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EFFECTS OF EXTRAFOCAL OBSERVATION WITH THE SOLAR SPECTROGRAPH OF THE BELGRADE ASTRONOMICAL OBSERVATORY. I. SOLAR ROTATION LINE-OF-SIGHT VELOCITIES

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(Received April 07, 1982.)

SUMMARY: The optical averaging of line-of-sight velocities in regions 3'.8 x 3'.8 at the solar disk has been imitated numerically. The contributions of local line-of-sight velocities at any point of the disk have been assumed as proportional to the photospheric continuum intensity at the same point. Such a procedure yealds systematically smaller line-of-sight velocities of the solar rotation. The necessary corrections depending on heliographic parameters P and B_0 have been found.

INTRODUCTION

When the photosphere is observed extrafocally under the conditions of a spatial integration suitable for averaging line-of-sight components of a selected velocity field, it is necessary to know the possible contribution of any other known velocity field to the measured line-of-sight velocity. Before all it concerns the stationary photospheric motions contributing systematically to an observed line-of-sight velocity field. The most prominent and everywhere in the photosphere present is the solar rotation line-of-sight velocity field.

In this paper the spatial integration of solar rotation line-of-sight velocities in the observational program of Belgrade Astronomical Observatory has been numerically imitated and for each observed photospheric point a systematic correction is evaluated.

GEOMETRY OF THE OBSERVATION

During the last several years of the observations of global-scale photospheric motions at Belgrade a permanent set of preselected points at the solar disk were used, Figure 1 and Table I. The points from A to Z are always at the heliographic central meridian of the solar disk. The others cover two east and west lines parallel to the central meridian and one, so called equatorial line, which coincides with the heliographic equator when the latter passes through the centre of the disk ($B_0 = 0^\circ$).

The question is: can the averaged solar rotation line-of-sight velocity measured within the square area around a photospheric point be interpreted as the corresponding velocity of that point? That is not a priori clear – especially if the sides of the squares reach several minutes of arc.

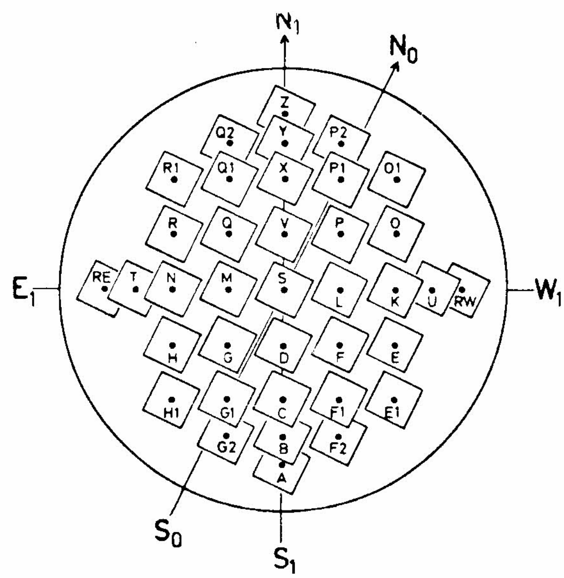

Fig. 1. Distribution of points (full circles) at the solar disk in Belgrade observational program. Around each point a square area (the central projection of the spectrograph grating into the focal image of the Sun) is shown. $N_0 - S_0$ is the north – south direction in the terrestrial equatorial coordinate system. N_1, E_1, S_1 and W_1 is the corresponding orientation of the heliographic coordinate system. The case $P = 26^\circ$ is shown.

Table I
Rectangular coordinates of photospheric points in Belgrade observational program
(in thousandths of the solar radius)

I	X	Y	I	X	Y	I	X	Y	I	X	Y	I	X	Y	I	X	Y
		south		west				south			south			south			south
A	0	790	RW	–790	0												
B	0	658	U	658	0	G2	250	658	F2	–250	658						
C	0	500	K	–500	0	G1	250	500	F1	–250	500	H1	500	500	E1	–500	500
D	0	250	L	–250	0	G	250	250	F	–250	250	H	500	250	E	–500	250
S	0	0															
V	0	250	M	250	0	Q	250	–250	P	–250	–250	R	500	–250	0	–500	–250
X	0	–500	N	500	0	Q1	250	–500	P1	–250	–500	R1	500	–500	01	–500	–500
Y	0	–658	T	658	0	Q2	250	–658	P2	–250	–658						
Z	0	–790	RE	790	0												
		north		east				north			north			north			north

THE NUMERICAL SOLUTION

The answer can be obtained in a numerical approach where one, taking into account various values of heliographic parameters P and B_0, seeks the difference between the calculated mean value of the line-of-sight velocity within each of the squares from Figure 1 and line-of-sight velocity of the corresponding central point. Continual integration of line-of-sight velocities within a square can be substituted with discretely calculated line-of-sight velocities for a set of, for example 25, equidistant points within the same square. For this purpose the whole square integration area is divided into 25 smaller equal squares having at their centers the points for which the individual solar rotation line-of-sight components will be calculated.

The distribution of these points within each of the mentioned integration areas with respect to the central point has been given in Table II in a rectangular coordinate system parallel to the square sides and expressed in thousandths of the mean solar radius. A point is identified with a pair of independent indices, i = 1,2 ...5 and k = 1, 2 ... 5. The spatial orientation of the network of these points is given by the directions N, E, S and W in the terrestrial coordinate system.

The procedure is the following. The rectangular coordinates $x^I_{i,k}$ and $y^I_{i,k}$ of each point within each square (Table II) around the observed photospheric points defined by the rectangular coordinates X^I and Y^I in Table I (index I represents the identification of a point from this Table) are given with the following expressions:

$$x^I_{i,k} = X^I + d\,(i-3)\cos P + d\,(k-3)\sin P$$
$$y^I_{i,k} = Y^I - d\,(i-3)\sin P + d\,(k-3)\cos P, \qquad (1)$$

where d is the distance between neighbouring points from Table II (d = 1 mm or 0.0476 in units of the radius of the solar disk) and P is position angle of the solar ro-

Table II
Coordinates of the points within an integration area with respect to its centre
(in thousandths of the solar radius)

k	i = 1		2		3		4		5	
1	95 W	95 N	48 W	95 N	0	95 N	48 E	95 N	95 E	95 N
2	95 W	48 N	48 W	48 N	0	48 N	48 E	48 N	95 E	48 N
3	95 W	0	48 W	0	0	0	48 E	0	95 E	0
4	95 W	48 S	48 W	48 S	0	48 S	48 E	48 S	95 E	48 S
5	95 W	95 S	48 W	95 S	0	95 S	48 E	95 S	95 E	95 S

tation axis taken as positive from north toward east. For 25 pairs of coordinates $x^I_{i,k}$ and $y^I_{i,k}$ the corresponding heliographic coordinates $B^I_{i,k}$ and $L^I_{i,k}$, and line-of-sight components of solar rotation velocities, $V^I_{i,k}$, can be found:

$$V^I_{i,k} = R\,\omega \cos B^I_{i,k} \sin L^I_{i,k} \cos B_o, \qquad (2)$$

where R is the radius of the Sun, B_o is heliographic latitude of the centre of the solar disk and ω is the sidereal angular velocity of the solar rotation. The angular velocity ω depends on heliographic latitude of the observed point. The differential rotation coefficients have been taken from Howard and Harvey (1970). The line-of sight velocity value (2) of the point i = 3, k = 3 (the centre of a square) $V^I_{3,3}$, is of course, identical with the line-of-sight velocity of the corresponding photospheric point from Table I. Therefore it can be simply designated as V^I.

As a numerical equivalent of optically averaged line-of-sight velocities within each square a weighted mean, V^I_t, of the line-of-sight velocities has been taken:

$$V^I_t = \frac{\sum_{i=1}^{5} \sum_{k=1}^{5} I^I_{i,k} V^I_{i,k}}{\sum_{i=1}^{5} \sum_{i=1}^{5} I^I_{i,k}} \,. \qquad (3)$$

According to the known procedure (Hart, 1954) the photospheric continuum intensity of the each point, $I^I_{i,k}$, has been taken as a weight in (3). It was found from the limb-darkening law of the solar disk,

$$I^I_{i,k} = 1 - u_1 + u_1 \cos \Theta^I_{i,k},$$

where $\Theta^I_{i,k}$ is the heliocentric angle of the points within the integration area, and u_1 is a constant (Allen, 1977) interpolated for the wavelength 630 nm, namely $u_1 = 0.525$.

Table III
Some of the calculated line-of-sight velocity fields (in m s^{-1})

k	i = 1	2	3	4	5
	Photospheric point S, $V^S_t = 0$				
1	244	162	80	− 1	− 82
2	204	122	40	− 41	−122
3	163	82	(0)	− 82	−163
4	123	41	−40	−122	−204
5	83	1	−81	−162	−244
	Photospheric point U, $V^U_t = 1251$				
1	1504	1421	1338	1255	1171
2	1465	1382	1299	1216	1133
3	1425	1343	(1260)	1178	1095
4	1385	1303	1220	1138	1056
5	1344	1262	1180	1098	1016

Table IV
Calculated differences ΔV^I for some selected dates (in ms^{-1})

P	0°.0	−23°.3	−26°.3	−13°.4	+0°.1	+13°.5	+22°.9	+26°.3	+13°.6
B_o	− 3°.5	− 7°.2	− 6°.1	− 0°.0	+3°.5	+ 6°.2	+ 7°.2	+ 6°.2	0°.0
Date	6.I	7.IV	7.V	6.VI	7.VII	8.VIII	9.IX	9.X	7.XII
CM	0	0	0	0	0	0	0	0	0
RE, RW	18	15	14	17	18	17	15	14	17
T, U	11	9	9	10	11	10	9	9	10
N, K	7	6	5	6	7	6	6	5	6
M, L	3	2	2	3	3	3	2	2	3
G2, F2	5	5	5	5	4	4	3	3	5
G1, F1	4	4	3	4	4	4	3	3	4
G, F	3	3	3	3	3	3	3	3	3
Q, P	3	3	3	3	3	3	3	3	3
Q1, P1	4	3	3	4	4	4	4	3	4
Q2, P2	4	3	3	5	5	5	5	5	5
H1, E1	10	9	8	9	9	8	7	7	9
H, E	8	6	6	7	8	7	6	6	7
R, O	8	6	6	7	8	7	6	6	7
R1, O1	9	7	7	9	10	10	9	8	9

The expected difference of the weighted mean of the line-of-sight velocities within each integration area and the line-of-sight velocity of the central point is obtained as

$$\Delta V^I = V_t^I \quad V^I. \tag{4}$$

For each given parameter I (each integration area) and a combination of heliographic parameters P and B_o, the calculation yealds a two-dimensional line-of-sight velocity field $V_{i,k}^I$. As an example, two such calculated fields of line-of-sight velocities for P = +26°.3 and B = +6°.2 are given in Table III together with their weighted mean values V_t^S and V_t^U.

As one could expect,the mutual differences of the corresponding individual absolute values of line-of-sight velocities within an integration area in the centre of the solar disk are negligible . Hence, the difference between the weighted mean value (V_t^S) and the line-of-sight velocity that one should expect at the centre of the integration area (V^S) equals to zero. On the contrary, for a distant point U the corresponding differences of the individual line-of-sight velocities are considerably greater and depend systematically on the heliographic coordinates. Consequently the difference between the weighted mean value (V_t^U = 1251 ms^{-1}) and the expected velocity (V^U = 1260 ms^{-1}) is greater.

Thus for a given pair of parameters P and B_o one can obtain a field of differences (4) within the solar disk. These differences, ΔV^I, change in time with an annual period. They are shown in Table IV for a set of nine selected combinations of heliographic parameters: for the days of a year when either of them is about its extreme or zero value. The parameters P and B_o , as well as the corresponding dates (in 1980), are given at the head of the Table. The values ΔV for the central meridian points, being always zero, are shown in the first line, CM. The other, east and west, points are grouped in pairs because of the symmetry with respect to the central meridian of the line-of-sight velocity averaging effect. The averaging effect acts in such a way that the absolute value of the averaged line-of-sight velocity is always smaller compared to the expected line-of-sight velocity at the centre of the integration area: for the approaching eastern part of the disk ΔV^I is always positive and for the receding western one it is always negative.

CONCLUSION

The values of differences ΔV^I in Table IV are not negligible if one studies photospheric global-scale velocity fields with velocities of the order of one meter per second. To each line-of sight velocity obtained through an averaging procedure, as in Belgrade observational program, a correction amounting to $|\Delta V^I|$ and of the sign equal to the sign of the observed rotational line-of-sight velocity has to be added. For the everyday application a more detailed table of these corrections has been prepared.

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ON THE TELLURIC LINES POSITION INSTABILITY

I. Vince

(Received January 12,1982.)

SUMMARY: On the ground of the observational data as well as the measurements of the relative positions of the telluric lines in the solar spectrum it has been established that these lines have an unstable position. To a position change during a day corresponds a Doppler velocity of 100 m s^{-1}.

The existence is pointed out of the diurnal position variations of the telluric lines and there is some indication of the diurnal variations being superimposed by some long-periodical or irregular changes.

The aerological factors are found to contribute to the position instability of the telluric lines, while the instabilities of the position differences of the investigated spectral lines of water vapor and molecular oxygen can practically completely be accounted for by the convective motion of the air masses.

The possibility of the position instability of telluric lines being only a consequence of the instrumental errors has also been examined.

INTRODUCTION

The telluric lines in the solar spectrum have been discovered as far back as the first half of the past centry. The investigations of Brewster, Gladston, Piazzi, Secchi, Janssen and others have indicated that the telluric lines of the visible spectral region are mainly a consequence of the absorption produced by the water vapor and the molecular oxygen.

Later, however, the telluric lines acquired an outstanding role, becoming a foundation of the measuring procedure of the spectral lines of celestial bodies. This applies particularly to the determination of radial velocities by Doppler method.

Nowadays, the understanding of the behaviour of the reference spectral lines under different conditions is indispensable as the line-of-sight velocities of even up to 10 m s^{-1} are detectable.

Several researchers have studied the stability of the telluric lines and the connection of their displacement with various factors. The investigations have been carried out by various methods and equipment, but the results failed to be satisfactory or mutually accordant.

In the present paper I give a brief account of the observational investigations accomplished to date along with my own results of measurements and analysis of the telluric lines instability.

PREVIOUS INVESTIGATIONS OF THE INSTABILITY OF TELLURIC LINES

At measuring the wave length of a spektral line of atmospheric molecular oxygen in the solar spectrum, Perot (1915) observed that it varied during the day as a function of time: it increased from morning to noon, but was decreasing from noon to evening. Perot interpreted this as a Doppler shift due to the motion of the absorption centres in the radial direction at a velocity of about 3 km s^{-1}.

This peculiar result was verified by St. John and Babcock (1922) at the Mount Wilson observatory. Their work can be regarded as one of the most important in the field of the telluric lines stability. According to these authors, radial velocities of 3 km s^{-1}, if real at all, must be very rare and bear a local character. From the results of their measurements they draw the conclusion that: " ... we feel justified in using the atmospheric lines as reliable standards of reference, even in work requiring the highest precision."

The investigations of the instability of the telluric lines position in the seventies took a similar course to that in the second decade of the present centry.

Tshistjakov (1970) inferred, on the basis of his measurements that both the telluric lines and the solar lines were shifting depending on the Sun's zenith distance. The displacement of these lines corresponds to a radial velocity 3.5 km s^{-1} for the descending half of the Sun's apparent path, i.e. for the one from the meridian to the horizon.

But this author's argumentation that the position changes of these lines have their origin in the atmosphere is insufficient. It is rather his method that is responsible for his results.

Mel'nikov et al. (1972) published the results of their measurements carried out in 1969. They stated the existence of the air currents at velocities of even 150 m s^{-1} at some altitudes, whereby a displacement of the telluric lines must be produced.

In order to establish the amount of these displacements these authors carried out measurements of the relative telluric lines positions with respect to those of the Sun. As a result they found the telluric lines to change their position all the day from longer towards shorter wavelengths. The averaged change of the vawe length in the time interval during which the observations were made (9^h to 16^h) was –0.5 pm, corresponding to an air current velocity of 200 m s^{-1} in the line-of-sight direction.

These authors advanced the suggestion that the cause of this displacements rested in some global atmospheric phenomenon, possibly in the Stark effect or some other effects.

Intent of continuing the above mentioned investigations, Khilov and Solonsky (1973) photographed, in 1971, two groups of telluric lines. In one of the groups were the spectral lines caused by the water vapor absorption and in the second the spectral lines of the molecular oxygen. As standard reference lines served those originating from the centre of the solar disk.

The result they obtained was in conformity with that derived by Mel'nikov et al. A steady displacement of the telluric lines over the period of observation (8^h to 17^h) towards the shorter wavelegths was found. The averaged data from the first group of photographs gave a displacement of –0.7 pm, while those from the second group yielded a displacement of –0.13 pm. No interpretation was given by the two authors of the results of their measurements. Of particular interest is the difference of the telluric lines shifts produced respectively by the water vapor and by the molecular oxygen absorption.

Abdusamatov and Zlatopol'skij (1980) have also studied the position instability of the telluric lines. They found a displacement of the telluric lines towards blue in the morning and a displacement towards red in the afternoon. These displacements amounted, on the average, to about 0.5 pm. The authors tried to explain the results of their observations by the pressure variability of the air strata through which the Sun's light rays are passing during the day. But it remains unclear why there is a sharp drop following the maximum of their curves, i.e. a sudden shift towards red about noon.

All the above presented works on the position instability of telluric lines are essentially observational ones. Theoretical investigation in this field have also been made but I do not wish to expose them in detail. Yet, one must state that no theoretical foundation has been offered of the position instability of the telluric lines, nor has it been possible to interprete the data of observations. It follows, therefore, that further studies of this phenomenon are indispensable.

OBSERVATIONS AND MEASUREMENTS

The observations I caried out were made with the equatorially mounted solar spectragraph of the Belgrade Observatory. The instrument is described in detail by Kubičela (1975).

Before the spectrograph slit an iodine tube is fixed so as to achieve the spectrograph camera to simultaneously produce the photographs of the iodine absorption lines and those of the solar spectrum lines.

The iodine vapor in the tube was kept at about atmospheric pressure, while its temperature was controlled and regulated electrically. The working temperature in the iodine tube was 321 K.

An analysis of the perameters (the profile, equivalent width etc) aimed at finding out the most suitable spectral lines in both the solar and iodine spectres, made me choose the following ones: the telluric line of the molecular oxygen in the vibration band (2,0) with the rotation line P_7 (λ = 629.5178 nm) and a nearby iodine spectral line (λ = 629.4849 nm). I termed the position measurements of these spectral lines as measurements in the 630 nm spectral region.

It is well known that the densities of the molecular oxygen and the water vapon, in the Earth's atmosphere display a certain difference according to altitude. The air strata at different altitudes are therefore rightfully expected to contribute to the forming of the water vapor and oxygen telluric lines. Thus, by the position measurements of the telluric lines, originating from the molecular oxygen, with respect to the water vapor lines, the information can be procured on the effects of some atmospheric parameters on the position stability of those lines. With this in mind I formed another observing programme.

The observations were confined to the region around 693 nm, 0.2 nm wide, where telluric lines of different origin are located. There are two spectral lines of the molecular oxygen and three belonging to the water vapor. As most suited to measurements among these spectral lines I chose two molecular oxygen lines from the vibration band (1,0), with the rotation line P_{23} (λ = 692.8728 nm and λ = 692.9599 nm) and one water vapor line in the vibration band (1,0,3) with the rotation line R_5 (λ = 692.9390 nm). In carrying out the observations the use has been made in addition to the Belgrade spectrograph, of the horizontal solar spectrograph of the Ondrejov observatory, Czechoslovakia.

Spectra were photographed on the Orwo Document Film DK-5 (spectral region 630 nm) and on Kodak Solar Patrol Film, type SO-392 (spectral region 693 nm)

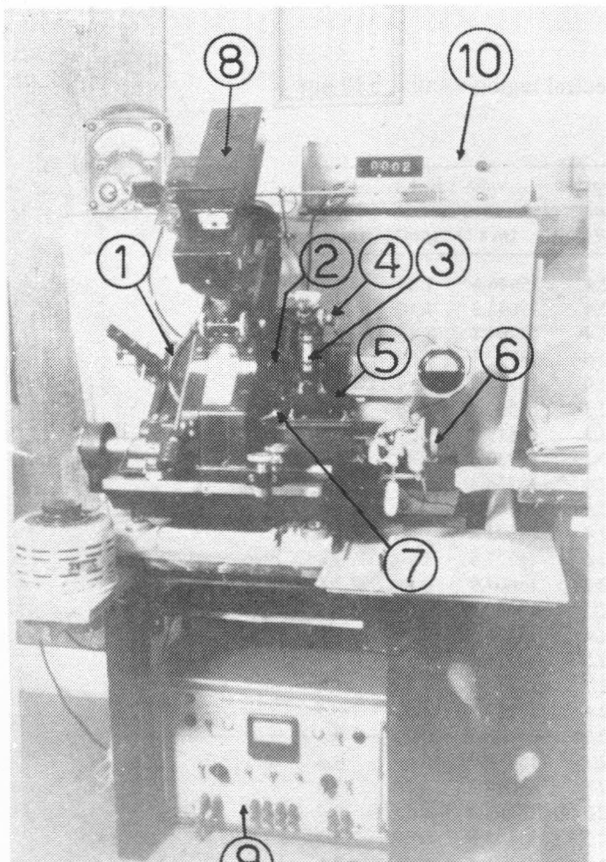

Fig. 1 Photoelectrical spectrometer of the Belgrade Observatory.

The separation of the spectral lines recorded on the spectrograms was measured by means of an apparatus shown in Fig. 1. This is, in fact, a photoelectrical spectrometer of the Belgrade observatory, whose main parts are: a movable platform (1), the spectrogram support (2), a microscope (3), with a drum (4) allowing measurements down to one micron, a glass scale (5), a micrometer screw (6) comanding the motion of the movable platform, the light source (7) illuminating the spectrogram, electro-optical system by which the central position of the spectral line is indicated (8), connected with a stabilized tension source (9) and a measuring instrument (10).

The measuring procedure is the following. By means of the optical system the spectrogram image is formed on a screen provided by two slits. The screen slits are as wide as to allow the passing of the steepest parts of the wings of the spectral lines as these are projected on the screen. The two light beams thus formed impinge on the two photoelectrical resistors of a Wheatstone bridge.

The measurement of spectral line positions imples the displacement of the movable platform with the spectrogram on it by the micrometer screw until the spectral line image reaches such a position that equal radiation fluxes are passing through both slits.This platform position is distinguishable by the equilibrium state of the Wheatstone bridge.

It should be remarked that the lost motion of the micrometer screw does not affect the results of measurements.

Special care must be taken that total radiation flux, inpinging on the photoresistors, with the Wheatstone bridge being in the equilibrium state, is kept unchanged throughout the measurements. This is realized by adjusting the intensity of the light source in such a way that the total electricity current, streaming through the Wheatstone bridge, is kept constant. By this it is achieved that the photoresistors are working all the time under the same regime.

The accuracy of the measurements is affected by several factors. One of the most important among them is the density gradient within the spectral line. The second is the instability of the electro-optical system. This instability is either a consequence of the loosening of the mechanical parts or of the instability of the electrical components of the system. The third factor is the non-uniform density of a recorded line.

To minimize the effect of the accidental errors each particular position has been derived from a set of 10 to 15 single measurements, made on various spectrograms, photographed at practically the same time (i.e. within an interval of a few minutes).

Provided the photographic material is carefully handled and the measuring components of the photoelectrical spectrometer are held under proper control, an accuracy of the measured positions of spectral lines of about 1 μm can be achieved.

The deficiency of the phoelectrical spectrometer arises from the slowness of measurements. A relatively long time is necessary before the equilibrium position of the Weatstone bridge is established and the measuring microscope is read up.

The telluric lines position at a particular instant, relative to the standard spectral line is deduced, as above indicated, as a mean value of several single measurements pertaining to different spectrograms. For each of these mean values the mean spectrograph dispersion value, related to the mean time of photographic recording, is determined. The dispersion is obtained by measuring the position differences of other neighboring telluric lines whose wavelengths differences I regarded constant. They were taken around 0.1 nm near the spectral region, wherein the instability of the telluric lines is studied.

THE ANALYSIS OF THE OBSERVED DATA

The processing of measurings made within the spectral region around 630 nm furnished results presented in Table I. The columns in the Table give: date and the time of observation, the number of spectrograms, the mean separation of the spectral lines (μm), dispersion (mm nm^{-1}) for the particular set of measurements, relative Doppler velocity, corresponding to the mean interval between the spectral lines, mean square error of the mean value of measurements (μm), and the same mean error, expressed in m s^{-1}.

As can be seen, a minimum of two series of spectrograms have been recorded on each one day of observation, making thereby possible an analysis of the re-

Table I
Results of the measurements in the spectral region around 630 nm

Date	Time (^{h} ^{m})	Number of spectrograms	Mean value (μm)	Dispersion (mm/nm)	Velocity (m s^{-1})	R.m.s. error (μm)	R.m.s. error (m s^{-1})
31.05.1979.	09 42	15	2377.87	72.4	15646.6	1.85	12.2
31.05.1979.	10 06	29	2377.66	72.4	15645.3	1.10	7.2
31.05.1979.	10 50	18	2387.06	72.4	15707.1	1.47	9.7
31.05.1979.	12 25	21	2392.00	72.6	15707.1	0.89	5.8
31.05.1979.	12 48	12	2396.40	72.6	15736.0	0.74	4.8
01.06.1979.	09 38	22	2366.40	72.3	15592.7	1.36	9.0
01.06.1979.	10 22	18	2370.50	72.3	15619.7	1.57	10.3
01.06.1979.	10 38	18	2388.70	72.3	15739.6	1.46	9.6
01.06.1979.	11 58	21	2391.80	72.4	15738.3	1.07	7.0
01.06.1979.	12 30	17	2389.35	72.4	15722.2	1.22	8.0
04.06.1979.	10 24	19	2374.40	72.4	15623.8	1.60	10.5
04.06.1979.	12 18	19	2396.00	72.6	15727.5	1.50	9.8
05.06.1979.	09 28	21	2368.70	72.3	15607.9	0.78	5.1
05.06.1979.	09 24	11	2367.60	72.3	15600.6	0.81	5.3
05.06.1979.	10 34	21	2389.09	72.4	15720.5	1.20	7.9
05.06.1979.	12 20	20	2392.20	72.5	15719.2	1.07	7.0
08.06.1979.	09 43	20	2377.80	72.1	15711.3	1.78	11.8
08.06.1979.	12 00	21	2390.50	72.4	15729.8	1.30	8.5
26.06.1979.	08 54	59	2384.19	72.5	15666.8	0.50	3.3
26.06.1979.	12 50	40	2378.55	72.1	15716.2	0.69	4.6
02.08.1979.	10 45	25	2379.84	72.5	15638.0	0.76	5.0
02.08.1979.	11 38	17	2392.88	72.3	15767.2	1.47	9.7
08.08.1979.	08 52	41	2379.39	72.5	15645.8	0.80	5.2
08.08.1979.	11 10	25	2409.60	72.1	15921.4	0.85	5.6
31.08.1979.	11 06	43	2388.81	72.3	15740.4	0.92	6.1
31.08.1979.	12 40	40	2396.72	72.5	15748.9	0.72	4.7
31.08.1979.	13 08	42	2419.90	72.7	15857.5	0.70	4.6

lative changes of velocity during the day. Unfortunately, the difficulties connected with the shifting of the spectrograph about the telescope pilar from its eastward to the westward position, implying a timeconsuming additional adjustment, compelled us to make observations mainly in the forenoon.

The number of spectrograms forming a set was decided on in the course of observation, the quality of spectrum being the criterion. Under very good observational conditions the minimum number of spectrograms, forming a set, was ten. The number of photographs was enlarged as the observational conditions worsened.

We gather from Table I that the dispersion, on the whole, grows with time (from morning to noon). In three forenoons, however (June 26, August 2 and 3) the dispersion was decreasing. The evidence we possessed was not sufficient to provide an explanation of this occurence.

In Figure 2 the velocities from the 6th column of Table I are plotted as a function of the time of observation. The graph in Figure 2 indicates a general shift of the telluric lines towards red in the course of day. This shift's amount corresponds, on the average, to a Doppler velocity change of about 35 m s^{-1} h^{-1} (the slope of the linear approximation of our measurements). This, in turn, corresponds to a velocity change of about 140 m s^{-1} for the entire period of observations. This result is surprising and is at variance with the theoretical expectations (see van de Hulst, 1945), fitting in the sparse data of other authors only partially(StJonn and Babcock 1922; Khilov et al., 1973; Abdusamatov and Zlatopol'ski, 1980).

For the period comprised by our observations just an opposite (towards blue) shift of the telluric lines is predicted by van de Hulst's theory. This discrepancy is, evidently, an idication that, in our case, a

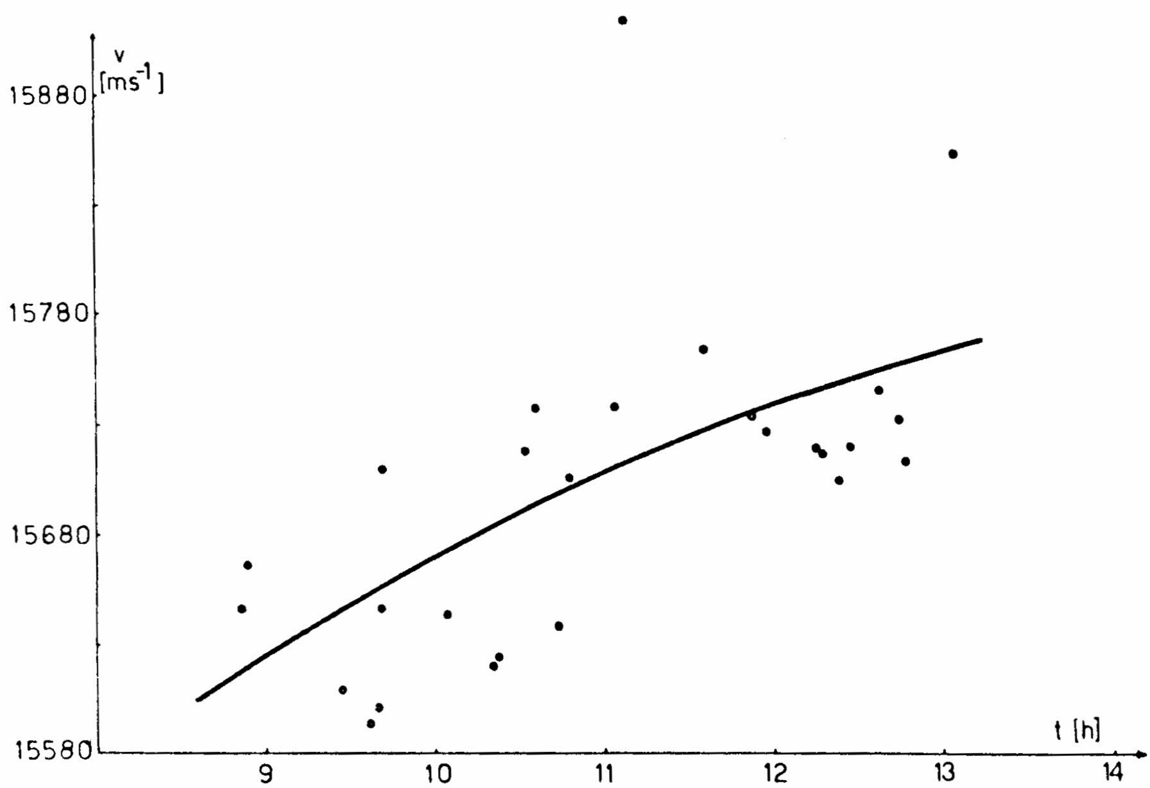

Figure 2. Doppler velocity (v) with time (t). The ordinate axis origin is taken arbitrary. The circlets represent the averaged measured velocities. The solid line is a second order curve, approximating the measurements. (Spectral region near 630 nm).

dominant effect on the telluric lines shift has been produced by factors not taken into account in the theoretical considerations of the problem.

Mel'nikov et al. (1973) pointed out the possibility of the telluric lines shift being due to the air currents at high altitudes, deploying velocities as high as 150 ms^{-1} To verify his supposition I took into consideration the wind velocity field, jet currents and convective motion of the air strata over Belgrade.

The data on the winds over Belgrade are borrowed from the aerological almanacs. In order to form a general picture of winds over Belgrade I found the mean values of the wind velocities and directions for the period 1958 to 1965. The results are illustrated in Figure 3. The forming of the mean values was made for two "seasons". The one "season" extended from March to September (thus covering the astronomically more active period) – curves a and c. The second "season" comprised the period from October to February (astronomically less active period) – curves b and d.

As shown in Figure 3, the wind at higher altitudes (about 10 km) blows at an average velocity of only 10 m s^{-1} in the west-east direction. Accordingly, the part of the telluric lines shift, produced by the wind is, on the average, surely bellow 10 m s^{-1}. From the aerological data (Vukmirović, 1979) we see that there were no jet currents over Belgrade on the days of our observations. According to the theory of convective motion, under the atmospheric conditions prevailing on the days of our observations, the occurence of vertical air currents of up to 70 m s^{-1} is possible. However, our aerological measurements furnished considerably lower values (up to 30 m s^{-1}).

It follows,therefore, that the cumulative effect of the motion of air masses above Belgrade can be responsible, having regard to the geometry of observation, for 15 to 20 percent of our total Doppler shift at the most. We are, thus, led to the conclusion that the telluric lines shift cannot wholly be accounted for by the effect of the aerological factors alone.

In order to determine the sens of the spectral lines shift, necessary in our analysis of the measurements made in the region around 693 nm, I assumed the water vapor spectral line to be stationary. In reference to it I determined the shift of the molecular oxygen lines.

The results of the position measurements of the telluric lines in the spectral region above indicated are summarized in Table II. The following data are entered into: the date of observation, time of observation the secant of the zenith distance of the Sun, the number of

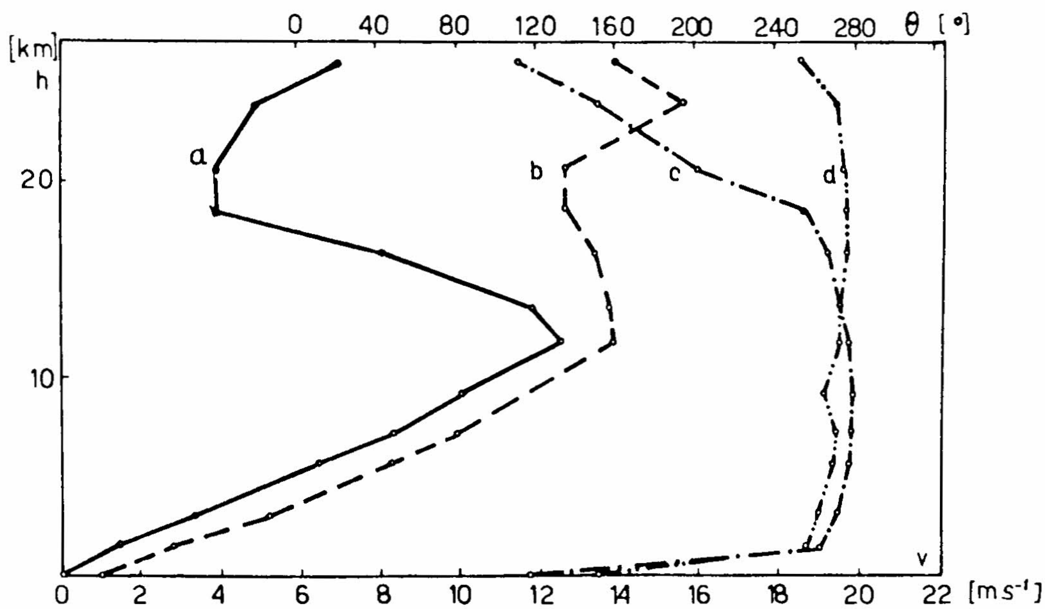

Figure 3. The averaged wind velocity (v) above Belgrade versus altitude (h) for the period March-September (curve a) and the period October-February (curve b). The averaged wind directions (θ) versus altitude (h) for the period October-February (curve c) and for the period March-September (curve d). The data are borrowed from the Aerological Almanac (published by the Federal Hidrometeorological Institute).

Table II
Results of the measurements in the spectral region around 693 nm

Date	Time	Secand of the zenith distance	Number of measurements	Relative distances (pm)	Relative distances (pm)	Doppler velocities ($m s^{-1}$)	Doppler velocities ($m s^{-1}$)	R.m.s. errors ($m s^{-1}$)	R.m.s. errors ($m s^{-1}$)	Place of observation
22.05.1979.	$15^h 31^m$	1.224	11	57.80	29.29	25027.6	12681.7	8.64	9.17	Ondrejov
22.05.1979.	16 39	1.388	5	57.83	29.26	25037.5	12671.8	7.53	9.86	Ondrejov
22.05.1979.	17 02	1.470	6	57.86	29.23	25050.6	12658.7	4.04	13.90	Ondrejov
22.05.1979.	17 30	1.603	6	57.81	29.28	25031.7	12677.7	4.80	10.60	Ondrejov
22.05.1979.	18 02	1.812	5	57.82	29.27	25032.8	12676.5	7.40	3.76	Ondrejov
11.06.1979.	09 50	1.166	18	57.59	29.50	24937.1	12772.2	5.52	7.86	Beograd
11.06.1979.	11 28	1.086	19	57.57	29.52	24928.8	12780.5	4.04	3.41	Beograd
25.06.1979.	10 12	1.128	28	57.62	29.47	24947.4	12761.9	5.39	7.08	Beograd
26.06.1979.	07 22	1.780	19	57.71	29.38	24988.9	12720.5	7.66	5.77	Beograd
26.06.1979.	09 27	1.210	24	57.62	29.47	24948.7	12760.6	5.21	5.53	Beograd
26.06.1979.	12 22	1.086	26	57.67	29.42	24969.7	12739.6	6.26	5.09	Beograd
02.08.1979.	10 04	1.201	30	57.62	29.47	24946.9	12762.5	9.78	3.93	Beograd
02.08.1979.	12 20	1.130	33	57.60	29.49	24937.6	12771.2	4.56	3.24	Beograd
03.08.1979.	09 41	1.252	21	57.58	29.51	24928.9	12780.4	3.48	4.65	Beograd
03.08.1979.	10 54	1.140	20	57.51	29.58	24902.3	12807.1	3.46	2.14	Beograd
03.08.1979.	12 00	1.124	19	57.53	29.56	24907.3	12802.0	4.36	3.12	Beograd
03.08.1979.	12 34	1.144	15	57.59	29.50	24936.0	12773.3	8.97	3.12	Beograd
08.08.1979.	08 00	1.710	23	57.65	29.44	24960.2	12749.1	5.59	4.59	Beograd
08.08.1979.	10 24	1.187	20	57.62	29.47	24947.1	12762.2	4.50	4.13	Beograd
08.08.1979.	12 20	1.150	20	57.62	29.47	24949.6	12759.8	5.48	4.99	Beograd
24.08.1979.	09 58	1.297	19	57.60	29.49	24937.7	12771.7	9.64	8.94	Beograd
24.08.1979.	12 08	1.196	21	57.60	29.49	24939.7	12769.5	5.26	5.46	Beograd

spectrograms taken, the relative distances of the first and the second spectral line of the molecular oxygen with reference to the water vapor line (pm) the corresponding Doppler velocities ($m s^{-1}$), the mean error of the Doppler velocities, the site of observation.

In Figure 4., representing the Doppler velocities, listed in the 6th column as a function of time, the Belgrade data (white circles stand clearly out relative to those obtained at Ondrejov (dark circles). The difference between these two goups of Doppler velocities amounts, on the average, to about 100 $m s^{-1}$. A displacement of the Ondrejov data towards blue in comparison with these obtained at Belgrade can be stated. It is clear from the magnitude of this displacement that no accidental character can be ascribed to it. Its origin must be sought in the different geographic positions, different instruments used for observations, different hours at which the observations were made (the observations at Belgrade have been carried out in the forenoon, those at Ondrejov in the afternoon), different atmospheric conditions etc. The lack of knowledge of these factors made me separate in the further analysis the Belgrade from Ondrejov observations.

The graph v = f (t) (Figure 5) illustrates the Belgrade data. If a line, connecting the measurements on the same day, is drawn, two basic characteristics of the velocity change can be noticed. First, the curves, featuring the measurements of the same day (weak lines) are systematically displaced relative to each other, i.e. with respect to the measurements made approximately at the same hours or at approximately at the same zenith distances but on different days. These displacements go as far as 60 $m s^{-1}$. Second, the tendency is manifest of the Doppler velocity to grow during the greater part of the forenoon, attaining its maximum about 11^h.

Concerning the scattering of the data obtained at different days, it can probably be ascribed to the action of one or several long-periodical (over one day) seasonal or similar influences.

An analysis of the factors playing part in the shaping of the observed profile of the spectral lines could not, on account of the unsufficient number of data, yield conclusive results. It could, however, be established that there existed some connection between the changes of equivalent widths, perhaps even of the profile of some telluric lines, and the atmospheric turbidity. Sometimes a sudden decrease of the equivalent

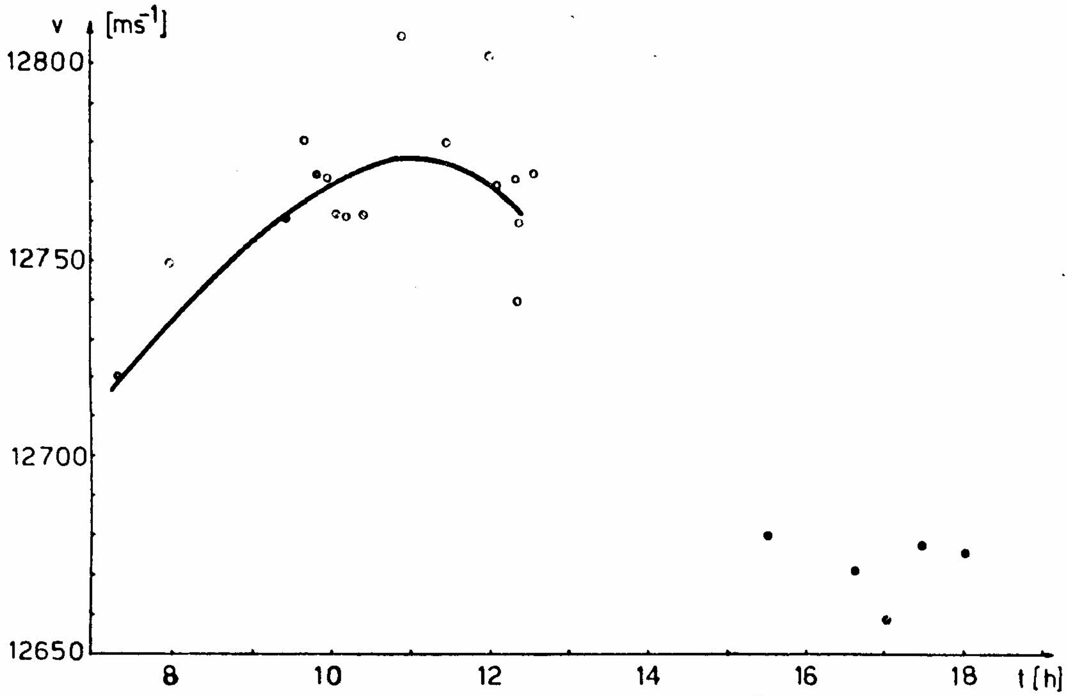

Figure 4. Doppler velocity (v) with time. The ordinate origin is arbitrary. Open circlets represent the Belgrade measurements and the dark ones those made at Ondrejov. The solid line is a second curve, approximating the measurements.

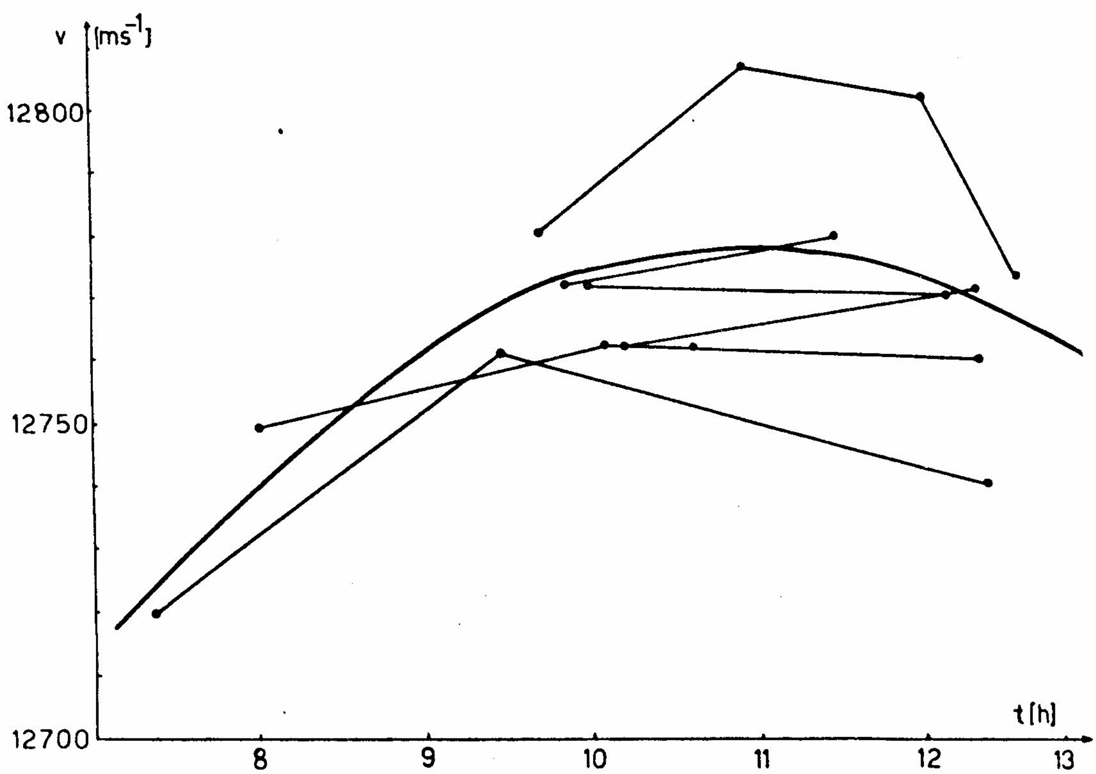

Figure 5. Doppler velocity (v) with time. Only Belgrade data from Figure 4 are represented. The weak lines join the points illustrating the measurements in the course of one day.

width of the water vapor lines in the course of observation could be noticed that might be related to the relatively rapid cumulus forming in the line-of sight direction, whereby the quantity of the water vapor is substantially reduced and, by this very fact, the number of absorbtion centers must also have been reduced. But a thorough study of the found changes would imply a year-long observing programme, combined, on one hand, by the exploration of the atmospheric turbidity and by the spectrographic and aerologic measurements on the other.

The analysis of the daily changes in the Doppler velocity was made by approximating the measured data by a second order polynomial (Figure 5). I was thus able to take from this curve the velocity changes in the interval in which the measurements were made. By comparing the volocities, indicated by the curve, at 7^h (the beginnig of the measurements) and at 11^h (the curve's maximum) I obtained velocity change of 60 ms^{-1}. This change is, in all probability, somewhat exagerated, a consequence of the measurements in the interval 7^h to 8^h being performed on the very days on which the mesured velocities had systematically the lowest values.

Such a behaviour of the telluric lines might be brought into connection with the convective air motion. Namely, in the course of the clear forenoons, speaking in general, conditions are created for the convective air motion. To be more definite, in the early morning hours we are looking through an air mantle that slowly starts its upwards motion. As the convective velocity is then low and the angle between line of sight and the direction of convective motion still wide, the radial velocity component of the convective motion has a low value. But, as the velocity of the convective motion increases with time and the angle mentioned above decreases, the radial component of velocity grows. In consequence, the red shift becomes larger. This process is going on until the velocity of convective motion reaches its maximum value (about 11^h) and the angle betwen the line of sight and the direction of convective motion becomes small. After that, the convective motion velocity begins decreasing, the angle keeps either unchanged or is increasing and the red shift, consequently, is getting smaller.

However, one should keep in mind that the real picture of the phenomenon must be more complicated in view of the fact that our measurements of the red shift of the molecular oxygen lines are made with respect to the spectral lines of the water vapor, itself draged into the convective motion. Accordingly, our measurements give in fact the differences in the Doppler velocities of the molecular oxygen and the water vapor. These differences stem from the different vertical density distribution of these molecules in the atmospehere.

From the aerological standpoint our observational days can be divided into three groups. The first group comprises the days on which a continuous extension of the red shift is recorded. The second group consists of days on which both extension and recession of the red shift is stated. On the rest of days a very small (up to 2 fm) change in the wavelength has been noticed. On juxtaposing these three groups of the found red shifts and the data on convective motion (Table III) it becomes evident that the first group is associated with days on which the convection has taken place, the second group corresponds to the days on which an exceptionally rapid development and slowing down of the convection has been measured while the third corresponds to days without any convection. Thus, we are led to the conclusion that there is a strong qualitative correlation between the convection and the shift of the telluric lines. The lack of knowledge of the spatial characteristics of the convective process, as well as of those depending on time prevented me from calculating convective velocities that would fit in each one of the measured red shifts. Nevertheless, I was able to discern a general characteristic, consisting in that the radial component of the maximum convective velocity was persistently higher, by at least 50%, than the measured Doppler velocity (Table III). This was to be expected as the measurements were relative ones. Namely, it is invariably the maximum velocity of the air masses in the convective current that is determined by the aerological measurements. This velocity usually is stated with the air strata at altitudes (4 to 10 km), which contain the molecular oxygen, but where no water vapor in any

Table III
Data on convective and observed Doppler velocities
(spectral region around 693 nm)

Date	Doppler velocity ($m s^{-1}$)	Velocity of the convective air flow ($m s^{-1}$)	Line of sight velocity of the convective air flow ($m s^{-1}$)
11.6.1979	10	18	16
02.8.1979	8	32	28
03.8.1979	27	67	60
08.8.1979	0	0	0
24.8.1979	1	0	0
26.8.1979	40		

significant quantities is found. The lower air strata, containing more water vapor, move slower. For this reason the radial component of the convective velocity is, in our case, to be diminished by the amount of the radial component of the velocity of water vapor motion.

SOME ADDITIONAL CONSIDERATIONS

At analysing the data pertaining to the spectral region near 630 nm it became evident that the red shift of the molecular oxygen lines, corresponding to a Doppler velocity of 100 m s^{-1}, cannot be wholly accounted for by aerological factors. This was the reason why yet another possibility has been considered, the one, namely, that the shifts might be due to the position changes of the reference spectral lines of the iodine vapor. As our measurements show, the changes preserve the same sense during the forenoon. The parameter, that could produce precisely such changes in the reference lines positions, is the external temperature (the one of the instrument's suroundings), which in known to rise nearly always in the course of observation. The temperature effect on the iodine spectral line can give rise to the appearance of a weak line beside the strong one, the final result being the deformation of the profile of the strong line. The iodine vapor density varies, namely, as a function of the temperature changes, whereby, in turn, the intensity of the spectral lines is also changed. Accordingly, the contribution of the weak spectral line to the profile deformation of our reference line is changeable as well, which is reflected in our measurements by the position chages of the reference line.

There are two ways in which the iodine temperature change can be brought about. First, as a result of the temperature gradient along the iodine tube, whose insulation cannot be perfect. The intensity of this gradient can change with time due to the change in the iodine tube position during observation. This effect could be eliminated by a better tube insulation and by keeping the tube in a stationary position, but this is achievable only with the static solar spectrographs.

Second, the temperature shange inside the iodine tube can be produced by the one occuring in the small glass vessel, containing crystal iodine attached to the iodine tube. A part of this attached small glass vessel is not insulated in order to make its coolling off to proceed more rapidly than the one of the iodine tube. By this, the sublimation of the iodine vapor in the attached vessel is secured. The non-insultated part of this side vessel is evidently subject to a more intense influence of the external temperature than is the rest of the iodine tube, whereby the steadiness of the iodine vapor density can be deranged. Furthermore, the position of the side glass vessel, relative to the point at which the temperature is measured is aslo changing. This is an additional cause of the iodine tube temperatue to be affected by, that is yet another reason for the iodine gas density to be deranged, the final result being the position change of the spectral lines.

A greater attention ought to be paid to the investigation of these and of other potential influences on the iodine spectral lines, for the iodine spectrum is one of the very suitable ones to be exploited as a reference spectrum in the absorption spectroscopy. It is noteworthy in this respect that several authors (St John and Babcock, 1922; Beckers, 1978; Howard, 1980) have already used, or are using, the iodine spectrum for that purpose. However, no information is given on its behaviour under different conditons by any of these authors.

Apart from the possible instability of the iodine spectral lines it should not be overlooked that the telluric lines themselves might be subject to shifting under the influence of some, hitherto unknown, factors. Finally, a simultaneous and combined influence of various factors must also be reckoned with.

Our analysis of data relating to the spectral region around 690 nm did not yield an elucidation of the difference between the Ondrejov and Belgrade data. If this difference is not of instrumental provenience, then new prospects are open in the study of the telluric lines by simultaneous observations from geographically different sites.

CONCLUSION

The analysis of the observstional data acquired, related to the spectral region near 630 nm and 690 nm shows that the telluric lines of the molecular oxygen and water vapor are instable. The order of magnitude of this instability is such that it cannot be disregarded in the precision measurements of the shift of solar lines.

Systematic daily position changes of the telluric lines have been found and there is also some evidence for the daily changes to be superimposed by some long term or irregular ones.

It has been established that the aerological factors contribute to the instability of the telluric lines, while the instability of the position differences of the water vapor and molecular oxygen lines can be practically completely accounted for by the convective air motion.

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THE MINOR PLANET PREMATURE AND BELATED DISCOVERIES

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SUMMARY: By applying the mean opposition magnitude criterion, lists of the prematurely and belatedly discovered minor planets are compiled. The involved observational selection effects, especially those connected with the dynamical and physical properties of considered objects, are discussed. A general reference regarding the future occurence of untimely discoveries is given.

INTRODUCTION

Common properties of minor planets and the structure of the minor planet belt are most frequently studied by means of the statistical methods applied to the sample of numbered minor planets. However, it has been shown (Knežević, 1979) that the numbered sample cannot always be considered as being representative of the whole minor planet population, since serious statistical biases have been introduced into the sample through the influence of various selection effects. A number of papers published so far deal just with these selection effects - their origin and extent, the methods of how to take them into account in statistical investigations, and how to remove or, at least, diminish their influence in the minor planet statistics. Well-known studies of this kind are, for example, those by Kiang (1966) on the bias-free statistics of minor planets, Kresak (1967) on the so-called "southern excess', Van Houten et al. (1970) and Kiang (1971) on the biases affecting the PLS results, or, more recently, the study by Zellner (1979) on the distribution in diameter and semimajor axis of different minor planet compositional types, etc. One of the most elegant demonstrations of the selection effects, the distorted statistical picture thus produced and the erroneous conslusions reached, has been presented by Kresak (1971) in the paper on the hypotetical jet-stream within the Nysa family, which turned out to be unreal and apparently produced by the observational selection in connection with the PLS limitations in longitude and latitude.

The aim of the present paper from this viewpoint is the investigation of some interesting consequences of the observational selection affecting the discovery of minor planets. The numbered objects considered here, represent peculiar exceptions from the statistical point of view, thus permitting the most straightforward examination of the effects causing their appearance.

Kiang (1966) proved that the mean inclination of minor planets steadily increases "along the restricted discovery sequence" (within a certain range of the mean opposition magnitude), and that, therefore, the numbered minor planet sample is biased in the sense of containing too many low inclination objects beyond the mean opposition magnitude 15. He correctly attributed this effect to the practice of confining the search for minor planets to a narrow band about the ecliptic, favouring the discoveries of low inclination objects. Recent re-consideration of some statistical properties of the inclination distribution in the numbered sample (Knežević, 1982) confirmed on the whole both Kiang's conclusions. At the same time, however, certain intriguing exceptions have been noticed, which deserve further interest.

In Table I the bivariate number frequency distribution is presented of the numbered minor planets according to the mean opposition magnitude and ordering number. The list of 2393 numbered objects published in the Ephemerides of Minor Planets for 1982 and in the MPCs up to No 6102 (discarded were 7 lost objects), has been used as the source of data for Tab. I. Group 1 consists of minor planets Nos 1 to 200, Group 2 comprises Nos 201 to 400 etc., while Group 12 consists of objects from No 2201 to 2400. Due to the omission of the lost objects, some groups are not exactly equal in size, but the differences are small and therefore statistically insignificant.

Table I: The bivariate number frequency distribution of numbered minor planets according to the mean opposition magnitude B(a,O), and the ordering number. Group 1 comprises the objects Nos 1 to 200, Group 2 Nos 201 to 400, etc., while Group 12 consists of objects from No 2201 to 2400.

B (a,0) \ Group	1	2	3	4	5	6	7	8	9	10	11	12
$<9^m.0$	3											
$9^m.0 - 9.9$	5											
10.0 – 10.9	13		1									
11.0 – 11.9	32	6	5	2							1	
12.0 – 12.9	62	26	12	8	4			1		1	1	
13.0 – 13.9	67	60	48	27	5	2	1				1	
14.0 – 14.9	16	67	84	81	51	27	15	4	5	1	1	1
15.0 – 15.9	2	36	39	58	90	106	101	68	58	31	39	19
16.0 – 16.9		4	7	18	44	50	63	100	115	114	97	130
17.0 – 17.9			3	4	3	9	16	25	20	41	49	41
18.0 – 18.9					1	3	3	1	2	8	7	6
19.0 – 19.9					1					2	2	2
>20.0						1	1			2	2	1

The magnitude – ordering number correlation, clearly displayed by Tab. I, exhibits a fairly regular trend towards fainter magnitudes with the increasing number of minor planets included in the list of numbered objects. However, a closer inspection of the magnitude distributions in individual columns of Tab. I reveals that, almost as a rule, both tails of the distributions include a number of objects unexpectedly bright or faint for a given range of ordering numbers. Moreover, these minor planets frequently have high inclination orbits (see Fig. 6 in Knežević, 1982), something that for the bright objects might have been expected, but for the faint objects is in evident contradiction with Kiang's findings.

It is clear that these peculiar cases are due to the influence of various selection effects connected with the discoveries of minor planets and their inclusion into the list of numbered objects. Accordingly, the investigation of such special cases can contribute to our better understanding of the problems of selection effects distorting the minor planet statistics.

THE DEFINITION OF UNTIMELY DISCOVERIES

Generally speaking, there are two classes of selection effects connected with the minor planet discoveries. First, those which enter the value of the mean opposition magnitude and which depend on the minor planet size, albedo and semimajor axis. Since the entirely different combinations of these parameters can yield the same value for B(a,0), one can hardly distinguish the relative statistical contribution of these effects. However, once we convert the sizes, albedos and distances to the mean opposition magnitudes, we are faced with effects which form the second class and which are connected with the orbital eccentricity and inclination (to some extent with the other orbital elements, and with the brightness variation due to the rotation), the changes of observational activity, the chain identifications, the increased attention paid to the observation of "interesting" objects of unusual motion, etc. The role of main effects of the latter class in originating the aforesaid peculiar discoveries is more easily recognizable, and it is dealt with here in more detail.

Clearly, it is first of all necessary to define which objects are to be considered too faint or "premature discovery", and which too bright or "belated discovery", for a given range of ordering numbers. Note that the use of the term "discovery" implies that the selection effects connected with the inclusion into the list of numbered objects are not taken into account. Indeed, effects like the changes in requirements for assigning of permanent numbers, appear to be very limited in duration and extent, and frequently masked by the other effects, so that, in terms of the problem treated here, they can safely be neglected. On the other hand, the chain identifications of older discoveries add to the numbered minor planet sample mostly typical main-belt objects of low inclination, for which a greater number of observed apparitions is usually available among the data on unnumbered minor planets.

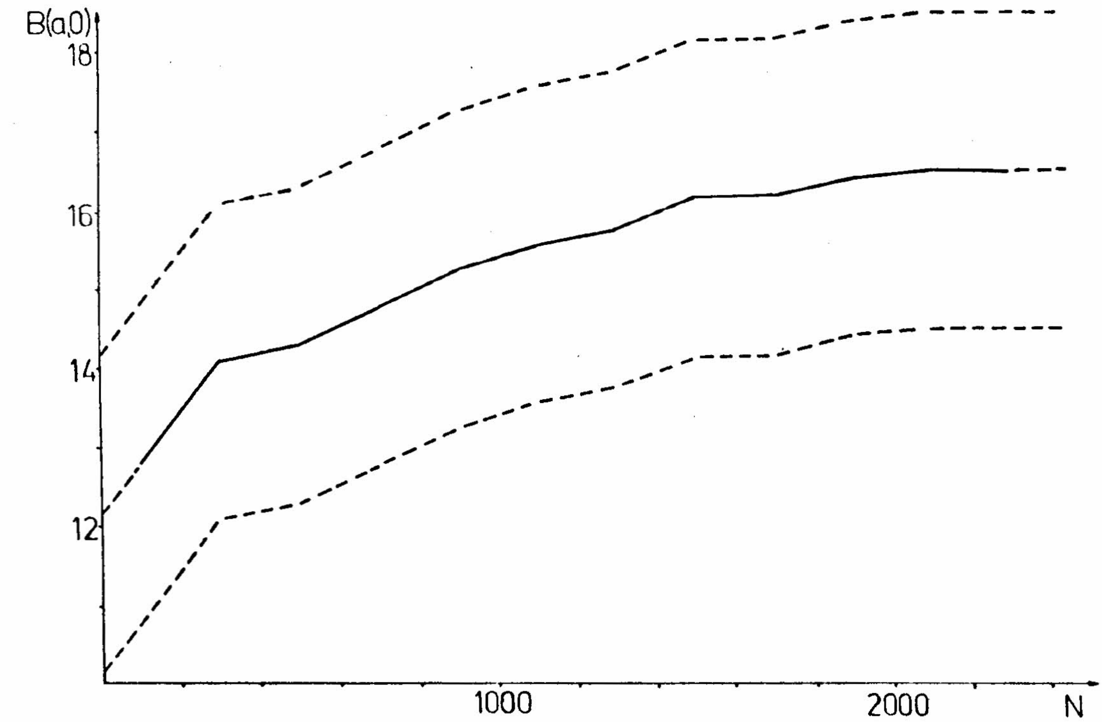

Figure 1: The resulting median magnitude curve (solid line), and the boundary curves (dashed lines) corresponding to the limiting deviation of $\pm 2\overset{m}{.}0$ from the median magnitude curve.

Magnitude distributions in the groups of Tab. I exhibit two common properties: they are slightly asymmetrical, and the majority of comprised objects is concentrated in three or four magnitude intervals, the peripheral intervals being populated each by less than 5% of the total number of minor planets included in the particular group. Of course, Group 1 (Nos 1 to 200) and partially Group 2 (Nos 201 to 400) represent here a natural exception, since there are included all the brightest minor planets and any discussion of possible belated discoveries, for example, simply makes no sense.

Because of the asymmetry of the magnitude distributions, the group median values have been used in the present paper as the reference points desribing the more or less steady increase of the mean opposition magnitude with the increasing ordering number of objects included in the list of numbered minor planets. For the sake of simplicity, each pair of consecutive medians has been connected by a line, resulting for the whole numbered minor planet sample in a zig-zag curve shown in Figure 1. Note, however, that the "small-scale" variations of the increasing magnitude trend are better followed in this way as well.

Table II:
The group magnitude medians – M, and the coefficients A and B of the linear fit – B(a,O) = A N + B.

GROUP	M	A	B
1	$12\overset{m}{.}8$		
		+0.0065	12.15
2	14.1		
		10	13.80
3	14.3		
		25	13.05
4	14.8		
		25	13.05
5	15.3		
		15	13.95
6	15.6		
		10	14.50
7	15.8		
		20	13.20
8	16.2		
		–	16.20
9	16.2		
		125	14.075
10	16.45		
		075	15.025
11	16.6		
		–	16.60
12	16.6		

Finally, those objects are defined as untimely discoveries whose mean opposition magnitude deviates from the corresponding linear part of the resulting curve by 2.0 mag or more. The limiting deviation of 2.0 mag corresponds very closely to 2σ, where σ denotes the standard deviation.

Table II contains the median values and the coefficients A and B of linear interpolation – B(a,0) = A N + B – for all 12 minor planet groups, while Tables III and IV list the numbered minor planets representing premature and belated discoveries in the above defined sense.

Table III: The list of prematurely discovered minor planets. ΔB denotes the deviation of mean opposition magnitude of particular minor planet from the resulting median magnitude curve, in the sense – ΔB = B (a,O) – MMC, while in the 10th column the minor planet place of discovery is given.

Minor Planet	B(a,0)	ΔB	B(1,0)	TYPE	D	a	i	e	Observatory	Remark
	m	m	m							
155 Scylla	15.9	+2.7	12.5	CMEU	32.8	2.7616	11.44	0.2728	Pola	
157 Dejanira	15.5	2.3	12.4			2.5786	12.14	.1987	Marseille	
228 Agathe	16.1	2.5	14.0			2.2011	2.54	.2422	Vienna	
262 Valda	15.9	2.0	12.9	U	17.1	2.5558	7.74	.2124	Vienna	
296 Phaetusa	16.1	2.0	14.0			2.2296	1.75	.1600	Nice	
315 Constantia	16.3	2.2	14.0			2.2416	2.43	.1679	Vienna	
319 Leona	16.2	2.1	11.6			3.3802	10.76	.2432	Nice	Librator
452 Hamiltonia	17.1	2.8	13.4			2.8652	3.22	.0297	Mt Hamilton	
457 Alleghenia	17.1	2.8	13.0			3.0872	12.95	.1831	Heidelberg	
561 Ingwelde	16.5	2.0	12.3			3.1677	1.50	.1320	Heidelberg	
594 Mireille	17.1	2.6	14.0			2.6269	32.58	.3541	Heidelberg	
603 Timandra	16.6	2.0	13.6			2.5427	7.98	.1687	Taunton	
610 Valeska	17.3	2.7	13.3			3.0790	12.73	.2639	Heidelberg	
632 Pyrrha	16.7	2.1	13.4			2.6641	2.23	.1896	Heidelberg	
646 Kastalia	16.7	2.0	14.3			2.3251	6.91	.2128	Heidelberg	
649 Josefa	17.2	2.5	14.2			2.5487	12.64	.2736	Heidelberg	
668 Dora	16.9	2.2	13.4			2.7995	6.84	.2313	Heidelberg	
730 Athanasia	17.0	2.1	14.8			2.2434	4.23	.1772	Vienna	
765 Mattiaca	17.1	2.1	14.1			2.5475	5.58	.2798	Heidelberg	
843 Nicolaia	17.3	2.1	15.0			2.2791	7.99	.2088	Bergedorf	
887 Alinda	18.0	2.7	15.1	S	4.7	2.5017	9.19	.5535	Heidelberg	Amor
944 Hidalgo	19.2	3.8	11.9	MEU	28.6	5.8523	42.37	.6551	Bergedorf	
1009 Sirene	20.1	4.6	16.9			2.6270	15.76	.4543	Heidelberg	
1125 China	18.5	2.9	14.3			3.1493	3.03	.2038	Nanking	
1134 Kepler	18.1	2.5	14.8			2.6830	15.17	.4664	Heidelberg	
1198 Atlantis	18.2	2.5	16.0			2.2512	2.72	.3348	Heidelberg	
1205 Ebella	18.2	2.5	15.3			2.5365	8.91	.2771	Heidelberg	
1221 Amor	20.4	4.7	19.2			1.9203	11.89	.4346	Uccle	Amor
1230 Riceia	17.8	2.1	14.7			2.5715	10.50	.1794	Heidelberg	
1316 Kasan	18.2	2.4	15.5			2.4105	23.97	.3200	Simeis	
1373 Cincinnati	18.9	3.0	14.3			3.3989	38.94	.3277	Mt Wilson	Librator
1647 Menelaus	18.3	2.1	11.6			5.2438	5.64	.0256	Mt Wilson	Trojan
1863 Antinous	18.9	2.5	16.6			2.2597	18.42	.6066	Mt Hamilton	Apollo
1869 Philoctetes	19.1	2.7	12.3			5.3063	3.96	.0624	P – L	Trojan
1870 Glaukos	18.7	2.3	12.0			5.2332	6.58	.0308	P – L	Trojan
1871 Astynax	19.2	2.8	12.4			5.3406	3.57	.0343	P – L	Trojan
1873 Agenor	18.5	2.1	11.8			5.2570	21.86	.0916	P – L	Trojan
1915 Quetzalcoatl	22.3	5.8	19.4			2.5273	20.51	.5777	Palomar	Amor
1916 1953 RA	18.6	2.1	16.3	S	3.0	2.2725	12.84	.4498	Uccle	Amor
1917 Cuyo	18.6	2.1	16.6			2.1498	23.98	.5046	El Leoncito	Amor
1921 Pala	20.0	3.5	15.7			3.2343	19.66	.4122	Palomar	Librator
1981 Midas	18.8	2.3	18.1			1.7759	39.84	.6499	Palomar	Apollo
2059 Baboquivari	19.3	2.7	16.1			2.6466	11.04	.5292	Goethe Link	Amor
2061 Anza	20.4	3.8	18.1	C	2.5	2.2635	3.74	.5381	Lowell	Amor
2099 Opik	18.9	2.3	16.5			2.3029	26.93	.3631	Palomar	
2101 Adonis	20.6	4.0	19.5			1.8730	1.37	.7648	Uccle	Apollo
2128 Wetherill	18.6	2.0	15.2			2.7371	16.83	.3791	Palomar	
2135 Aristaeus	19.1	2.5	19.2			1.5997	23.04	.5033	Palomar	Apollo
2148 Epeios	18.7	2.1	12.0			5.1863	9.17	.0569	ESO	Trojan
2198 Ceplecha	18.8	2.2	15.7			2.5938	3.64	.1980	Agassiz	
2201 1947 XC	18.7	2.1	16.7			2.1751	2.52	.7118	Lowell	Apollo

Table III (Continued)

Minor Planet	B(a,0)	ΔB	B(1,0)	TYPE	D	a	i	e	Observatory	Remark
	m	m	m							
2202 Pele	20.9	4.3	18.5			2.2905	8.78	.5122	Lick	Amor
2298 1915 TA	18.6	2.0	16.0			2.4073	5.15	.1710	Heidelberg	
2329 1976 WA	18.9	2.3	16.3			2.4035	24.39	.6584	ESO	Apollo
2368 1977 RA	18.6	2.0	16.8			2.1042	5.26	.4134	Zimmerwald	Amor

Table IV: The list of belatedly discovered minor planets.

Minor Planet	B(a,0)	ΔB	B(1,0)	Type	D	a	i	e	Observatory	Remark
	m	m	m							
324 Bamberga	11.3	−2.8	8.1	C	256	2.6815	11.14	0.3404	Vienna	
349 Dembowska	11.0	3.1	7.2	R	145	2.9244	8.26	.0911	Nice	
354 Eleonora	11.0	3.2	7.5	U	156	2.7983	18.41	.1136	Nice	
387 Aquitania	11.8	2.4	8.4	S	113	2.7410	18.07	.2356	Bordeaux	
409 Aspasia	11.4	2.8	8.3	C	194	2.5774	11.24	.0687	Nice	
433 Eros	11.5	2.7	12.4	S	20.0	1.4583	10.83	.2228	Berlin	Amor
451 Patientia	11.7	2.6	7.7	C	281	3.0680	15.21	.0674	Nice	
471 Papagena	11.5	2.8	7.8	S	145	2.8861	14.96	.2329	Heidelberg	
511 Davida	11.6	2.7	7.4	C	335	3.1806	15.91	.1744	Heidelberg	
532 Herculina	10.4	4.0	7.0	S	219	2.7730	16.34	.1756	Heidelberg	
554 Peraga	12.4	2.0	9.8	C	104	2.3752	2.93	.1523	Heidelberg	
584 Semiramis	12.4	2.1	9.8	S	56.8	2.3733	10.71	.2348	Heidelberg	
654 Zelinda	11.9	2.8	9.5	U	73.5	2.2961	18.15	.2317	Heidelberg	
674 Rachele	12.4	2.3	8.6	S	95.9	2.9204	13.54	.1962	Heidelberg	
675 Ludmilla	12.7	2.0	9.3			2.7692	9.77	.2034	Taunton	
702 Alauda	12.5	2.3	8.3	CU	217	3.1929	20.54	.0319	Heidelberg	
704 Interamnia	11.2	3.6	7.2	U	338	3.0596	17.29	.1522	Teramo	
712 Boliviana	12.3	2.5	9.3	C	128	2.5759	12.81	.1886	Heidelberg	
747 Winchester	12.7	2.2	8.8	C	208	3.0010	18.15	.3412	Winchester	
751 Faina	12.8	2.1	9.8	C	113	2.5527	15.60	.1534	Simeis	
776 Berbericia	12.5	2.5	8.7	C	183	2.9316	18.22	.1645	Heidelberg	
804 Hispania	12.5	2.6	8.9	C	175	2.8401	15.35	.1394	Barcelona	
914 Palisana	12.9	2.4	10.1	C	75.1	2.4566	25.30	.2119	Heidelberg	
925 Alphonsina	12.9	2.4	9.6	S	59.2	2.7003	21.08	.0785	Barcelona	
980 Anacostia	12.5	2.9	9.2	S	79.4	2.7392	15.92	.2019	Washington	
1212 Francette	13.3	2.4	8.0	U	114	3.9514	7.59	.1863	Algiers	Hilda
1467 Mashona	14.1	2.0	9.6	C	115	3.3641	22.08	.1461	Johannesburg	
1566 Icarus	12.3	3.9	17.7	U	1.9	1.0779	22.91	.8266	Palomar	Apollo
1620 Geographos	14.1	2.1	16.7	S	2.2	1.2446	13.32	.3353	Palomar	Apollo
1865 Cerberus	12.3	4.1	17.6			1.0801	16.09	.4670	Bergedorf	Apollo
2062 Aten	11.0	5.6	18.4	S	1.1	0.9665	18.93	.1826	Palomar	Aten
2063 Bacchus	13.4	3.2	18.8			1.0776	9.42	.3494	Palomar	Apollo
2100 Ra-Shalom	12.7	3.9	17.0			0.8320	15.76	.4365	Palomar	Aten
2131 1975 RA	14.6	2.0	13.5			1.8874	33.99	.1107	Lick	

Tab. IV (list of belated discoveries) includes only the objects with ordering numbers 323 and higher. As is well-known, 323 Brucia was the first minor planet discovered by means of photography, and it is only since then that one can speak of the belatedly discovered bright objects, which had escaped previous visual detection.

MINOR PLANET PROPERTIES AND ASSOCIATED SELECTION EFFECTS AS THE SOURCES OF PREMATURE AND BELATED DISCOVERIES

Let's consider the dynamical properties of minor planets and associated selection effects favouring the early discovery of an object. It appears at once obvious that under favourable conditions, like a perihelion opposition, otherwise faint minor planet, but with a highly eccentric orbit, can penetrate the zone of visibility and become accessible to detection. On the other hand, belated discoveries should be more frequent among high inclination objects due to the relatively short time span spent by such an object in the ecliptical zone of intensive search (Van Houten et al., 1970). This span is even shorter in the favourable perihelion opposition, because of the faster motion of minor planets around the perihelion. Besides, a peculiar orbit is mostly associated with a peculiar direction of the apparent motion, and, if the telescope follows the mean motion of normal main-belt minor planets, a peculiar object appears fainter (a dash instead of a star-like image).

However, the problem is far more complex than it may look like at first glance. Namely, high orbital eccentricities are frequently associated just with high inclinations. Besides, other parameters and effects of minor planet size, shape, type and distance, or biases introduced by the special observational programmes etc. additionally render the analysis of possible sources of untimely discoveries more difficult.

1. Even a preliminary inspection of the data on premature discoveries, contained in Tab. III, shows that the overwhelming majority of 55 listed minor planets do not represent typical mainbelt objects of the average size, eccentricity and inclination.

As illustrated in Figure 2 (upper histogram) they are spread throughout the numbered sample, being for the recently numbered objects (Nos 1850 to 2250) relatively more frequent. Considering these data with respect to magnitude distributions of Tab. I, one easily finds that small groupings of premature discoveries between Nos 150 and 350, 550 and 650, or Nos 1100 and 1250 are related to the magnitude threshold shift towards fainter magnitudes. According to Tab. III, on the other hand,the concentration of premature discoveries among the newly numbered minor planets is obviously due to the special observational programmes of search for minor planets of Apollo and Amor type (Helin and Shoemaker, 1979) and Trojans (Degewij and Van Houten, 1979).

In Figures 3 and 4 the distribution of premature discoveries is shown in the (i,a) and (e,a) planes, respectively. In comparison to the corresponding median values of the sample of numbered minor planets as a whole, marked by a cross in the figures, the properties of the distribution of premature discoveries can be summarized as follows:

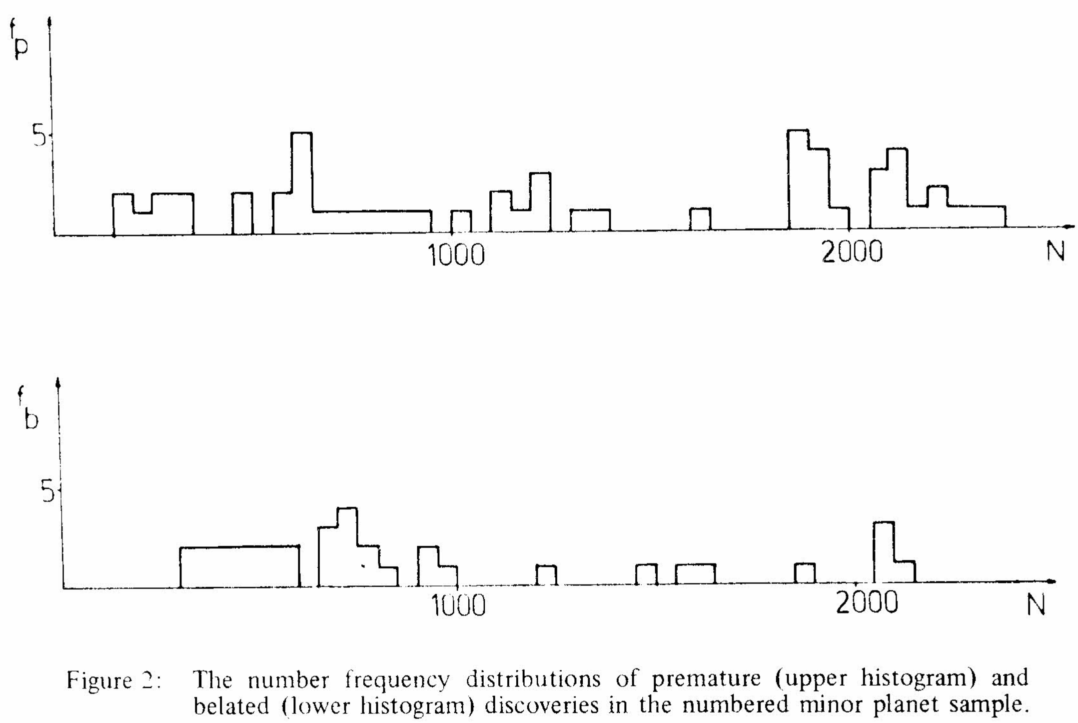

Figure 2: The number frequency distributions of premature (upper histogram) and belated (lower histogram) discoveries in the numbered minor planet sample.

– with respect to the semimajor axis, the distribution of premature discoveries exibits a conspicuous predominance of the objects from the inner part of the belt (sample median M_a = 2.7422 AU; premature discoveries median M_{ap} = 2.5487 AU). This is due to the numerous objects of Apollo and Amor type, included in the numbered sample only recently;

premature discoveries median M_{ep} = 0.274).

Of the minor planet orbital elements, accordingly, conforming to the expectation, the eccentricity proved to be most significant in originating the premature discoveries. It overbalances, in particular cases, the counterinfluence of high inclinations and enables even the distant objects to reach, under favourable co-

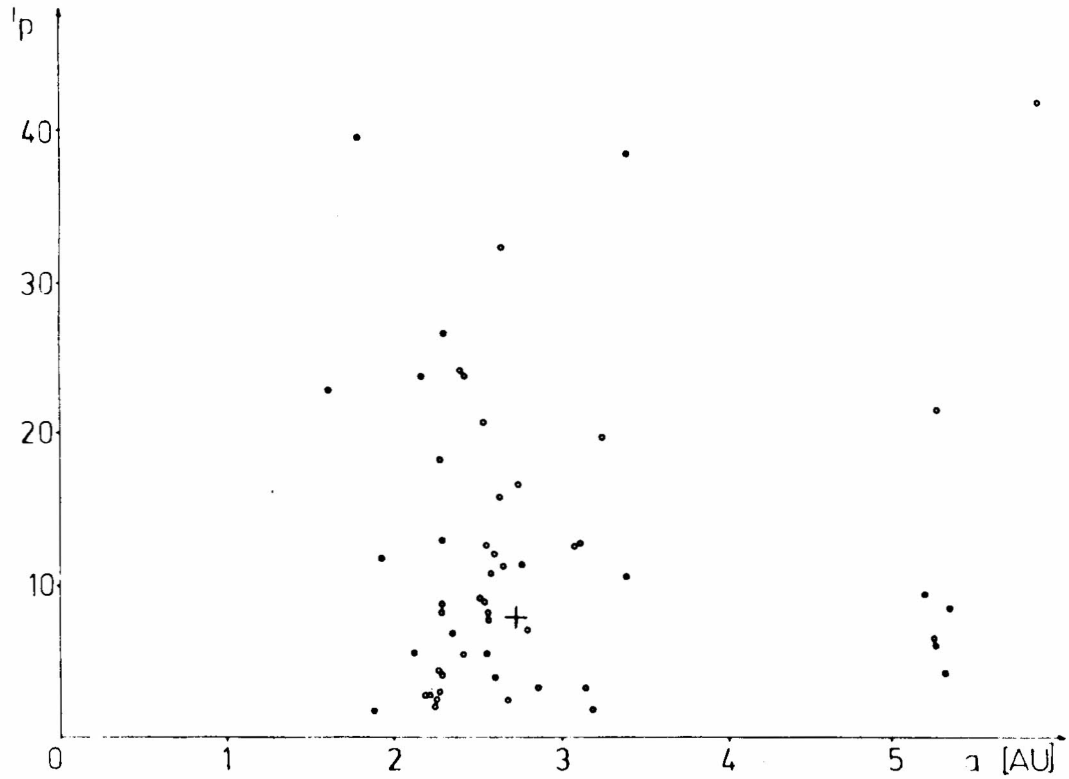

Figure 3: The distribution of premature discoveries in the (i,a) plane. The cross stands for the corresponding median of the numbered minor planet sample as a whole.

– 21 of 55 prematurely discovered minor planets have the orbital inclination lower than the median of the numbered minor planet sample as a whole (sample median $M_i = 7^\circ\!.886$). Most of the others have moderately high inclinations between 10° and 20°, while 4 objects (2 main-belt + 1 Apollo + 944 Hidalgo) have inclinations higher than 30°. Consequently, a slight prevalence of high inclination objects exists among the premature discoveries (premature discoveries median $M_{ip} = 9^\circ\!.168$);

– all the prematurely discovered minor planets, except 452 Hamiltonia, 561 Ingwelde and the Trojans, have highly eccentric orbits (sample median M_e = 0.157;

nditions, apparent magnitudes accessible to detection. The semimajor axis is obviously of secondary importance here.

In the period of visual observation of minor planets, 7 premature discoveries were made at 4 different observatories, otherwise very active at that time. With respect to the observational programmes of particular observatories, therefore, these discoveries can be considered as being made purely by chance. Similarly, the premature discoveries of 16 minor planets made at Heidelberg are due to the extraordinary efficiency of the Heidelberg programme only, and not to a specially organized search. One would infer that their coverage

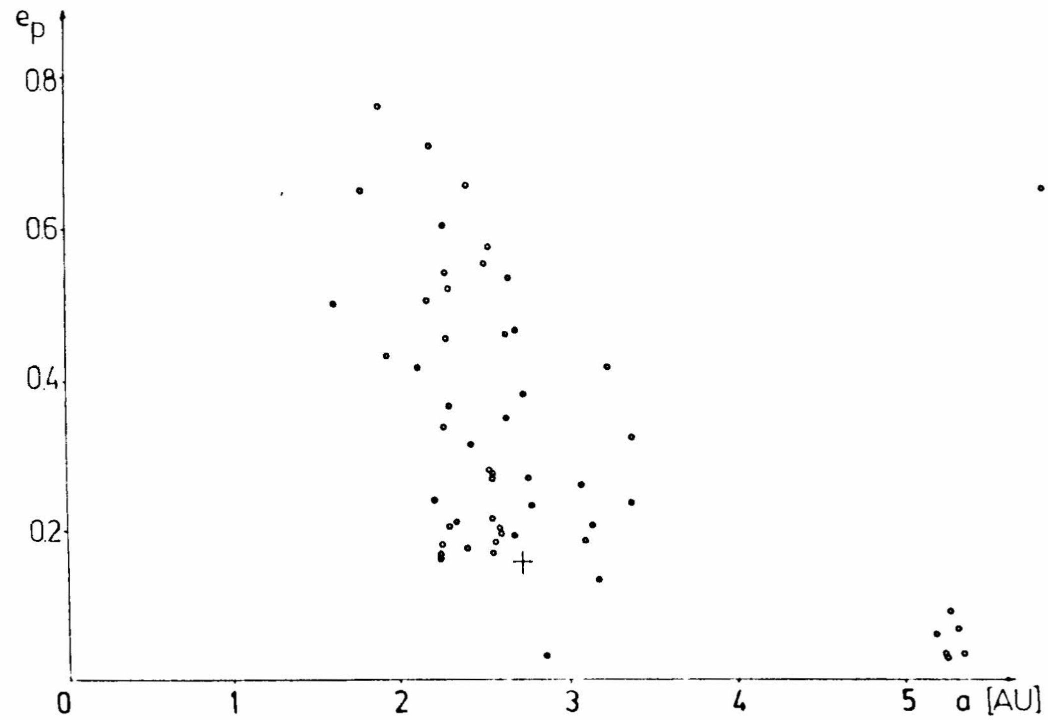

Figure 4: The distribution of premature discoveries in the (e,a) plane.

in latitude was wider than that the of other observers, and that the time span covered by observations was long enough to let many faint, high-inclination objects appear near their perihelion and nodal oppositions. Moreover, since more new minor planets were discovered than could have been followed up by observation and orbit computation, some selection in favour of those objects peculiar at first glance, due to the deviation from the average length and/or direction of their trails on the plates, would be quite logical. However, the contribution of the Heidelberg objects to the subsample of premature discoveries is about the same ($\sim 29\%$) as the contribution to the sample of numbered objects itself ($\sim 33\%$). Besides, only one of the premature discoveries of the Apollos, Amors or Trojans (887 Alinda) has been made at Heidelberg.

Entirely different situation is found with the Palomar premature discoveries. Most of them range among the "interesting" objects, coming from the above mentioned Apollo-Amor and Palomar-Leiden Trojan Survey. Also, the main-belt object 1921 Pala is one of the three known Griqua-type minor planets, librating around the 1 : 2 resonance in an orbit of considerable inclination and eccentricity. The remaining premature discoveries made at various observatories can again be considered as being made by chance.

In the TRIAD table of polarimetrical and radiometrical data (Morrison and Zellner, 1979) out of the prematurely discovered minor planets only 887 Alinda is listed, with a radiometric diameter of 4 km and the implied visual albedo of 0.180. In the TRIAD table of Bowell et al. (1979) 887 Alinda is classified as an S-type object, while five other premature discoveries – 155 Scylla, 262 Valda, 944 Hidalgo, 1916 1953RA and 2061 Anza – are classified as CMEU, U, MEU,S and C types, with diameters of 32.8,17.1,28.6,3.0 and 2.5 km, respectively. Although, accordingly, data comprised in the TRIAD file are far from being sufficient for a reliable analysis of common properties, the diversity of types of the prematurely discovered minor planets implies the different albedos. On the other hand, the data on diameters and the considerable difference between the median absolute magnitudes of prematurely discovered minor planets, $M_{B(1,0)p} = 14^m.7$, and of all the numbered minor planets, $M_{B(1,0)} = 12^m.2$, suggest that most of the premature discoveries belong to the relatively small-sized objects.

Note, finally, that 7 minor planets considered as lost (Table V) are all fainter than predicted by the resulting median magnitude curve. Moreover, 4 of them can be considered as premature discoveries in the sense of our definition.

Table V: The minor planets considered as being lost. Some of them represent the premature discoveries.

MINOR PLANET	B(a,0)	ΔB
330 Adalberta	$15^m.3$	$+1^m.2$
473 Nolli	15.0	0.6
719 Albert	19.9	5.1
724 Hapag	17.6	2.8
878 Mildred	19.1	3.9
1026 Ingrid	16.9	1.4
1179 Mally	18.2	2.5

2.According to Fig. 2 the belatedly discovered minor planets exhibit a conspicuous concentration in the range of Nos 324 to 1000. Out of 34 objects considered as being discovered belatedly (see Tab. IV) as many as 25 belong to the above range. Obviously, this is in connection with the introduction of photographic methods of observation, making possible a more systematic search and easier discovery of relatively bright, but high-inclination objects. Out of the remaining 9 minor planets 6 are "interesting" objects, 4 of them being Apollos and 2 Atens, but for some of them high apparent brightness is fictitious, since the method of computation of the mean opposition magnitude fails to provide a reasonably close representation for objects of small semimajor axis, and high eccentricity and inclination. Note however, that such an object appears as a dash instead of a star-like image on the plates if the telescope follows the mean motion of main-belt objects. Therefore, it seems fainter than it really is, and escapes the detection for some time.

In analogy with Figs. 3 and 4, the distribution of belated discoveries is shown in Figures 5 and 6 in the (i, a) and (e,a) planes, respectively. The crosses denote corresponding median values of the numbered minor planet sample as a whole. It should be emphasized that:

– the distribution of belated discoveries does not show any significant bias with respect to the semimajoraxis (M_{ab} = 2.7198 AU);

– with a single exception – 554 Peraga – the belatedly discovered minor planets all have moderately high or high inclinations ($M_{ib} = 15^{\circ}.835$);

– 12 of 34 belated discoveries have the orbital eccentricity lower than the median of the whole numbe-

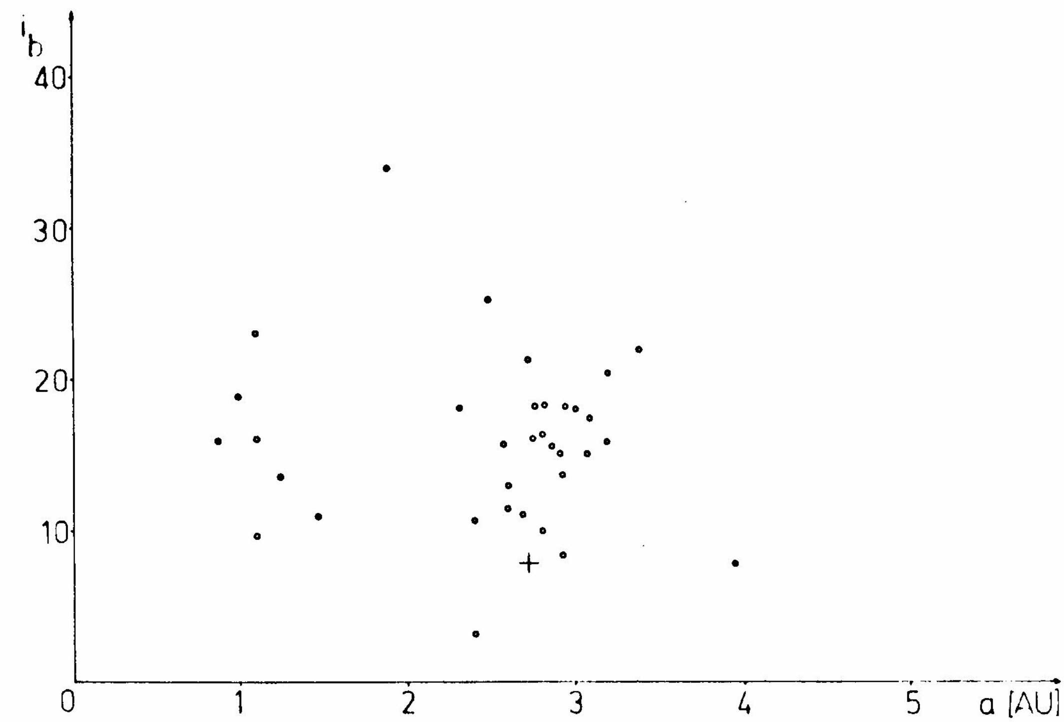

Figure 5: The distribution of belated discoveries in the (i,a) plane.

red sample, 20 have the moderately eccentric orbits, while 2 Apollos: 1566 Icarus (e = 0.827) and 1865 Cerberus (e = 0.467), as well as Aten-type object 2100 Ra-Shalom (e = 0.436) represent obvious exceptions in that respect. The median eccentricity of belated discoveries amounts to M_{eb} = 0.187, which is not very much higher than the median of the numbered sample as a whole.

Accordingly, again in agreement with expectation, the inclination turns out to be the most significant factor for the belated discoveries.

By the way, it seems rather peculiar that 532 Herculina ($\Delta B = -4^{m}.0$), an object of considerable size, average semimajor axis and eccentricity, and moderately high inclination, could have escaped discovery for quite a long time. To certain extent this refers also to 704 Interamnia and, eventually, 554 Peraga.

It appears that no special conclusion can be drawn with regard to the places of discovery of minor planets considered to be discovered belatedly. Heidelberg discoveries, 11 in all, which represent 32% of the belated discoveries subsample, dominate in the period immediately following the introduction of photography, while the contribution of other observatories clearly reflects the changing observational activity at these observatories. Obviously, all Palomar discoveries come from the special surveys.

Due to their apparent brightness, all but five belatedly discovered minor planets can be found in the TRIAD list of Bowell et al. (1979). The 12 belatedly discovered C-types all range among the large or very large minor planets. There are also 10 S-types ranging in diameter from 1.1 km of 2062 Aten to 219 km of 532 Herculina, this range being even wider for 5 U-type objects.

The low albedo C-types are underrepresented in the subsample of belated discoveries with respect to their 75% representation in the minor planet main belt (Zellner, 1979), while the high albedo types are overrepresented.

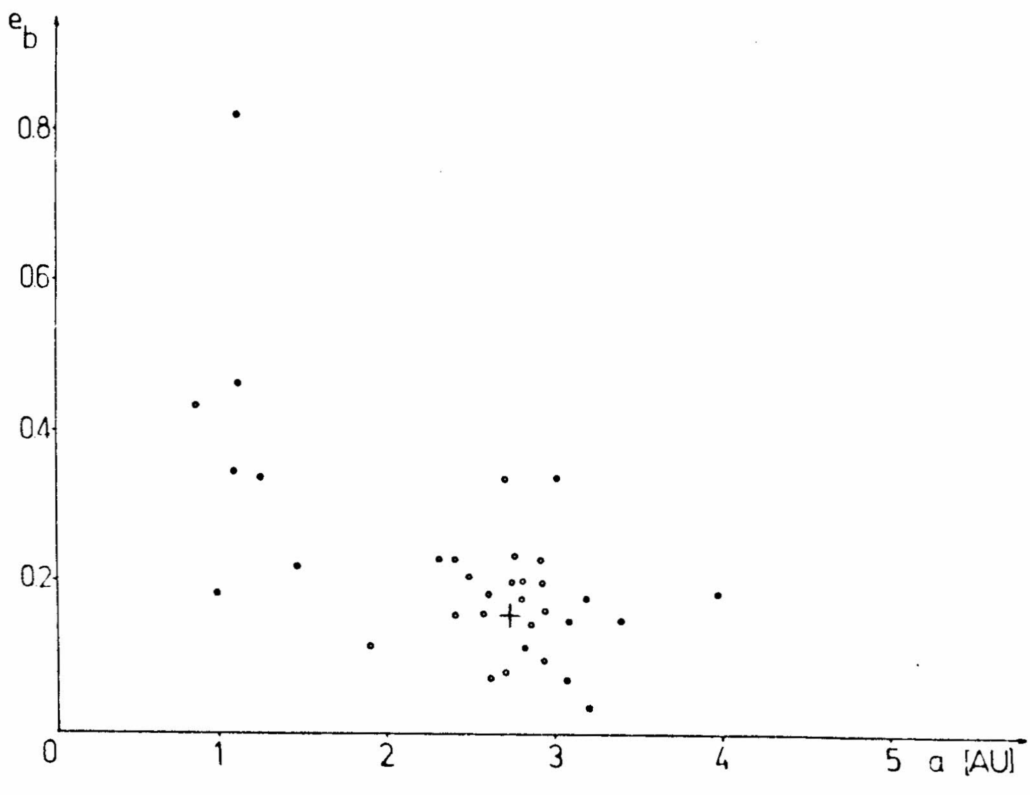

Figure 6: The distribution of belated discoveries in the (e,a) plane.

CONCLUSION

It is shown that various observational selection effects played an important role in the formation of the numbered minor planet sample. The sample is biased in the sense of lacking on low distance-high inclination minor planets, as well as on those of moderate size and low albedo, etc. The premature and belated discoveries, being a result of a complex influence of observational selection connected with the more or less unusual dynamical and physical properties of these objects, though they might not be affected by the considered effects only, permitted, in that respect, the simple straightforward analysis of the sources and extent of some selection effects in the numbered minor planet sample. At the same time, their importance is emphasized for the minor planet statistics in general.

As a matter of fact, one can expect, in the future, that there will be more premature discoveries, since new minor planet surveys are planned (Gehrels, 1979) or are already in progress (Bowell, 1979; Schmadel et al., 1979). Also, the space missions (Balogh et al., 1979; Morrison and Niehoff, 1979), which are to be realized in the near future, could provide practically unlimited number of new discoveries of faint minor planets. The contribution of "interesting" objects, in that respect, will probably be considerable, since for objects of unusual apparent motion once recorded on the plates, the efforts to obtain follow-up observations are greater as a rule than in the case of the main-belt minor planets.

By contrast, however, the belated discoveries in the sense of our definition are expected to be rather rare in the future, most likely appearing among the Earth-approaching minor planets.

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ORBITAL ELEMENTS OF THE BINARY SISTEM ADS 5958 = 0Σ170

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(Received February 23,1982.)

SUMMARY: Orbital elements, parallax, masses and absolute brightness of the components of the binary system ADS 5958 = 0Σ170 are reported.

This binary system was discoverd by O.Struve in 1844. The position angle has changed since by only 48°. Nevertheless, due to the high eccentricity and inclination of the orbit, about 2/3 of it appear to be well defined by the observations accomplished up to date. We therefore felt entitled to proceed to the derivation of the orbital elements of this pair. In the computer-drawn Fig. 1, the part of the apparent orbit from 1830 to 2030 is reproduced by points, the step being a year. The observations are denoted in this Fig. by crosslets. In Table 1 are given the basic catalogue data on this system and in

Table I

Indentification	0Σ170 = ADS 5958 = BDS 3949 = IDS 07122N0929
α, δ. (2000)	$7^h\ 17^m\!.2 + 9^\circ\ 19'$
m (ADS)	7.5 – 7.8
m (IDS)	7.6 – 7.9
Sp_A	GO
dπ(R.–M.)	0."020
dπ(J.–F.)	0.024
p.m. (ADS)	0."117 in 193.°9 (Cin018)
p.m. (IDS)	W028S114 sec "/1000 y

Table 2 the orbital elements and the standard astrophysical quantites. The ephemeris from 1980 to 2010, using a year step, are presented in Table III, while the Table IV summarises the observations and the residuals of the calculated orbit.

At calculating the orbital elements the effect of precession on the value of the position angle has been neglected. The Cambell's elements have been derived from the Innes'elements A,B,F,G, the latter being obtained using a geometrical method. In extracting the parallax and the mass of the components use has been made of components' apparent magnitudes as given in IDS catalogue as well as the empiric mass-luminosity relation for the main HR sequence (Popović , Angelov , 1970). The derived absolute brightnes of + 4.^{m}5 for the A component, combined with the observed GO spectrum, provided confirmation of the A component's belonging to the main HR sequence. The computed orbital parallax of 0."024 coincides competely with the dynamical one derived by Russel and Furner.

Table II

P = 206.^{y}04	A = + 0."29167	M_A = 4.51
n = 1.°74720	B = – 0.88214	M_B = 4.81
T = 1800.65	F = – 0.40476	
e = 0.72	G = – 0.65833	$\mathfrak{M}_A = 1.15\ \mathfrak{M}_\odot$
a = 1."10	C = + 0.58983	$\mathfrak{M}_B = 1.10\ \mathfrak{M}_\odot$
i = 116.°95	H = + 0.78330	
ω = 143.°02	t (Ω) = 1972.3	a = 45.8 AU
Ω = 89.°46	t (℧) = 2009.2	$\pi_{orb.}$ = 0."024

Table III

t	θ	ρ	t	θ	ρ
			1995.0	68.°5	0."52
1980.0	85.°6	1."06	96.0	65.8	0.47
81.0	85.0	1.03	97.0	62.4	0.42
82.0	84.3	1.00	98.0	58.1	0.37
83.0	83.7	0.98	1999.0	52.4	0.32
84.0	82.9	0.94	2000.0	44.5	0.27
85.0	82.2	0.91	01.0	33.3	0.22
86.0	81.3	0.88	02.0	16.9	0.18
87.0	80.4	0.84	03.0	354.7	0.16
88.0	79.5	0.81	04.0	330.6	0.17
89.0	78.4	0.77	05.0	310.4	0.20
90.0	77.2	0.73	06.0	295.9	0.23
91.0	75.9	0.69	07.0	285.4	0.27
92.0	74.4	0.65	08.0	277.4	0.30
93.0	72.8	0.61	09.0	270.8	0.33
1994.0	70.8	0.56	2010.0	265.1	0.35

In view of the rapid decreasing of components' separation it appears desirable to pursue the pair in the next dozen years, when the observations can be expected to be still reliable.

The completion of the list of observations (Table IV) was made possible by the curtesy of Dr. P.Couteau and Mrs.M.Fulconis of the Nice Observatory, to whom my best thanks are due.

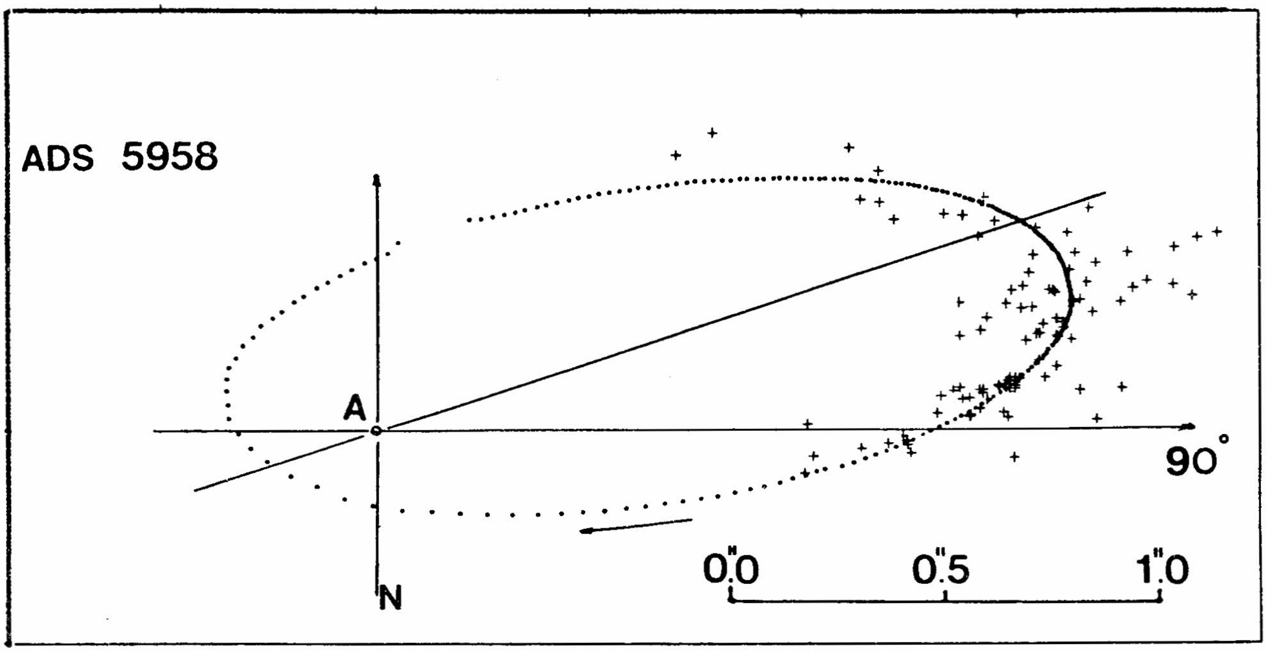

Figure 1.

Table IV

t	θ	ρ	n	Observer	0 – C	
1844.79	133°0	0″96	2	0Σ	-2°0	+0″13
49.25	132.0	1.06	2	0Σ	+0.9	+ .10
67.13	121.5	1.30	3	Δ	+1.1	+ .09
71.99	117.8	1.33	2	Δ	–0.5	+ .05
77.26	116.1	1.25	4	Sp	–0.2	– .10
82.25	114.7	1.30	4	Je	+0.2	– .11
91.88	111.8	1.53	13	Nis 6, Sp 7	+0.3	+ .02
93.15	112.9	1.30	3	Jones	+1.7	– .22
94.44	111.7	1.43	4	HΣ	+0.9	– .10
1898.03	110.9	1.47	4	Hu	+1.1	– .09
1900.58	109.1	1.53	4	SBn 1, Doo3	0.0	– .05
02.69	107.9	1.75	7	Maw 2, Sbk 3, Pos 2	–0.7	+ .16
03.2	108.4	1.47	12	GrO	0.0	– .13
06.03	107.8	1.62	19	Dob 3, Wz 7, Dob 3, Lv 3, Ino 3	+0.1	+ .01
09.93	106.4	1.68	22	Prz 6, Dob 3, Has 4, Gtk 1, Fox 3, Vou 3, J 1, Vdk 1	–0.3	+ .05
13.85	105.4	1.58	33	GrO 8, Neuj 2, RAn 3, Dob 3, Rabe 8, Phl 3, VRs 1, Roe 2, J 3	–0.3	– .07
18.20	104.8	1.69	29	FBn 3, Dob 3, Phl 3, Vvs 2, Lv 4, Chan 4, VBs 4,	+0.1	+ .03
21.150	104.0	1.56	2	Btz	0.0	– .10
21.70	103.6	1.67	17	B 3, GrO 4, Nv 12, Gcb 2, Dob 2, BerO 3, Prz 1	–0.2	+ .01

Table IV (Continued)

t	θ	ρ	n	Observer	0 – C	
1923.209	103°.9	1″.81	3	d	+0.4	+ .14
23.222	103.1	1.54	2	GΣ	–0.4	– .13
24.62	102.7	1.40	2	Fatou	–0.4	– .27
25.72	102.9	1.51	24	Kpz 4, Lv 4, Berm 4, Dob 3, Rabe 7, Bz 2	0.0	– .16
26.270	99.47	1.39	3	Rabe	–3.2	– .28
27.075	101.35	1.54	4	Rabe	–1.1	– .13
27.159	102.2	1.61	4	GΣ	–0.3	– .06
28.155	103.8	2.03	3	Kom	+1.5	+ .37
28.165	102.5	1.70	3	GΣ	+0.2	+0.04
29.110	103.4	1.91	3	Kom	+1.4	+ .25
29.60	101.8	1.49	5/4	Bz	–0.1	– .17
30.08	103.7	1.73	2	Dob	+1.9	+ .07
30.100	103.8	1.98	3	Kom	+2.0	+ .32
30.367	99.9	1.42	5	Wanur	–1.8	– .24
30.44	102.3	1.62	4	RB	+0.6	– .04
30.941	99.8	1.70	4	Ol	–1.8	+ .04
31.448	101.6	1.84	2	Ferdir	+0.1	+ .18
31.864	101.0	1.44	3	Sim	–0.4	– .22
32.056	99.9	1.94	3	Kom	–1.4	+ .28
32.163	102.3	1.61	3	Barb	+1.0	– .05
32.255	101.0	1.67	1	GΣ	–0.3	+ .01
32.844	101.16	1.55	16/9	Sim	+0.1	– .11
33.016	100.2	1.77	2	GΣ	–0.9	+ .11
33.860	101.0	1.90	3	Wil.J.	+0.1	+ .24
34.53	99.7	1.60	3	Bz	–1.0	– .05
36.207	100.99	1.663	6	Rabe	+0.7	+ .01
36.958	101.2	1.80	2	d	+1.1	+ .15
37.009	99.5	1.57	4	Sim	–0.6	– .08
39.194	99.36	1.629	6	Rabe	–0.2	– .01
39.21	98.9	1.62	3	Dur	–0.7	– .02
42.239	98.76	1.546	1	Jeffers	–0.0	– .07
42.239	98.36	1.610	1	Jeffers	–0.4	– .01
42.242	98.18	1.602	5	Rabe	–0.6	– .02
42.79	98.3	1.52	3	V	–0.4	– .10
43.203	97.87	1.642	6	Rabe	–0.7	+ .02
46.205	99.0	1.56	4	Lyons	+1.2	– .04
49.51	95.8	1.60	3	Prêtre	–1.1	+ .03
49.820	96.65	1.549		Lick Ob.	–0.2	– .02
50.197	95.84	1.588	10	Rabe	–0.9	– .03
51.226	95.02	1.562	8	Rabe	–1.5	± .00
53.212	95.13	1.496	9	Rabe	–0.8	– .04
54.202	94.87	1.472	8	Rabe	–0.7	– .10
55.220	94.65	1.465	7	Rabe	–0.7	– .05
56.217	93.40	1.421	8	Rabe	–1.6	– .09
57.093	94.6	1.48	2	Dj, Dc	–0.2	– .01
57.17	94.7	1.49	3	C	–0.1	+0.00
59.13	94.2	1.40	6	H	±0.0	–0.07
59.135	94.2	1.50	4	P	±0.0	+ .03
59.174	95.2	1.50	5	hi	+1.0	+ .03
59.182	95.4	1.48	3	d	+1.2	+ .01
59.48	94.8	1.45	3/2	D.Jones	+0.8	–0.01
60.202	93.4	1.36	1	hi	–0.4	– .09
60.202	93.7	1.75	1	p	–0.1	+ .30
61.135	94.3	1.41	1	d	+0.8	– .03
61.16	94.4	1.34	3	D.Jones	+0.9	– .10
61.808	91.4	1.69	1	Hld	–1.9	+ .26
62.14	94.9	1.37	3	MCandy	+1.7	– .06
62.226	94.7	1.50	4	hi	+1.5	+ .08
62.226	94.5	1.45	4	la	+1.3	+ .03

Table IV (Continued)

t	θ	ρ	n	Observer	O – C	
1962.234	93.7	1.65	4	p	+0.5	+ .23
62.762	93.8	1.31	4	B	+0.8	– .11
63.05	91.7	1.48	4	LSymms	– 1.2	+ .07
63.225	92.7	1.40	3	DZ 1, Dj 2	–0.1	– .01
63.258	94.2	1.49	4	hi	+1.4	+ .08
63.479	91.9	1.38	4	Wor	– 0.9	– .03
63.595	92.3	1.30	4	Wor	– 0.4	– .10
64.15	92.1	1.39	4	hz	0.4	– .01
64.221	92.3	1.47	3	p	– 0.2	+ .08
64.228	93.9	1.41	3	hi	+1.4	+ .02
65.239	93.6	1.38	4	Walker Jr.	+1.1	± .00
66.16	91.9	1.38	3	Bertin	+0.1	+ .02
71.934	88.1	1.24	1	GP	–1.5	– .01
71.934	91.9	1.00	1	DZ	+2.3	– .25
72.073	87.9	1.49	1	VBs	– 1.6	+ .24
72.22	91.0	1.05	1	DZ	+1.5	– .20
73.084	89.4	1.20	4	Wor	+0.3	– .03
74.12	89.0	1.23	3	hz	+0.4	+ .02
76.079	90.1	1.22	1	Hld	+2.4	+ .06
77.058	88.5	1.12	3	Hld	+1.6	± .00
77.08	89.5	1.24	3	hz	+2.3	+ .10
81.236	87.4	1.01	4	DZ	+2.6	– .02
1981.240	84.7	1.01	5	GP	– 0.1	–0.02

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MICROMETER MEASURES OF DOUBLE STARS
(Series 35)

G.M. Popović

(Received February 15, 1982.)

SUMMARY: Presented are 179 measures of 76 double and multiple systems of stars.

Presented are 179 measures of 76 double and multiple systems. This is the 35th Belgrade series of the double stars measures and, at the same time, a continuation of my measures published as Series 34 (G.M.Popović, 1982). The structure of the measured pairs according to ρ is given in Table I.

Table II lists the measurements in the form identical to that of my previous series. In calculating the 0–C differences in the orbital pair I use has been made of the paper of P.Muller and P. Couteau (1979).

Table I

$\rho < 0''50$	$0''50 \leqslant \rho < 1''00$	$1''00 \leqslant \rho < 2''00$	$\rho \geqslant 2''00$	Σ
4m 2.2%	57m 31.8%	[illegible]9m 44 1%	39m 21.8%	179 100%

Table II

ADS Disc. α, δ 1900-2000 m Mult.	Epoch 1900+	θ	ρ	m	Weight	Notes
– COU 1046	81.72	35°6	2"30	9.0--12.0	1+1	
00042-094N4159-92						
9.5 – 11.1 (3n)						
3956 Σ 677	81.22[illegible]	150.1	0.89	8.0 -8.5	1+2	
05153-247N6317-26	81.22[illegible]	154.6	0.91	dm = 0.6	1+2	
7.9 - 8.2	81.22[illegible]	152.4	0.90	dm = 0.6	2n	Heintz, 1962: –4°7, –0"14
4891 β 18	81.154	280.1	1.72	8.5 -9.5	1+1	
06120-166S1201-03	81.157	277.9	1.67	9.0 - 10.5	1+1	
7.0 – 8.7	81.156	279.0	1.70	8.8 - 10.0	2n	
4950 Σ 881	81.223	132.9	0.68	8.0 – 9.0	1+2	
06132-221N5925-23	81.225	132.3	0.66	dm = 1.5	2+2	
6.2 – 7.7 AB	81.234	132.8	0.78	8.0 – 9.0	2+1	
	81.227	132.6	0.70	dm = 1.2	3n	The angle has increased by 43° since 1830
5051 J 260	81.217	183.6	1.38	9.0 - 11.0	1+1	
06203-257N0748-45	81.220	183.5	1.44	dm = 3.0	1+1	
8.8 - 11.7	81.218	183.6	1.41	dm = 2.5	2n	

Table II (Continued)

ADS α . δ m	Disc. 1900-2000 Mult.	Epoch 1900+	θ	ρ	m	Weight	Notes
5053	A 2723	81.217	22°.1	0".75	10.8 - 11.2	1+1	
06204-258N0750-47		81.220	26.5	0.64	10.0 10.7	1+1	
9.1 10.7		81.218	24.3	0.70	10.4 11.0	2n	
5081	J 910	81.122	330.9	1.85	dm = 0.5	1+1	
06213-285N4308-05		81.154	333.0	1.50	9.5 – 9.6	1+1	
10.0 - 10.4	AB	81.206	332.5	1.64	9.5 – 10.0	1+2	
		81.167	332.2	1.66	dm = 0.4	3n	Retrograde motion
5197	Σ 932	81.239	311.7	1.91	dm = 0.0	2.2	Hopmann,1959: +0°.7, +0".14
06286-343N1449-44							
8.1 8.2							
5400	Σ 948	81.239	80.8	1.76	dm = 0.5	1+2	Brosche, 1955: +2°.6, +0".07
06374-463N5933-27							
5.3 6.2	AB						
5423	AGC 1	81.225	46.0	10.14	–	1+1	
06408-452S1635-41		81.234	47.7	10.07	–	1+1	
1.58 8.5	AB	81.230	46.8	10.10		2n	van den Bos,1960: +1°.0, +0".22
5469	A 2731	81.217	56.7	0.94	8.5 - 9.0	2+1	
06432-486N0744-38		81.225	54.7	0.92	9.0 – 9.8	1+2	
8.7 9.5		81.234	56.9	1.03	8.0 – 9.0	1+2	
		81.225	56.1	0.96	8.5 - 9.2	3n	Muller, 1956: –5°.0, 0".00
5570	Σ 981	81.239	131.8	1.79	9.0 – 9.3	2+2	Hopmann,1971: –0°.7, +0".09
06491-555N3018-10							
8.9 8.9							
5596	Σ 1033	81.154	276.1	1.49	8.0 - 9.0	1+1	
07069-148N5243-33		81.206	276.1	1.51	8.0 - 9.0	2+2	
7.7 8.3	AB	81.189	276.1	1.50	8.0 - 9.0	2n	
5958	OΣ 170	81.217	84.3	1.02	7.5 – 7.6	2+2	
07122-172N0929-19		81.220	83.3	1.05	8.0 – 8.2	1+2	
7.6 – 7.9		81.223	82.3	0.97	7.5 - 7.7	1+2	
		81.225	84.9	1.00	8.0 - 8.3	2+2	
		81.283	86.6	1.02	dm = 0.0	3+3	
		81.240	84.7	1.01	dm = 0.1	5n	Popović, 1981: +0°.1, –0".01
–	GP 133	81.223	34.7	9.00	9.0 11.0	1+1	GP 133 = BD + 35°1773 (9^m.3)
08047-112N3545-28		81.228	36.5	9.23	10.0 11.0	1+2	
9.4 11.0 (5n)		81.231	34.4	9.05	9.5 – 11.0	2+2	
		81.228	35.2	9.10	9.5 11.0	3n	
–	GP 111	81.288	49.9	0.89	10.0 10.2	3+2	
08084-149N3553-35							
9.9 10.1 (3n)							
6671	β 1244	81.217	16.7	1.06	8.7 – 9.0	2+1	
08086-138N0177-59		81.223	15.8	0.95	8.5 - 9.0	1+1	
8.3 8.5		81.280	18.6	1.04	8.0 9.0	2+2	
		81.246	17.3	1.03	8.4 9.0	3n	The angle has decreased by 33° since 1891.
7067	Σ 1280	81.217	119.5	1.30	8.0 8.2	2+2	
08460-557N7071-48		81.220	120.3	1.23	8.0 - 8.0	2+2	
9.3 9.4	AB	81.223	121.2	1.28	dm = 0.1	1+2	
		81.220	120.2	1.27	dm = 0.1	3n	Heintz 1973: – 1°.9, +0".06

Table II (Continued)

ADS α . δ m	Disc. 1900-2000 Mult.	Epoch 1900+	θ	ρ	m	Weight	Notes
7081	AG	81.308	186°.2	1″.57	9.0 – 9.5	1+1	The angle has decreased by 51° since 1912.
08491-546N1659-36							
9.3 – 9.4							
7203	Σ 1306	81.220	3.0	3.12	dm = 5.0	1+2	
09016-104N6732-08		81.223	3.9	3.13	dm = 5.0	1+2	
5.0 – 8.2	AB	81.283	4.2	3.10	dm = 3.0	2+2	
		81.286	1.9	3.07	dm = 4.0	1+1	
		81.357	2.4	3.03	–	1+1	
		81.268	3.3	3.10	dm = 4.0	5n	Baize, 1947: – 0°.6, –0″.14
7307	Σ 1338	81.308	253.4	1.01	7.2 – 7.5	1+1	
09147-210N3837-12		81.379	255.1	1.10	dm = 0.8	2+2	
6.6 – 6.8	AB	81.355	254.5	1.07	dm = 0.6	2n	Starikova, 1966: –4°.6, +0″.18
7404	A 130	81.226	100.2	0.96	11.8–12.0	1+1	Slow retrograde motion.
09249-305N2052-26							
11.0 – 11.0							
–	GP 151	81.226	82.8	0.42	9.0 – 9.1	1+1	GP 151 = BD + 44°1931 (8.2)
09503-567N4427-00		81.228	77.5	0.62	9.0 – 9.1	1+2	
8.9 – 9.0 (4n)		81.283	78.1	0.46	9.4 – 9.5	3+3	
		81.258	78.8	0.50	9.2 – 9.3	3n	
7624	Hu 631	81.226	257.3	0.85	dm = 1.5	1+2	
09582-641N3268-39		81.234	260.0	0.72	dm = 1.5	1+1	
7.8 – 9.4		81.280	256.4	0.83	8.0 – 9.5	1+1	
		81.244	257.8	0.81	dm = 1.5	3n	Slow retrograde motion.
–	KUI 47	81.283	285.2	1.34	–	3+2	
10017-111N7537-08		81.289	283.5	1.27	10.0–10.0	2+2	
10.6 – 10.7		81.302	282.0	1.21	10.0–10.0	1+2	
		81.290	283.8	1.28	10.0–10.0	3n	Baize, 1954: +2°.1, +0″.04
7704	0Σ 215	81.228	185.0	1.36	dm = 0.5	1+1	
10108-163N1774-44		81.239	185.6	1.57	8.0 – 8.7	1+1	
7.3 – 7.5		81.286	186.0	1.43	–	1+1	
		81.357	187.6	1.44	dm = 0.3	1+1	
		81.371	185.6	1.36	dm = 0.3	1+2	
		81.303	185.9	1.42	dm = 0.3	5n	Wierzbinski, 1953: +3°.0, +0″.03 Zaera, 1957: +5.2, + 0.04
7758	Σ 1429	81.280	182.0	0.63	dm = 0.0	2+2	
10195-250N2468-38		81.288	182.3	0.62	9.0 – 9.0	2+2	
9.0 – 9.0		81.302	189.0	0.65	dm = 0.0	2+1	
		81.289	184.0	0.63	dm = 0.0	3n	Zulević, 1981: – 0°.2, +0″.04
7888	0Σ 227	81.226	358.9	0.86	8.5 – 8.8	1+2	
10364-416N1076-45		81.228	357.1	0.94	8.0 – 8.5	1+1	
8.0 – 9.0		81.280	363.5	0.85	dm = 0.5	1+2	
		81.247	360.2	0.88	dm = 0.4	3n	The angle has increased by 34° since 1845.
8032	A 1590	81.302	344.8	1.32	9.5 – 10.2	1+1	
10576-635N5464-32		81.308	344.5	1.25	dm = 1.2	1+1	
9.2 – 9.7		81.357	348.1	1.43	dm = 0.5	1+1	
		81.322	345.8	1.33	dm = 0.8	3n	Heintz, 1963: +3°.6, +0″.11
8119	Σ 1523	81.239	101.8	2.73	dm = 0.5	1+1	
11128-182N3166-33		81.280	101.5	2.86	dm = 1.0	2+2	
4.4 – 4.9		81.266	101.6	2.82	dm = 0.8	2n	Heintz, 1966: 0°.0, +0″.02

Table II (Continued)

ADS / Disc. / α . δ 1900-2000 / m Mult.	Epoch 1900+	θ	ρ	m	Weight	Notes
8128 Σ 1527	81.218	35°.3	1".28	7.0 – 8.2	1+1	
11138-191N1449-16	81.220	35.1	1.35	7.5 – 8.5	1+1	
6.9 – 8.1	81.223	35.9	1.33	8.2 – 9.0	1+1	
	81.239	32.2	1.22	8.5 – 9.5	1+2	
	81.225	34.4	1.29	7.8 – 8.8	4n	Hopmann, 1958: +3°.6, –0".21
8197 OΣ 235	81.283	223.6	0.31	dm = 1.0	1+2	Heintz, 1971: +3°.6, –0".09
11267–324N6138-05						
5.8 – 7.1						
8311 β 603	81.283	354.0	0.88	dm = 4.0	1+1	
11435-487N1450-17	81.289	354.7	0.82	6.0 – 8.0	2+2	
5.9 – 10.1	81.287	354.5	0.84	dm = 2.7	2n	Heintz, 1962: +5°.7, –0".19 Muller, 1977: +0°.8, –0".39
8355 OΣ 241	81.376	139.5	1.40	7.5 – 9.0	1+2	
11511-563N3560-27	81.379	142.7	1.54	dm = 2.0	1+2	
6.8 – 8.7 AB	81.378	141.1	1.47	dm = 1.8	2n	The angle has increased by 22° since 1949
8421 Σ 1601	81.371	297.7	1.87	dm = 2.0	1+1	
12010-061N3883-50	81.379	300.6	2.03	9.0 – 10.0	3+3	
9.1 – 10.3	81.377	299.9	1.99	dm = 1.2	2n	Retrograde motion.
8561 Σ 1645	81.431	157.5	9.88	dm = 0.7	2+2	
12232-281N4481-48						
7.4 – 8.0						
8569 OΣ 251	81.289	52.1	0.54	8.5 – 10.0	2+2	Baize, 1955: –1°.5, –0".06.
12242-292N3157-24						
8.3 – 10.0						
8575 Σ 1647	81.280	239.3	1.37	dm = 0.3	1+1	
12255-306N0976-43	81.283	239.5	1.31	8.5 – 8.6	2+2	
8.5 – 8.8	81.289	241.3	1.33	8.0 – 8.0	3+2	
	81.285	240.3	1.33	dm = 0.1	3n	Hopmann, 1950: –2°.0, 0".00
8635 A 1851	81.379	236.7	0.40	10.0 – 10.5	2+2	Baize, 1965: +4°.9, –0".02
12372-421N2654-21						
10.2 – 10.6						
8708 OΣ 256	81.226	93.5	0.89	dm = 0.0	1+1	
12513-564S0025-57	81.281	93.6	0.97	dm = 0.2	1+1	
7.2 – 7.6	81.254	93.6	0.93	dm = 0.1	2n	The angle has increased by 37° since 1848.
– GP 72	81.226	315.5	1.86	dm = 1.0	1+1	
13119-166N3464-32	81.283	317.2	1.76	12.0 – 13.0	3+2	
10.6 – 11.6 (5n)	81.267	316.7	1.79	dm = 1.0	2n	
– GP 119	81.283	12.7	0.56	10.0 – 10.3	3+2	GP 119 = BD + 41°2389 (9.m1)
13187-232N4061-30	81.289	14.5	0.64	10.0 – 10.2	2+2	
9.7 – 10.0 (4n)	81.286	13.5	0.60	10.0 – 10.3	2n	
8887 Ho 260	81.289	69.3	1.19	8.5 – 8.8	2+2	
13189-236N2945-14	81.302	71.4	1.07	9.0 – 9.5	2+2	
9.6 – 9.8	81.382	70.8	1.12	9.0 – 9.5	2+1	
	81.431	70.8	1.07	9.2 – 9.7	3+2	
	81.358	70.5	1.11	9.0 – 9.4	4n	Ambruster, 1978: –2°.1, –0".05

Table II (Continued)

ADS α, δ m	Disc. 1900-2000 Mult.	Epoch 1900+	θ	ρ	m	Weight	Notes
8895	OΣ 265	81.376	289°.0	24″.04	dm = 4.0	1+2	
13202-253N0082-51		81.382	289.4	24.81	dm = 4.0	1+2	
8.0 – 11.0	AB	81.379	289.2	24.42	dm = 4.0	2n	Probably optical!
8943	A 1095	81.283	252.9	0.42	9.0 – 9.4	3+2	
13290-336N2975-44		81.379	252.5	0.43	8.7 – 9.2	2+2	
8.9 – 9.5		81.326	252.7	0.42	8.9 – 9.3	2n	Zulević, 1964: –6°.5, +0″.02
8974	Σ 1768	81.376	101.7	1.66	–	1+1	Wierzbinski, 1955: –1°.9, +0″.17
13330-375N3648-17							
5.1 – 7.0	AB						
4.9 – 8.7	AC	81.371	320.6	215.1	–	1+1	Neither the position angle of 140° from 1918, nor the one of 248° from 1958, have been repeated. The pair is indentified beyond any doubt and the quadrant unambiguously determined.
		81.376	320.8	214.2	mc = 10.0	1+1	
		81.374	320.7	214.6	–	2n	
9174	Σ 1816	81.376	87.2	0.77	dm = 0.2	2+1	One is still not able to decide whther the pair is an optical or physical one.
14095-139N2934-06		81.379	84.2	0.82	dm = 0.3	2+1	
7.5 – 7.6		81.382	87.6	0.86	dm = 0.2	1+1	
		81.431	86.8	0.79	7.5 – 7.7	2+2	
		81.456	88.9	0.73	dm = 0.1	1+1	
		81.405	86.7	0.79	dm = 0.2	5n	The decrease in distance.
9269	Ho 542	81.283	222.8	0.83	9.0 – 9.0	3+2	
14230-277N2064-37		81.289	220.4	0.80	dm = 0.0	1+1	
10.7 – 10.7		81.285	222.1	0.82	dm = 0.0	2n	The angle has decreased by 52° since 1896.
–	GP 153	81.382	353.1	0.90	11.0–11.0	1+1	
13495-538N4134-04							
10.0 – 10.1 (2n)							
9340	Σ 1867	81.472	5.0	0.87	dm = 0.7	1+1	
14365-407N3143-17		81.480	4.6	0.86	dm = 0.7	1+1	
8.4 – 8.9		81.483	4.9	0.92	dm = 0.7	1+1	
		81.478	4.8	0.88	dm = 0.7	3n	The retrograde motion and the distance closes in.
9425	OΣ 288	81.447	173.2	1.41	8.0 – 8.7	1+2	Heintz, 1950: +2°.7, +0″.19
14487-534N1567-43							
6.9 – 7.6							
9530	A 1116	81.382	47.5	0.77	dm = 0.1	1+1	
15068-116N1030-08		81.431	45.0	0.78	dm = 0.0	2+2	
8.5 – 8.5		81.415	45.8	0.78	dm = 0.0	2n	Since 1905 the angle increased by 25°.
9630	Σ 1941	81.382	217.9	1.45	dm = 0.0	3+2	
15215-257N2659-38		81.431	217.8	1.38	9.0 – 9.0	2+2	
9.1 – 9.1		81.447	219.8	1.32	9.0 – 9.0	1+2	
		81.414	218.3	1.39	dm = 0.0	3n	The retrograde motion.
9716	OΣ 298	81.540	220.6	0.66	dm = 0.0	2+2	
15325-361N3968-48		81.546	221.2	0.74	dm = 0.3	1+2	
7.4 – 7.7	AB	81.543	220.8	0.69	dm = 0.1	2n	Couteau, 1965: +2°.9, +0″.05
9742	A 2076	81.431	0.3	0.69	dm = 0.0	2+2	
15360-405N1860-41		81.442	359.3	0.60	9.0 – 9.1	1+1	
8.4 – 8.4		81.448	0.8	0.66	9.0 – 9.2	1+2	
		81.439	0.2	0.66	dm = 0.1	3n	Since 1909 the angle increased by 34°.

Table II (Continued)

ADS / α.δ 1900-2000 / m	Disc. / Mult.	Epoch 1900+	θ	ρ	m	Weight	Notes
9804	Σ 1982	81.541	298°.9	4″.82	9.5 – 9.6	3+2	
15465-498N4265-47							
9.6 – 9.8							
9814	β 810	81.540	83.9	1.33	8.5 – 12.0	2+1	
15476-510N4246-28							
8.9 – 11.6							
10075	Σ 2052	81.289	137.4	1.49	8.0 – 8.3	1+2	
16245-289N1837-25		81.442	134.3	1.45	8.0 – 8.3	2+2	
7.8 – 7.8	AB	81.448	132.8	1.51	dm = 0.0	2+2	
		81.483	139.0	1.47	dm = 0.3	1+1	
		81.415	135.3	1.48	dm = 0.2	4n	Siegrist, 1950: +1°.6, +0″.02
10429	A 2984	81.382	356.2	1.00	–	2+2	
17114-165S0020-27		81.431	359.9	0.87	–	2+1	
4.9 – 7.9		81.403	357.8	0.94		2n	Since 1915 the angle increased by 60°
–	COU 1294	81.541	81.7	0.89	10.0–10.1	1+1	
17125-157N4023-16							
10.3 – 10.3 (3n)							
11483	OΣ 358	81.431	165.2	1.89	dm = 0.1	3+2	
18314-359N1654-59		81.726	165.2	1.71	dm = –0.1	2+2	
6.8 – 7.2	AB	81.562	165.2	1.81	dm = 0.0	2n	Starikova, 1966: +5°.1, +0″.28
							Hopmann, 1970: +4°.1, +0″.27
11989	H 126	81.289	201.2	1.21	–	1+1	
18584-643S2141-32		81.382	205.5	1.27	dm = 0.6	2+2	
7.5 – 7.8		81.351	204.1	1.25	dm = 0.6	2n	Gottlieb, 1946: +12°.1, + 0″.30
12040	Σ 2454	81.541	282.2	1.06	dm = 2.0	2+2	Baize, 1975: +3°.1, –0″.17, elipt.
19023-062N3017-26							Olević, 1977: +2°.6, –0″.06, rectil.
8.5 – 9.7	AB						
12497	Hu 1194	81.557	42.0	0.92	9.0 – 9.0	1+1	
19245-281N3508-20		81.688	39.1	0.92	dm = 0.0	2+2	
9.5 – 9.7	AB	81.727	38.6	0.94	9.3 – 9.3	1+2	
		81.770	39.5	0.91	dm = 0.0	3+2	
		81.707	39.6	0.92	dm = 0.0	4n	
–	GP 34	81.557	51.0	2.54	–	1+1	Whether the pair is an optical or physical will be known in a few years.
19252-289N3503-25		81.598	47.8	3.38	10.0–14.0	1+1	
9.6 – 13.2 (19n)	AB	81.688	48.7	3.33	9.5 – 14.0	1+1	
		81.724	48.4	3.02	10.0–13.0	2+2	
		81.726	48.8	2.64	10.0 – 13.0	2+1	
		81.770	45.3	3.24	–	3+2	
		81.776	48.7	2.90	–	1+2	
		81.711	48.0	3.02	9.9 – 13.3	7n	The angle has decreased by 31° since 1969.
	AC	81.726	3.5	34.02	10.0 – 12.0	1+2	
–	GP 135	81.688	33.8	1.79	10.0 – 11.5	1+1	
19253-290N3456-78		81.770	38.1	1.80	11.0 – 13.0	1+1	
10.7 – 11.9 (7n)		81.729	36.0	1.80	10.5 – 12.2	2n	
–	GP 155	81.557	95.4	3.82	10.0 – 13.0	1+1	
19260-297N3458-71		81.727	98.5	3.93	10.0 – 12.0	1+1	
10.0 – 12.1 (5n)		81.642	97.0	3.88	10.0 – 12.5	2n	

Table II (Continued)

ADS Disc. α, δ 1900-2000 m Mult.	Epoch 1900+	θ	ρ	m	Weight	Notes
– GP 24	81.727	246°.0	7".54	9.5 – 11.0	1+2	GP 24 = BD +34°4278 (9.5)
21019-059N3435-59						
9.5 – 11.2						
– GP 22	81.688	95.3	6.14	9.5 – 12.0	1+1	GP 22 = BD +34°4283 (9.5)
21025-066N3412-56	81.727	96.1	5.94	9.0 – 11.0	1+1	According to C.d.C the angle 1920
9.4 – 11.0 (5n) AB	81.708	95.7	6.04	9.2 – 11.5	2n	has been ~80° and distance ~7".5.
14784 Σ 2783	81.541	8.4	0.73	dm = 0.1	1+2	The angle has decreased by 33° since
21114-141N5753-78						1831. ρ closes in.
7.8 – 7.8						
14889 OΣ 437	81.541	23.3	2.13	dm = 0.3	1+2	
21166-208N3202-28	81.727	25.3	2.10	dm = 0.7	1+2	
6.9 – 7.6 AB	81.765	26.4	2.07	dm = 0.4	1+2	
	81.678	25.0	2.10	dm = 0.5	3n	The angle has decreased by 43° since 1845.
15270 Σ 2822	81.541	297.9	1.91	dm = 1.5	1+2	
21397-441N2817-45	81.598	298.1	1.88	dm = 1.5	1+1	
4.7 – 6.1 AB	81.765	295.8	1.76	dm = 1.5	1+1	
	81.776	299.9	1.90	–	2+2	
	81.787	295.9	1.91	5.0 – 7.5	1+1	
	81.694	297.9	1.88	dm = 1.8	5n	Heintz, 1965: –1°.3, +0".12.
15769 Σ 2881	81.541	80.3	1.24	dm = 0.7	2+2	The angular decrease by 31° since
22100-145N2905-35						1830 and decrease in distance.
7.6 – 8.1						
16317 Σ 2950	81.727	291.7	1.57	dm = 1.5	1+2	There is C component.
22474-513N6109-41	81.765	287.4	1.41	dm = 2.0	1+1	The angle decreased by 30° since 1932.
6.1 – 7.4 AB	81.855	286.8	1.45	dm = 1.0	1+1	
	81.774	289.1	1.49	dm = 1.5	3n	
16472 Σ 2973	81.776	39.4	7.53	7.5 – 10.0	1+2	
22582-628N4331-63	81.855	43.5	7.06	dm = 3.5	1+1	
6.4 – 9.6	81.808	41.0	7.34	dm = 3.0	2n	
30 OΣ 514	81.727	171.8	5.21	7.5 – 11.0	1+2	
23595-646N4132-65						
6.1 – 8.7						

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MICROMETER MEASURES OF DOUBLE STARS
(Series 36)

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(Received February 28,1982.)

SUMMARY: Presented here are 167 measures of 77 double stars made with 65/1055 cm refractor of Belgrade Observatory.

The present list is a continuation of the published series of measures of double stars in Belgrade, made in the period 1981.15 – 1981.95. In the Table II of measures the columns give: ADS number, double star designation, multiple, position for 1900 (IDS), epoch omitting the century, position angle, separation, estimated magnitudes, number of nights and notes. An asterisk in the second column indicates that there is a note at the end of Table II.

In the present work the distribution of 167 measures of distances is as follows (Table I):

Table I

$\rho < 0''50$	$0''50 < \rho \leq 1''00$	$1''00 < \rho < 1''50$	$1''50 < \rho \leq 2''00$	$\rho > 2''00$
5 3.0%	47 28.9%	70 41.9%	23 13.8%	22 13.2%

Table II

ADS	DISC. IDS	Mult.	Epoch 1900+	p	ρ	Est.mag,	n	Notes
2122	STF 305	AB	81.948	310°1	3″52	7.4 -8.3	1	Rabe,1940: +1°0; -0″13
	02418N1857							
3956	STF 677		81.220	153.2	0.94	8.0-8.3	1	Heintz,1962: -3°9; -0″10
	05153N6317							
4891	BU 18		81.154	285.3	1.54	7.0-8.5	1	
	06120S1201		81.157	285.4	1.45	8.0-9.5	1	
			81.155	285.4	1.49		2	
4950	STF 881	AB	81.206	131.0	0.89	6.5-7.3	1	
	06132N5925							
5051	J 260		81.217	181.1	1.48	8.0-11.0	1	
	06203N0748		81.220	182.3	1.45	8.5-11.5	1	
			81.219	181.7	1.46		2	
5053	A 2723		81.217	28.5	0.78	8.7-9.5	1	
	06204N0750		81.220	26.9	0.70	Δm = 0.5	1	
			81.219	27.7	0.74		2	

Table II (Continued)

ADS	DISC. IDS	Mult.	Epoch 1900+	p	ρ	Est.mag,	n	Notes
5081	J 910	AB	81.154	335°.0	1".38	9.5–10.0	1	
	06213N4308		81.163	334.6	1.42	9.4–9.9	1	
			81.206	334.4	1.45	9.0–9.5	1	
			81.174	334.7	1.42		3	
5197	STF 932		81.239	313.8	1.75	8.0–8.1	1	Hopmann,1959: +2°.8; –0".02
	06286N1449							
5400	STF 948	BC	81.239	80.4	1.71	5.5–6.5	1	Brosche,1955: +2°.2; +0".02
	06374N5933							
5423	AGC 1	AB	81.225	45.2	10.00		1	Bos,1960: –0°.7; +0".11.
	06408S1635							
5469	A 2731		81.217	52.8	0.91	8.5–9.5	1	
	06432N0744		81.225	55.5	0.96	8.5–9.5	1	
			81.234	55.9	0.95	8.7–9.5	1	
			81.225	54.7	0.94		3	Muller,1956: –6°.5; –0".02
5570	STF 981		81.239	136.0	1.62	8.5–8.6	1	Hopmann,1971: +3°.5; –0".08
	06491N3018							
5896	STF 1033	AB	81.154	276.8	1.44	7.5–8.0	1	
	07069N5243		81.163	276.0	1.53	7.5–8.0	1	
			81.206	278.5	1.43	8.3–9.0	1	
			81.174	277.1	1.47		3	
5958	STT 170		81.217	87.0	1.09	7.5–7.7	1	
	07122N0929		81.220	88.8	0.98	Δm = 02.	1	
			81.225	86.1	0.97	7.5–7.8	1	
			81.283	87.7	1.01	7.5–7.6	1	
			81.236	87.4	1.01		4	Popović, 1982: +2°.6; –0".03
6671	BU 1244		81.217	17.4	0.92	8.2–8.8	1	
	08086N0177		81.280	19.5	0.95	8.5–9.0	1	
			81.249	18.5	0.93		2	
7067	STF 1280	AB	81.217	120.8	1.23	8.2–8.3	1	
	08460N7071		81.220	120.0	1.18	8.0–8.1	1	
			81.223	121.0	1.21	8.0–8.1	1	
			81.220	120.6	1.21		3	Heintz,1973: –1°.5, 0".00
7081	AG –		81.308	187.9	1.52	9.1–9.3	1	
	08491N1659							
7203	STF 1306	AB	81.220	3.5	3.06	5.0–9.0	1	
	09016N6732		81.223	5.2	3.11	5.0–9.0	1	
			81.283	2.3	3.01	Δm = 3.3	1	
			81.286	359.9	3.08	Δm = 3.5	1	
			81.253	2.7	3.06		4	Baize, 1947: –1o2, –0".18
7307	STF 1338	AB	81.308	258.7	1.04	7.0–7.4	1	Starikova, 1966: –0°.3, +0".15
	09147N3837							
7404	A 130		81.225	105.3	0.79	12.5–12.6	1	
	09249N2052							
7624	HU 631		81.226	255.1	0.76	8.0–8.8	1	
	09582N3268		81.234	259.2	0.79	8.1–8.1	1	
			81.280	264.1	0.68	7.0–8.5	1	
			81.247	259.5	0.74		3	

Table II (Continued)

ADS	DISC. IDS	Mult.	Epoch 1900+	p	ρ	Est.mag.	n	Notes
DM	KUI 47		81.283	105.°8	1.″14	Δm = 0.1	1	
N75403	10017N7537		81.283	106.0	1.15	0.1	1	
			81.288	104.9	1.31	0.0	1	
			81.302	103.4	1.20	10.6–10.7	1	
			81.289	105.0	1.20		4	Baize, 1964: +3.°2, –0.″05
7704	STT 215		81.239	185.8	1.48	7.5–7.7	1	
	10108N1774		81.286	185.8	1.34	Δm = 0.1	1	
			81.357	184.2	1.48	Δm = 0.1	1	
			81.300	185.0	1.43		3	Wierzbinski, 1953: +3.°1; +0.″03
7758	STF 1429		81.280	181.5	0.68	8.5–8.5	1	
	10195N2468		81.288	181.4	0.61	Δm = 0.0	1	
			81.302	183.8	0.60	8.5–8.5	1	
			81.290	182.2	0.63		3	Zulević, 1981: –2.°8; +0.″03
788	STT 227		81.226	0.5	0.77	9.0–9.5	1	
	10364N1076		81.280	0.9	0.86	Δm = 0.4	1	
			81.253	0.7	0.81		2	
8032	A 1590		81.302	344.6	1.26	9.0–9.4	1	
	10576N5464		81.308	344.6	1.27	9.0–9.4	1	
			81.305	344.6	1.27		2	Haintz, 1963: +2.°4; +0.″05
8119	STF 1523		81.239	101.0	2.73	4.7–4.9	1	
	11128N3166		81.280	103.2	3.10	4.7–4.9	1	
			81.365	102.8	2.81	4.7–4.9	1	
			81.365	100.8	2.87	4.7–4.9	1*	
			81.312	101.9	2.88		4	Heintz, 1966: +0.°4; +0.″08.
8128	STF 1527		81.218	35.4	1.37	7.0–8.0	1	
	11138N1449		81.220	36.6	1.42	7.5–7.7	1	
			81.223	35.9	1.41	Δm = 0.5	1	
			81.239	35.8	1.44	Δm = 0.8	1	Hopmann, 1958: +5.°1; –0.″09
			81.225	35.9	1.41		4	
8311	BU 603		81.283	355.8	1.04	5.9–8.3	1	
	11435N1450		81.289	357.0	1.02	6.0–8.5	1	Heintz, 1962: +7.°6; 0.″00
			81.286	356.4	1.03		2	Muller, 1977: +3.°8; –0.″20
8355	STT 241	AB	81.379	142.4	1.54	Δm = 2.5	1	
	11511N3560							
8421	STF 1601		81.379	300.8	1.92	Δm = 0.5	1	
	12010N3883							
8539	STF 1639	AB	81.365	325.9	1.38	6.6–7.8	1	
	12194N2568		81.365	327.3	1.38	–	1*	
			81.387	327.2	1.43	6.6–7.8	1	
			81.396	326.6	1.39	–	1	
			81.378	326.8	1.39		4	Aller, 1947: +1.°0; –0.″11
8569	STT 251		81.289	54.3	0.59	Δm = 1.5	1	
	12242N3157		81.379	49.6	0.61	Δm = 2.0	1	
			81.334	52.0	0.60		2	Baize, 1955: –1.°6; 0.″00
8575	STF 1647		81.280	243.1	1.30	Δm = 0.1	1	
	12255N0976		81.283	241.5	1.29	Δm = 0.2	1	
			81.289	243.6	1.31	8.0–8.1	1	
			81.283	242.7	1.30		3	Hopmann, 1970: +0.4; –0.″03

Table II (Continued)

ADS	DISC. IDS	Mult.	Epoch 1900+	p	ρ	Est.mag,	n	Notes
8635	A 1851 12372N2654		81.379	237°.1	0".43	Δm = 0.3	1	Baize, 1965: +5°.2; +0".01
8708	STT 256 12513S0025		81.226	276.0	0.84	7.5–7.7	1	
			81.280	275.5	0.97	Δm = 0.2	1	
			81.253	275.7	0.90		2	
8887	HO 260 13189N2945		81.289	70.6	1.16	8.5–8.6	1	
			81.302	75.5	1.04	9.0–9.3	1	
			81.439	70.6	1.12	8.4–8.8	1	
			81.442	70.6	1.06	8.5–9.6	1	
			81.368	71.8	1.09		4	Ambruster, 1978: –0°.9; +0".03
8917	BU 113 13242N1160		81.396	252.1	1.31	8.6–11.0	1	
8943	A 1095 13290N2975		81.283	253.0	0.44	9.0–9.3	1	
			81.379	253.4	0.46	Δm = 0.3	1	
			81.331	253.2	0.45		2	Zulević, 1964: –6°.0; +0".05.
9031	STF 1785 13445N2689		81.387	158.9	3.25	7.9–8.2	1	
			81.396	160.5	3.23	–	1	
			81.391	159.7	3.24		2	Strand, 1953: –0°.7; –0".15
9174	STF 1816 14095N2934		81.379	91.0	0.68	Δm = 0.3	1	
			81.439	90.1	0.85	6.9–7.0	1	
			81.442	88.8	0.76	7.0–71	1	
			81.420	90.0	0.76		3	
9269	HO 542 14230N2064		81.283	224.6	0.83	8.7–8.7	1	
			81.289	221.5	0.93	Δm = 0.0	1	
			81.286	223.0	0.88		2	
9340	STF 1867 14365N3143		81.472	1.7	0.77	Δm = 0.5	1	
			81.483	4.2	0.87	Δm = 0.5	1	
			81.477	3.0	0.82		2	
9380	STF 1879 14414N0965	AB	81.412	90.2	1.38	7.6–8.6	1	
			81.527	89.9	1.55	7.6–8.6	1	
			81.469	90.1	1.46		2	Wierzbinski, 1956: +0°.5; –0".05
9425	STT 288 14487N1567		81.412	171.9	1.38	6.9–7.6	1	
			81.447	173.8	1.42	Δm = 0.6	1	
			81.559	170.6	1.28	6.9–7.6	1	
			81.473	172.1	1.36		3	Heintz, 1950: +1°.6; 0".00
9530	A 1116 15068N1030		81.382	224.5	0.69	Δm = 0.1	1	
			81.439	224.3	0.77	8.5–8.5	1	
			81.442	226.4	0.71	8.5–8.5	1	
			81.421	225.1	0.72		3	
9578	STF 1932 15140N2672		81.412	250.7	1.28	7.1–7.6	1	
			81.527	250.6	1.42	7.1–7.6	1	
			81.559	248.1	1.22	7.1–7.6	1	
			81.499	249.8	1.31		3	Heintz, 1964: –1°.4; –0".10
9626	STF 1938 15207N3742	BC	81.559	12.8	1.89	7.2–7.8	1	

Table II (Continued)

ADS	DISC. IDS	Mult.	Epoch 1900+	p	ρ	Est.mag,	n	Notes
9630	STF 1941		81.382	217°.7	1".36	Δm = 0.1	1	
	15215N2659		81.439	216.9	1.43	9.0–9.0	1	
			81.442	217.9	1.44	9.0–9.0	1	
			81.447	217.6	1.40	9.0–9.0	1	
			81.427	217.4	1.41		4	
9742	A 2076		81.439	360.0	0.72	8.4–8.4	1	
	15360N1860		81.442	360.0	0.72	8.4–8.4	1	
			81.447	359.2	0.72	8.4–8.4	1	
			81.443	359.7	0.72		3	
10075	STF 2052	AB	81.289	136.4	1.41	Δm = 0.1	1	
	16245N1837		81.442	133.9	1.29	7.8–7.8	1	
			81.447	135.1	1.33	8.0–8.0	1	
			81.483	135.6	1.34	7.8–7.8	1	
			81.532	134.3	1.34	7.8–7.8	1	
			81.543	133.8	1.36	7.8–7.8	1	
			81.456	134.8	1.35		6	Siegrist, 1950: +1°1; –0"11
10188	D 15		81.532	145.2	1.07	9.1–9.1	1	
	16408N4340		81.543	141.0	1.05	9.1–9.1	1	
			81.554	144.0	1.06	9.1–9.1	1	
			81.542	143.4	1.06		3	Wierzbinski, 1955: +2°6; –0"08
10235	STF 2107	AB	81.532	89.9	1.22	6.7–8.3	1	
	16479N2850		81.543	90.3	1.25	"	1	
			81.537	90.1	1.23		2	Rabe, 1926: +1°4; –0"15
10279	STF 2118		81.559	70.6	0.93	6.9–7.4	1	Giannuzzi: +2°1; –0"35
	16559N6511							
10312	STF 2114		81.527	186.2	1.20	6.5–7.7	1	
	16572N0836		81.554	188.6	1.09	6.5–7.7	1	
			81.540	187.4	1.15		2	
10345	STF 213		81.559	43.6	1.73	5.8–5.8	1	
	17033N5436							
10429	A 2984		81.439	355.1	0.81	4.6–7.6	1	
	17114S0020		81.527	353.5	0.80	4.6–7.6	1	
			81.483	354.3	0.81		2	
11483	STT 358	AB	81.439	162.7	1.75	5.8–7.2	1	
	18314N1654		81.532	163.4	1.75	6.8–7.2	1	
			81.554	164.3	1.61	6.8–7.2	1	
			81.506	163.5	1.70		3	Hopmann, 1970: +2°5, +0"15
11635	STF 2382	AB	81.532	354.6	2.57	5.1–6.1	1	
	18410N3934		81.543	354.7	2.58	5.1–6.1	1	
			81.549	355.0	2.69	5.1–6.1	1	
			81.554	355.8	2.62	5.1–6.1	1	
			81.545	355.0	2.64		4	Guntzel-Lingner,1955: +0°2; –0"03
11635	STF	CD	81.532	92.2	2.37		1	
	18410N3934		81.543	91.9	2.38		1	
			81.549	91.8	2.42		1	
			81.554	91.4	2.33		1	
			81.545	91.8	2.38		4	Guntzel-Lingner,1955: +8.9; +0"03

Table II (Continued)

ADS	DISC. IDS	Mult.	Epoch 1900+	p	ρ	Est.mag,	n	Notes
11989	H 126		81.289	202°.7	1″27	7.5–7.8	1	
	18584S2141		81.382	205.4	1.23	7.5–7.8	1	
			81.527	205.7	1.30	7.5–7.8	1	
			81.399	204.6	1.27		3	Zulević, 1981: +0°1; −0″01
12447	STF 2525		81.559	293.9	1.52	8.5–8.7	1	
	19225N2707		81.795	294.5	1.52	8.5–8.7	1	
			81.798	293.0	1.55	8.5–8.7	1	
			81.717	293.6	1.53		3	Tamburini,1967: +0°9; −0″33
12592	A 714		81.727	348.6	1.35	8.8–9.2	1	
	19296N4550		81.798	348.4	1.35	8.8–9.2	1	
			81.762	348.5	1.35		2	
12889	STF 2576	AB	81.543	355.9	2.10	9.3–9.3	1	
	19418N3322		81.549	355.8	7.98		1	
			81.554	356.8	1.99		1	
			81.548	356.2	2.02		3	Rabe, 1943: +1°1; −0″06
12945	ES 2182		81.554	226.3	1.64	9.3–9.4	1	
	19439N3542							
12965	STT 386		81.559	254.0	0.81	7.7–8.0	1	
	19446N3655							
14499	STF 2737	AD	81.798	288.2	0.98	5.8–6.3	1	Bos,1932: +2°8; −0″07
	20541N0355							
14783	A 48		81.847	256.6	0.77	7.1–7.3	1	Baize,1949: +5°1; +0″14
	21117N6400							
14573	STF 2744	AB	81.724	128.3	1.17	7.0–7.5	1	Popović,1962: +4°0; −0″10
	20580N0108							
15270	STF 2822		81.559	296.2	1.79	4.7–6.1	1	
	21397N2817		81.724	298.1	1.76	4.7–6.1	1	
			81.798	297.8	1.84	4.7–6.3	1	
			81.841	298.2	1.78	4.7–6.3	1	
			81.731	297.6	1.79		4	Heintz,1965: −1°6; +0″04
15972	Kr 60	AB	81.847	166.9	2.68	9.4–10.9	1	Wielen,1962: −0°8; −0″14
	22244N5712							
16326	A 632	AB	81.847	167.6	0.82	8.2–9.0	1	Heintz, 1961: +0°2; +0″03
	22480N5712							
16785	A 1487		81.798	163.4	0.92	9.0–9.5	1	
	23244N4009							
16951	A 1242		81.798	326.5	0.70	9.6–9.6	1	Zulević, 1977: +0°3; −0″05
	23380N1117							
17149	STF 3050		81.798	310.5	1.57	6.6–6.6	1	Heintz,1973: −1°1; +0″01
	23544N3310							
–	GP 72		81.226	314.5	1.48	11.0–12.0	1	
	13119N3504*		81.283	320.1	1.65	11.5–12.0	1	
			81.255	317.3	1.56		2	

Table II (Continued)

ADS	DISC. Mult. IDS	Epoch 1900+	p	ρ	Est.mag.	n	Notes
–	GP 111	81.288	51°.2	1″.00	Δm = 0.0	1	
	08084N3553*						
–	GP 119	81.283	193.2	0.61	10.0 10.1	1	
	13187N4101*	81.289	194.1	0.63	Δm = 0.2	1	
		81.286	193.7	0.62		2	
–	GP 151	81.226	259.8	0.40	9.0–9.0	1	
	09503N4427*	81.283	256.8	0.50	Δm = 0.0	1	
		81.255	258.3	0.45		2	

* α, δ for 1900.

Bull. Obs. Astron. Belgrade, N° 133 UDC 523.4

OBSERVATIONS OF THE SUN, MERCURY AND VENUS WITH THE BELGRADE MERIDIAN CIRCLE IN THE PERIOD 1979 TO 1981

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SUMMARY: The results of observations of the Sun, Mercury and Venus with the Belgrade large meridian instrument in the period from 1979 to 1981, are presented.

Differential observations of the Sun, Mercury and Venus are continuously carried out since 1974 at the Belgrade Observatory. At the observation of the Sun Suharev's filter was used for reducing the image brigtness. The Sun's right ascension was deduced, as usual, from the trailing the front and back edges and the declination from settings on the upper and lower edges. Venus was observed like the Sun if full, or only one of its edges if phased. Mercury, owing to its scarce visibility, was observed mostly by bisection. The transit times and declinations of these celestial bodies were deduced by reducing to the centre using their radius values, published together with the ephemeris by the Main Astronomical Observatory of the USSR, according to a programme M.Tchubei.

The method by which the observations were processed is described elsewhere (Sadžakov et al., 1976, 1981, 1982).

The mean apparent right ascensions ad declinations of the Sun and the two planets, as determined from the observations in the period 1979 to 1981, are compared with the ephemeris values and given in Table I.

Table I comprises: mean yearly differences $(0-C)_\alpha$, ϵ_1– mean error of the mean difference, ϵ_2 – mean error of one single position, n – the number of observations in right ascension, mean yearly differences $(0-C)_\delta$, ϵ'_1– mean error of the mean difference, ϵ'_2 – mean error of a single position, n' – the number of observations of declination.

The apparent right ascensions and declinations of the Sun, Mercury and Venus, as obtained on each particular day of observation, are compared with the ephemeris positions and given in Tables II, III and IV.

Tables II, III and IV comprise ten columns, whereby:

I column – date of observation
II column – observers: 1- S.Sadžakov, 2- D.Šaletić, 3- M.Dačić
III column – mean temperature inside the pavilion
IV column – the number of the reference FK4 stars
V column – observed right ascension (α)
VI column – $(0-C)_\alpha$ of the right ascensions
VII column – observed declinations (δ)
VIII column – $(0-C)_\delta$ of the declinations
IX column – epoch of observation
X column – clamp position

Table I

Object	$(0-C)_\alpha$	ϵ_1	ϵ_2	n	$(0-C)_\delta$	ϵ'_1	ϵ'_2	n'
Sun	$+0^s.015$	$\pm0^s.011$	$\pm0^s.070$	91	$-0''.10$	$\pm0''.07$	$\pm0''.45$	138
Mercury	$+0^s.020$	$\pm0^s.025$	$\pm0^s.085$	27	$-0''.09$	$\pm0''.14$	$\pm0''.53$	38
Venus	$+0^s.013$	$\pm0^s.014$	$\pm0^s.072$	97	$+0''.09$	$\pm0''.12$	$\pm0''.55$	117

SUN

Table II

Date of observ.	Observ	t°	n	α	(0–C)α	δ	(0–C)δ	Ep	Clamp
1979				h m s	s	° ′ ″	″	1900 +	
03.VIII	1	29°.4	3	08 51 51.440	–0.026	17 36 05.56	+ 0.04	79.59	W
06.VIII	1,	26.2	9	09 03 24.484	+ 42	16 48 06.99	– 89	79.59	W
07.VIII	1, 3,	23.5	9	09 07 14.209		16 31 36.34	+ 52	79.60	W
08.VIII	1, 3,	24.7	2	09 11 03.386	+ 9	16 14 47.92	+ 10	79.60	W
24.VIII	3,	24.5	12	10 10 56.983	+ 28	11 13 53.35		79.64	W
28.VIII	1, 3,	19.4	7	10 25 36.408	– 42	09 50 42.05		79.65	W
31.VIII	1, 3,	18.2	8	10 36 31.965	– 29	08 46 39.40	– 5	79.66	W
03.IX	1,2,3	22.0	5	10 47 24.412	– 78	07 41 21.32	– 47	79.67	W
18.IX	1,2,3,	17.8	3	11 41 20.468	– 24	02 01 03.09	– 12	79.71	W
19.IX	1, 3,	20.4	3	11 44 55.741	+ 29	01 37 48.91	+ 4	79.72	W
20.IX	1, 3,	22.6	4	11 48 30.944	– 27	01 14 32.48	+ 19	79.72	W
21.IX	1, 3,	24.6	4	11 52 06.288		00 51 13.37	– 46	79.72	W
25.IX	1,2,3,	18.4	3	12 06 28.451	– 34	–00 42 11.71	+ 18	79.73	W
03.X	1, 3,	13.0	6	12 35 21.065	– 64	–03 48 46.68	– 18	79.75	W
04.X	1, 3,	13.1	3	12 38 58.806	– 57	–04 11 57.43	– 13	79.76	W
05.X	1, 3,	16.0	3	12 42 36.904	– 26	–04 35 05.23	– 17	79.76	W
09.X	1, 3,	13.5	3	12 57 13.094	– 34	–06 06 58.79	+ 33	79.77	W
11.X	1, 3,	16.2	4	13 04 33.775	0	–06 52 29.32	– 10	79.78	W
12.X	1, 3,	17.4	3	13 08 14.921	+ 53	–07 15 06.66	– 39	79.78	W
16.X	1, 3	22.8	5	13 23 04.591	+ 31	–08 44 31.87	+ 55	79.79	W
03.XII	1,2,3,	14.2	2	16 36 13.885		–22 02 47.46	– 78	79.92	W
13.XII	3,	0.8	7	17 19 59.894		–23 07 23.79	– 23	79.95	W
18.XII	1,2,	6.6	5	17 42 07.867	– 42	–23 22 40.45	+ 49	79.96	W
19.XII	1, 3,	6.8	3	17 46 34.285	+ 88	–23 24 20.46	+ 5	79.96	W
25.XII	1, 3,	5.4	7	18 13 13.281	– 144	–23 24 25.17	+ 15	79.98	W
28.XII	3,	1.0	4	18 26 32.256	– 45	–23 18 06.47	– 22	79.99	W
1980									
31.I	1, 3	9.3	5	20 52 41.064	+ 120	–17 32 57.51	+ 31	80.08	W
20.II	1,2,3,	3.2	5	22 12 01.220	+ 10	–11 08 08.39	– 4	80.14	W
21.II	1, 3	3.8	12	22 15 51.482		–10 46 36.12	+ 62	80.14	W
05.III	1,	4.1	6	23 04 50.309	+ 36	–05 54 08.48	– 29	80.18	W
14.III	1, 3,	7.2	3	23 38 00.839		–02 22 47.91	– 63	80.20	W
14.IV	1, 3,	12.7	10	01 31 15.477	– 47	09 32 30.56	+ 83	80.28	W
15.IV	3,	16.2	8	01 34 57.495	+ 42	09 53 57.41	– 27	80.29	W
16.IV	1,2,	16.4	1	01 38 39.740		10 15 15.32	– 50	80.29	W
17.IV	1, 3,	18.0	1	01 42 22.420	+ 22	10 36 23.89	+ 8	80.29	W
12.V	1,2,3,	15.7	3	03 17 41.566	+ 14	18 13 33.08	+ 14	80.36	W
22.V	1,	16.9	18	03 57 26.351		20 27 21.84	– 6	80.39	E
23.VI	1, 3,	24.8	5	06 09 09.760		23 25 19.20	– 84	80.48	E
24.VI	1, 3,	27.0	5	06 13 19.150		23 24 12.87	– 20	80.48	E
01.VII	1, 3,	19.2	1	06 42 20.435		23 04 54.98	– 19	80.50	E
09.VII	1, 3,	25.4	1	07 15 15.029	+ 46	22 18 44.27	+ 43	80.52	E
14.VII	1, 3,	20.7	7	07 35 36.475	– 100	21 37 16.48	– 36	80.53	E
15.VII	1,2,	22.8	6	07 39 39.443	– 6	21 27 52.46	+ 16	80.54	E
16.VII	1,2,	25.8	7	07 43 41.812	+ 12	21 18 05.20	– 66	80.54	E
05.VIII	1, 3,	25.4	4	09 02 26.988		16 52 13.12	+ 4	80.59	E
06.VIII	1,2,3,	26.6	5	09 06 17.049		16 35 44.83	+ 28	80.60	E
07.VIII	1, 3,	25.4	7	09 10 06.532		16 18 59.75	– 18	80.60	E
08.VIII	1, 3,	25.8	6	09 13 55.438		16 01 58.91	– 62	80.60	E
10.VIII	3,	22.9	7	09 21 31.521		15 27 13.01	+ 36	80.61	E
11.VIII	1,2,3,	23.0	5	09 25 18.701		15 09 25.65	– 117	80.61	E
12.VIII	1, 3,	23.2	2	09 29 05.313		14 51 26.16	– 30	80.61	E
18.VIII	1,2,3	20.7	6	09 51 33.387		12 58 36.73	– 62	80.63	E
19.VIII	1, 3,	21.2	3	09 55 16.186	– 30	12 39 04.82	+ 51	80.63	E
20.VIII	3,	21.6	3	09 58 58.521	– 24	12 19 19.32	– 1	80.64	E
25.VIII	1, 3,	17.0	8	10 17 23.073	– 75	10 37 46.78	+ 38	80.65	E
26.VIII	1, 3,	19.5	9	10 21 02.774	+ 4	10 16 56.69	+ 27	80.65	E
27.VIII	1, 3,	17.9	11	10 24 42.008	+ 6	09 55 56.60	– 6	80.65	E

SUN

Table II (Continued)

Date of observ.	Observ	t°	n	α	(O–C)$_\alpha$	δ	(O–C)$_\delta$	Ep	Clamp
				h m s	s	° ′ ″	″	1900 +	
28.VIII	1, 3,	20.°1	3	10 28 20.867		09 34 47.19	– 0.024	80.66	E
04.IX	1,2,3,	18.4	3	10 53 44.321		07 02 42.29	– 49	80.68	E
05.IX	1,	18.0	2	10 57 20.935		06 40 28.88	+ 8	80.68	E
28.X	3,	12.4	6	14 11 28.125	+ 61	–13 14 33.50		80.82	E
29.X	3,	14.5	6	14 15 20.437	– 72	–13 34 28.27		80.83	E
31.X	3,	10.9	4	14 23 07.720	– 62	–14 13 39.10		80.83	E
17.XI	3,	10.6	2	15 31 33.845		–19 04 33.31	– 6	80.88	E
20.XI	1, 3,	7.3	2	15 44 03.358	+ 28	–19 46 34.04	– 52	80.89	E
21.XI	1, 3,	7.8	3	15 48 14.826	+ 54	–19 59 50.64	+ 20	80.89	E
24.XI	1,2,3,	11.1	6	16 00 53.981	+ 107	–20 37 29.62	+ 16	80.90	E
25.XI	3,	12.6	1	16 05 08.591	+ 119	–20 49 18.36	– 103	80.90	E
12.XII	1, 3,	4.4	2	17 18 57.331	– 36	–23 06 24.05	+ 83	80.95	E
15.XII	1, 3,	6.4	2	17 32 13.152	+ 90	–23 17 19.78	– 52	80.96	E
1981									
28.I	1, 3,	–3.2	2	20 43 27.242		–18 09 22.79	– 86	81.08	E
02.II	1, 3,	5.5	1	21 03 56.109	– 46	–16 46 04.82	+ 13	81.09	E
03.II	1,	5.2	1	21 07 59.571	+ 50	–16 28 31.45	– 35	81.09	E
10.II	1,	7.8	2	21 36 00.342	+ 30	–14 17 57.47	– 54	81.11	E
07.III	1, 3,	10.4	3	23 11 21.485		–05 13 13.17	+ 56	81.18	E
17.III	1, 3,	13.1	3	23 48 06.182		–01 17 25.84	– 19	81.21	E
23.III	1, 3,	14.1	4	00 09 57.998	+ 17	01 04 41.92	– 13	81.23	E
26.III	1,	14.5	8	00 20 52.780		02 15 26.36	– 50	81.23	E
29.III	3,	14.7	2	00 31 47.661		03 25 46.15	– 55	81.24	E
08.IV	1, 3,	16.0	4	01 08 17.671		07 15 11.27	+ 45	81.27	E
09.IV	1, 3,	18.1	5	01 11 57.678		07 37 32.05	– 36	81.27	E
13.IV	1, 3,	18.2	4	01 26 40.255		09 05 37.55	+ 21	81.28	E
15.IV	1, 3,	16.5	4	01 34 03.306		09 48 46.20	+ 8	81.29	E
13.V	1, 3,	16.2	5	03 20 40.046		18 24 50.40	– 18	81.36	W
14.V	1, 3	17.9	5	03 24 36.306		18 39 25.69	– 60	81.37	W
15.V	1, 3,	17.4	5	03 28 33.115	– 8	18 53 42.68	– 37	81.37	W
18.V	1, 3,	19.2	2	03 40 26.943	+ 21	19 34 36.70	– 33	81.38	W
26.V	1, 3,	24.8	4	04 12 34.432		21 08 44.82	– 2	81.40	W
01.VI	1, 2,	24.5	4	04 37 01.188	– 51	22 04 10.50	– 9	81.42	W
02.VI	1, 3	23.9	4	04 41 07.239	– 3	22 12 05.66	+ 30	81.42	W
03.VI	1, 3	24.5	4	04 45 13.647	+ 17	22 19 37.70	+ 79	81.42	W
04.VI	1, 3,	26.5	2	04 49 20.084	+ 69	22 26 45.37	+ 30	81.42	E
16.VII	1,	28.1	3	07 42 42.193		21 20 33.39	– 50	81.54	E
22.VII	1,	27.2	2	08 06 44.984	+ 45	20 14 59.07	– 63	81.56	W
23.VII	1,	26.0	3	08 10 43.506	+ 30	20 02 51.10	– 28	81.56	W
04.VIII	1, 3,	27.1	5	08 57 40.473	– 60	17 12 20.09	– 23	81.59	W
05.VIII	1, 3,	25.2	4	09 01 31.332		16 56 11.74	– 41	81.59	W
06.VIII	1,2,3,	26.0	3	09 05 21.514		16 39 46.70	– 89	81.60	W
07.VIII	1, 3,	27.8	8	09 09 11.095	+ 11	16 23 06.97	+ 3	81.60	W
10.VIII	1, 3,	26.8	3	09 20 36.165	– 11	15 31 31.51	– 4	81.61	E
17.VIII	1, 3,	25.5	5	09 46 54.674	+ 25	13 22 43.02	– 79	81.63	E
19.VIII	1, 3,	20.2	2	09 54 20.891	– 6	12 43 56.53	– 36	81.63	E
20.VIII	1, 3,	23.4	2	09 58 03.370	+ 63	12 24 14.67	– 39	81.63	E
21.VIII	3,	25.4	4	10 01 45.262		12 04 20.75	– 63	81.64	E
26.VIII	1, 3,	18.6	3	10 20 08.649	– 55	10 22 05.72	– 46	81.65	E

MERCURY

Table III

Date of observ.	Observ.	t°	n	α	(0–C)$_\alpha$	δ	(0–C)$_\delta$	Ep	Clamp
1979								1900+	
28.VIII	1, 3,	$19^{\circ}.4$	7	$09^h30^m27^s.634$	$+0^s.097$	$15^{\circ}53'52''.78$	$-0''.07$	79.65	W
31.VIII	1, 3,	18.2	8	09 52 14.690	+ 20	14 28 15.78	+ 95	79.66	W
03.IX	1,2,3,	22.0	5	10 14 36.940	– 120	12 41 53.46	+ 77	79.67	W
20.IX	1, 3,	22.6	4	12 12 26.789	– 73	–00 12 22.57	– 39	79.72	W
21.IX	1, 3,	24.6	4	12 18 41.857		–00 59 20.34	– 17	79.72	W
13.XII	3,	0.2	7	15 57 07.003	+ 23	–18 41 02.16	+ 9	79.95	W
18.XII	1,2,	5.8	5	16 24 58.399	– 79	–20 32 24.51	– 102	79.96	W
19.XII	1, 3,	6.0	3	16 30 52.621	+ 49	–20 53 16.42	+ 42	79.96	W
1980									
31.I	1, 3,	9.8	5	21 23 43.459	+ 81	–17 17 24.07	+ 41	80.08	W
16.IV	1,2,	15.8	1	00 13 20.857		01 24 55.43	+ 38	80.29	W
17.IV	1, 3,	17.5	1	00 18 50.471	+ 28	00 49 24.32	– 4	80.29	W
16.VII	1,2,	25.8	7	07 10 36.321	+ 3	17 32 39.23	– 20	80.54	E
04.VIII	1,2,3,	25.2	3	07 39 16.990		20 28 28.69	– 8	80.59	E
05.VIII	1, 3,	25.0	4	07 44 52.294		20 29 53.83	+ 59	80.59	E
06.VIII	1,2,3,	26.4	5	07 50 49.166		20 29 15.99	– 19	80.60	E
08.VIII	1, 3,	25.5	6	08 03 42.623		20 21 18.20	– 65	80.60	E
12.VIII	1, 3,	23.0	2	08 32 44.579		19 35 06.33	– 71	80.61	E
18.VIII	1,2,3,	20.5	6	09 20 39.052		17 06 40.92	– 96	80.63	E
19.VIII	1, 3,	21.0	3	09 28 44.541	– 29	16 33 39.27	+ 85	80.63	E
04.IX	1,2,3	18.8	3	11 26 06.945		05 00 12.13	– 80	80.68	E
21.XI	1, 3,	7.8	3	14 32 45.800	+ 20	–12 35 19.50	+ 4	80.89	E
24.XI	1,2,3,	11.1	6	14 46 50.056		–13 54 07.15	– 41	80.90	E
1981									
02.II	1, 3,	5.9	1	22 14 47.501	– 114	–10 21 42.22	+ 67	81.00	E
26.V	1, 3,	25.2	4	05 50 50.889		25 26 15.06	+ 78	81.40	W

VENUS

Table IV

Date of observ.	Observ.	t°	n	α	(0–C)$_\alpha$	δ	(0–C)$_\delta$	Ep	Clamp
1979								1900+	
03.VIII	1,	$29^{\circ}.4$	3	$08^h27^m56^s.581$	$+0^s.052$	$20^{\circ}01'41''.32$	$-0''.06$	79.59	W
06.VIII	1,	26.2	9	08 43 14.899	+ 132	19 11 21.26	– 55	79.59	W
07.VIII	1, 3,	23.5	9	08 48 18.789		18 53 30.36	+ 148	79.60	W
08.VIII	1, 3,	24.7	2	08 53 21.746	– 17	18 35 03.34	– 39	79.60	W
28.VIII	1, 3,	19.4	7	10 30 43.023	+ 31	10 50 40.68	– 51	79.65	W
31.VIII	1, 3,	18.2	8	10 44 46.443	– 57	09 28 29.75	+ 63	79.66	W
03.IX	1,2,3,	22.0	5	10 58 43.223	– 14	08 03 57.23	– 1	79.67	W
18.IX	1,2,3,	17.8	3	12 07 19.869	+ 46	00 37 43.41	– 91	79.71	W
19.IX	1, 3	20.4	3	12 11 52.260	– 57	00 07 12.28	– 8	79.72	W
20.IX	1, 3,	22.6	4	12 16 24.924	+ 126	–00 23 21.29	+ 2	79.72	W
21.IX	1, 3,	24.6	4	12 20 57.306		–00 53 55.31	+ 67	79.72	W
25.IX	1,2,3,	18.4	3	12 39 08.523	+ 73	–02 56 09.48	+ 22	79.73	W
03.X	1, 3,	13.0	6	13 15 44.642	+ 44	–06 57 37.23	+ 49	79.75	W
04.X	1, 3,	13.1	3	13 20 21.324	+ 115	–07 27 17.25	– 11	79.76	W
05.X	1, 3,	16.0	3	13 24 58.476	+ 52	–07 56 46.68	+ 34	79.76	W
08.X	3,	13.4	3	13 38 54.130		–09 24 11.61	+ 33	79.77	W
09.X	1, 3,	13.5	3	13 43 34.121	– 69	–09 52 55.47	+ 70	79.77	W
11.X	1, 3,	16.4	4	13 52 56.780	+ 2	–10 49 44.59	– 69	79.78	W
12.X	1, 3,	17.4	3	13 57 39.270	– 106	–11 17 46.12	– 28	79.78	W
16.X	1, 3,	23.2	5	14 16 39.265	+ 32	–13 07 08.85	+ 18	79.79	W
13.XII	3,	1.2	7	19 21 16.260	+ 118	–23 46 01.08	+ 50	79.95	W
18.XII	1,2,	7.1	5	19 48 00.096	– 26	–22 51 53.91	– 32	79.96	W
19.XII	1, 3,	7.5	3	19 53 17.725	– 146	–22 39 00.38	– 37	79.96	W
25.XII	1, 3,	5.8	7	20 24 39.206	– 36	–21 07 57.78	– 35	79.98	W

VENUS

Table IV (Continued)

Date of observ.	Observ.	t°	n	α	(O–C)$_\alpha$	δ	(O–C)$_\delta$	Ep	Clamp
1980									
31.I	1, 3,	9.5	5	23 20 09.209	–0.62	–05 27 40.34	– 58	80.08	W
20.II	1,2,3,	3.5	5	00 45 50.862	+ 31	04 58 34.29	– 43	80.14	W
05.III	1,	4.2	6	01 44 50.179	– 81	11 57 24.93	+ 69	80.18	W
14.III	1, 3,	7.7	3	02 22 51.202		16 01 23.18	+ 3	80.20	W
14.IV	1, 3,	13.0	10	04 31 56.860	+ 46	25 44 41.48	– 83	80.28	W
15.IV	3,	16.4	8	04 35 51.558	– 83	25 55 26.89	+ 55	80.29	W
16.IV	1,2,	16.8	1	04 39 44.471		26 05 38.75	+ 60	80.29	W
17.IV	1, 3,	18.4	1	04 43 35.119	– 43	26 15 17.22	– 56	80.29	W
12.V	1,2,3,	16.0	3	05 59 24.642	– 29	27 32 22.35	– 30	80.36	W
22.V	1,	17.3	18	06 11 06.241		23 48 30.72	+ 18	80.39	E
24.VI	1, 3,	27.0	5	05 13 43.792		19 54 09.79	– 77	80.48	E
01.VII	1, 3,	19.0	1	05 03 45.996		18 38 24.19	– 32	80.50	E
09.VII	1, 3,	25.0	1	05 02 01.150	+ 2	17 55 11.58	+ 126	80.52	E
15.VII	1,2,	22.5	6	05 07 02.584	– 29	17 50 02.27	– 68	80.54	E
16.VII	1,2,	25.3	7	05 08 20.708	+ 125	17 50 59.45	– 39	80.54	E
05.VIII	1, 3,	25.0	4	05 55 51.210		18 59 39.73	– 67	80.59	E
06.VIII	1,2,3,	26.4	5	05 59 04.526		19 03 26.41	– 11	80.60	E
08.VIII	1, 3,	25.1	6	06 05 42.162		19 10 31.65	+ 42	80.60	E
10.VIII	3,	22.2	7	06 12 33.592		19 16 51.51	+ 16	80.61	E
11.VIII	1,2,3,	22.8	5	06 16 04.170		19 19 41.38	– 51	80.61	E
12.VIII	1, 3,	23.0	2	06 19 37.834		19 22 18.42	+ 43	80.61	E
18.VIII	1,2,3,	20.4	6	06 41 58.829	+ 125	19 31 56.84	– 108	80.63	E
19.VIII	1, 3,	20.9	3	06 45 51.107	+ 29	19 32 26.25	– 76	80.63	E
20.VIII	3,	21.1	3	06 49 45.796	+ 50	19 32 34.72	+ 1	80.64	E
25.VIII	1, 3,	16.7	8	07 09 50.506	– 33	19 27 28.96	+ 27	80.65	E
26.VIII	1, 3,	19.0	9	07 13 57.139	– 82	19 25 13.86	– 47	80.65	E
27.VIII	1, 3,	17.5	11	07 18 05.646	+ 15	19 22 34.62	+ 33	80.65	E
28.VIII	1, 3,	18.9	3	07 22 15.692		19 19 28.59	+ 50	80.66	E
04.IX	1,2,3,	18.1	3	07 52 05.986		18 45 00.02	+ 62	80.68	E
05.IX	1,	17.8	2	07 56 26.516		18 38 10.11	– 87	80.68	E
23.X	3,	12.2	3	11 30 42.900		04 30 24.00	– 90	80.81	E
28.X	3,	12.0	6	11 52 59.506	+ 133	02 18 59.54	– 18	80.82	E
		°		h m s		° ′ ″		1900+	
29.X	3,	14.0	6	11 57 26.917	– 44	01 52 14.11	– 61	80.83	E
31.X	3,	10.4	4	12 06 22.548	– 55	00 58 22.53	+ 24	80.83	E
25.XI	3,	12.4	1	14 00 15.291	+ 44	–10 18 50.14	– 86	80.90	E
15.XII	1, 3,	6.2	2	15 37 43.210	+ 110	–17 55 59.86	+ 56	80.96	E
1981									
02.II	1, 3,	5.3	1	19 59 29.863	+ 11	–21 07 29.77	– 71	81.09	E
23.III	1, 3,	14.0	4	23 58 14.459	– 34	–01 44 38.61	+ 58	81.23	E
15.V	1, 3,	17.4	5	04 10 01.010	+ 15	21 05 17.62	+ 74	81.37	W
18.V	1, 3,	19.2	2	04 25 32.940	– 43	21 50 30.05	+ 64	81.38	W
26.V	1, 3,	25.0	4	05 07 38.218		25 26 15.06	+ 78	81.40	W
01.VI	1, 3,	24.7	4	05 39 41.016	+ 52	24 05 08.28	+ 66	81.42	W
02.VI	1, 3,	24.3	4	05 45 02.971	+ 7	24 09 36.65	– 23	81.42	W
03.VI	1, 3,	24.8	4	05 50 25.212	– 35	24 13 23.88	+ 37	81.42	W
04.VI	1, 3,	27.0	2	05 55 48.238	– 68	24 16 28.35	+ 102	81.42	E
16.VII	1,	28.5	3	09 32 45.450		16 16 20.88	+ 99	81.54	E
22.VII	1,	27.8	2	10 01 02.795	– 45	13 48 44.90	+ 64	81.56	W
23.VII	1,	26.9	3	10 05 41.527	+ 40	13 22 49.36	– 72	81.56	W
04.VIII	1, 3,	27.8	5	11 00 03.004	+ 28	07 48 48.89	+ 7	81.59	W
07.VIII	1, 3,	28.5	8	11 13 17.928	– 61	06 20 03.93	+ 36	81.60	W
10.VIII	1, 3,	27.5	3	11 26 26.627	+ 21	04 49 50.73	+ 6	81.61	E
17.VIII	1, 3,	26.1	5	11 56 47.494	+ 89	01 15 24.22	– 83	81.63	E
19.VIII	1, 3,	20.7	2	12 05 24.116	+ 34	00 13 32.24	– 80	81.63	E
20.VIII	1, 3,	24.1	2	12 09 42.105	+ 64	–00 17 26.44	– 75	81.63	E

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TABLE DES MATIERES