.240
	5	204.325	MD	IV	10.225	10.250
	5	204.490	RG	V	10.126	10.221
	17	216.310	RG	IV	-	10.240
	17	216.430	MD	V	10.212	-
	20	219.310	RG	IV	-	10.121
	20	219.445	MD	V	10.127	10.104
	25	224.435	RG	V	10.275	10.196
	27	226.430	RG	V	10.237	10.225
VII	3	232.415	RG	V	10.142	10.220
	10	239.395	RG	V	10.265	10.263
	10	239.555	RG	VI	10.382	10.323
	13	242.385	RG	V	10.133	10.116
	13	242.555	RG	VI	10.231	10.174
	16	245.375	RG	V	10.208	10.212
	16	245.545	RG	VI	10.311	10.267
	24	253.355	RG	V	10.178	10.167
	24	253.525	RG	VI	10.279	10.248
	28	257.320	RG	V	10.225	-
	28	257.510	RG	VI	10.200	10.188
VIII	1	261.360	RG	V	-	10.342
	1	261.480	RG	VI	10.357	-
	7	267.315	MD	V	10.291	10.363
	7	267.485	MD	VI	10.324	10.270
	14	274.320	MD	V	-	10.345
	14	274.440	MD	VI	10.336	-
IX	8	299.395	MD	VI	10.177	10.308
	12	303.385	RG	VI	10.298	10.301
	13	304.385	MD	VI	10.313	10.324
	17	308.375	RG	VI	10.368	10.392
	17	308.535	MD	I	10.260	10.257
	28	319.340	RG	VI	10.184	10.304
	28	319.530	MD	I	-	10.260
X	10	331.330	RG	VI	-	10.258
	10	331.475	RG	I	10.286	10.280
	11	332.330	MD	VI	-	10.241
	17	338.455	RG	I	10.288	10.333
	27	348.265	MD	VI	10.273	10.367
	27	348.425	RG	I	10.354	10.274
XI	2	354.230	RG	VI	10.243	-
	11	363.220	RG	VI	10.391	10.368
	12	364.190	MD	VI	10.358	-
	12	365.385	RG	I	10.359	10.260
	14	366.215	RG	VI	10.276	10.310
	14	366.375	MD	I	10.296	10.259
	20	372.205	MD	VI	10.264	10.254
	20	372.365	RG	I	10.319	10.267
	30	382.360	MD	I	-	10.200

XII	21	403.275	RG	I	10.253	10.256
	21	403.440	RG	II	10.238	10.242
	22	404.275	MD	I	10.327	10.319
	22	404.435	MD	II	10.366	10.283
	28	410.230	RG	I	10.308	-

YU ISSN 0373–3734

Bulletin de l'Observatoire astronomique de Belgrade N° 142, Beograd, 1990.

CONTENTS