Bull. Astron. Belgrade № 146 (1992), 15–20

UDC 524.38(083.8)
Original scientific paper

SYSTEMATIC EFFECTS IN THE BELGRADE CATALOGUE OF DOUBLE STARS

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(Received: August 24, 1992)

SUMMARY: The comparison of the Belgrade Catalogue of Double Stars (BCDS) with the Preliminary Compilation of DS-Programme Star Positions (PCDS) was analysed in right ascension, declination, magnitude and spectral type. Existence of systematic $\Delta\alpha$ and $\Delta\delta$ deviations for all star types is evidenced. The effects can probably be explained by the difference in the atmospheric refraction for different spectral types. This depends on the quality of the determined right ascensions and declinations derived from observations of stars at particular observatories.

1. INTRODUCTION

The Preliminary Compilation of DS-Programme Star Positions (PCDS) (Cvetković, 1992) contains right ascensions for 930, and declinations, for 1225 stars with magnitudes $6.0 < m < 9.0$ between $+90^o$ and -10^o declination. Stars of this catalogue were observed in the period 1980-1987 with 6 meridian circles at 6 observatories, Belgrade Observatory being one of them. Its mean epoch is 1982.91 in right ascension and 1983.19 in declination, the mean error in right ascension being $\pm 0^s.019 \sec\delta$ and in declination $\pm 0''.27$.

The Belgrade Catalogue of Double Stars (BCDS) (Sadžakov and Dačić, 1990) covers the celestial sphere between -30^o and $+60^o$. It contains 1576 stars with magnitudes $6.0 < m < 9.0$. Every star was observed four times on the average, in the period 1981-1987. The mean epoch of observations is 1983.90 for right ascension, 1983.84 for declination, the mean error in right ascension is $\pm 0^s.026 \sec\delta$, in declination $\pm 0''.34$.

There are 1161 stars that are common to both catalogues. The mean error of a single difference in right ascension is $\pm 0^s.028 \sec\delta$ and in declination $\pm 0''.51$. In the comparison of these two catalogues we use the proper motions taken from the AGK3.

2. ANALYSIS OF SYSTEMATIC EFFECTS

The comparison of the above-mentioned catalogues was carried out through the analysis of systematic effects of the types $\Delta\alpha_o$, $\Delta\delta_o$, $\Delta\alpha_\delta$, $\Delta\delta_\delta$, $\Delta\alpha_\alpha$, $\Delta\delta_\alpha$, $\Delta\alpha_m$, $\Delta\delta_m$, $\Delta\alpha_{sp}$, $\Delta\delta_{sp}$, where the suffices indicate their character.

It has to be noted that $\Delta\alpha_o$ and $\Delta\delta_o$ is the mean systematic difference in right ascension and declination for these two catalogues from all stars that are common to both of them.

We started from the simple relation:

$$\Delta\alpha = \alpha_{BCDS} - \alpha_{PCDS} =$$

$$\Delta\alpha_o + \Delta\alpha_\delta + \Delta\alpha_\alpha + \Delta\alpha_m + \Delta\alpha_{sp}$$

$$\Delta\delta = \delta_{BCDS} - \delta_{PCDS} =$$

$$\Delta\delta_o + \Delta\delta_\delta + \Delta\delta_\alpha + \Delta\delta_m + \Delta\delta_{sp} \ .$$

Table 1 shows the values of the differences, as well as the number of stars (N) from which they were calculated.

From the above values $(\Delta\alpha_o+\Delta\alpha_\delta)$ and $\Delta\delta_o+\Delta\delta_\delta$ we derived $\Delta\alpha_\delta$ and $\Delta\delta_\delta$ assuming $\Delta\alpha_o=+0^s.001$ and $\Delta\delta_o=+0''.04$.

Table 1. The systematic effects of all types in right ascension and declination

δ	$\Delta\alpha_\delta$	$\epsilon_\alpha\cos\delta$	N_α	$\Delta\delta_\delta$	ϵ_δ	N_δ
-10^o-00^o				$-0''.03$	$\pm0''.04$	111
00^o-10^o				$+0''.07$	$\pm0''.04$	132
10^o-20^o	$+0^s.000$	$\pm0^s.002$	168	$+0''.04$	$\pm0''.04$	173
20^o-30^o	$+0^s.002$	$\pm0^s.002$	154	$+0''.01$	$\pm0''.04$	155
30^o-40^o	$+0^s.004$	$\pm0^s.002$	182	$+0''.08$	$\pm0''.04$	181
40^o-50^o	$+0^s.002$	$\pm0^s.002$	170	$+0''.01$	$\pm0''.04$	175
50^o-60^o	$-0^s.009$	$\pm0^s.003$	122	$-0''.08$	$\pm0''.05$	128
$\delta > 60^o$	$-0^s.003$	$\pm0^s.003$	105	$-0''.18$	$\pm0''.05$	106
α	$\Delta\alpha_\alpha$	$\epsilon_\alpha\cos\delta$	N_α	$\Delta\delta_\alpha$	ϵ_δ	N_δ
$00^h - 04^h$	$-0^s.009$	$\pm0^s.002$	166	$+0''.06$	$\pm0''.04$	197
$04^h - 08^h$	$-0^s.004$	$\pm0^s.002$	188	$+0''.09$	$\pm0''.03$	252
$08^h - 12^h$	$+0^s.002$	$\pm0^s.003$	88	$-0''.04$	$\pm0''.04$	128
$12^h - 16^h$	$+0^s.005$	$\pm0^s.003$	81	$-0''.15$	$\pm0''.05$	113
$16^h - 20^h$	$+0^s.003$	$\pm0^s.002$	172	$-0''.02$	$\pm0''.03$	220
$20^h - 24^h$	$+0^s.007$	$\pm0^s.002$	206	$-0''.03$	$\pm0''.03$	251
m	$\Delta\alpha_m$	$\epsilon_\alpha\cos\delta$	N_α	$\Delta\delta_m$	ϵ_δ	N_δ
$m < 7.0$	$-0^s.000$	$\pm0^s.002$	132	$-0''.02$	$\pm0''.04$	180
7.0-7.5	$-0^s.000$	$\pm0^s.003$	118	$+0''.12$	$\pm0''.04$	159
7.5-8.0	$-0^s.003$	$\pm0^s.002$	149	$-0''.02$	$\pm0''.04$	192
8.0-8.5	$+0^s.003$	$\pm0^s.002$	231	$-0''.01$	$\pm0''.03$	282
$m > 8.5$	$-0^s.001$	$\pm0^s.002$	271	$-0''.02$	$\pm0''.03$	348
Sp	$\Delta\alpha_{sp}$	$\epsilon_\alpha\cos\delta$	N_α	$\Delta\delta_{sp}$	ϵ_δ	N_δ
O, B, A	$-0^s.000$	$\pm0^s.001$	348	$+0''.00$	$\pm0''.02$	447
F	$-0^s.001$	$\pm0^s.001$	246	$+0''.01$	$\pm0''.03$	316
G	$+0^s.001$	$\pm0^s.002$	125	$-0''.02$	$\pm0''.04$	166
K, M, N	$+0^s.002$	$\pm0^s.002$	113	$-0''.03$	$\pm0''.05$	128

The values $\Delta\alpha_\delta$ vary from $-0^s.009$ to $+0^s.004$, $\Delta\delta_\delta$ vary from $-0''.18$ to $+0''.08$ and the errors $\epsilon_\alpha\cos\delta$ and ϵ_δ for all zones are $\pm0^s.002$ and $\pm0''.04$. These values were calculated with weights, on the basis of the number of stars in each interval.

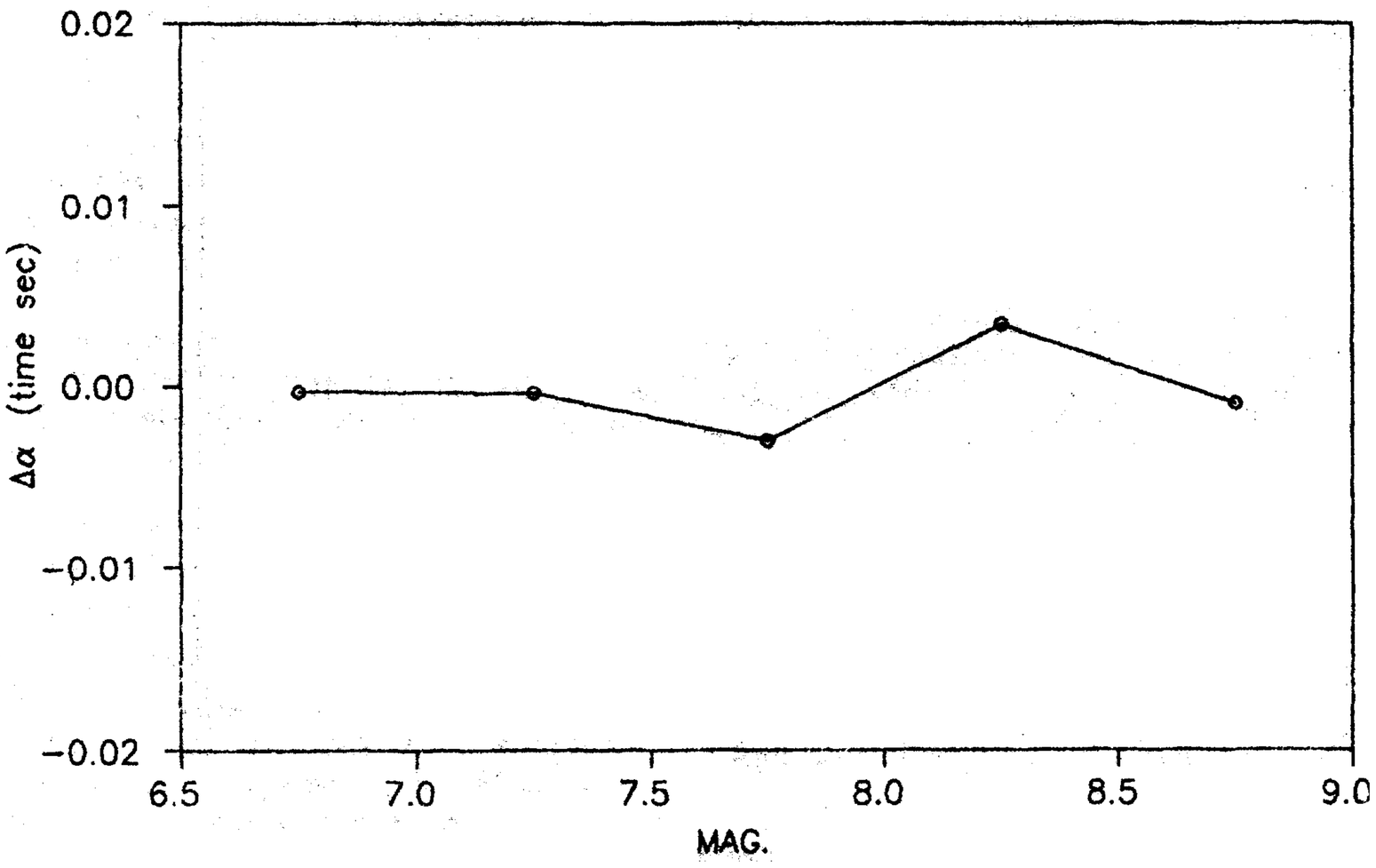

Fig. 1. Systematic effects of the $\Delta\alpha_m$ type.

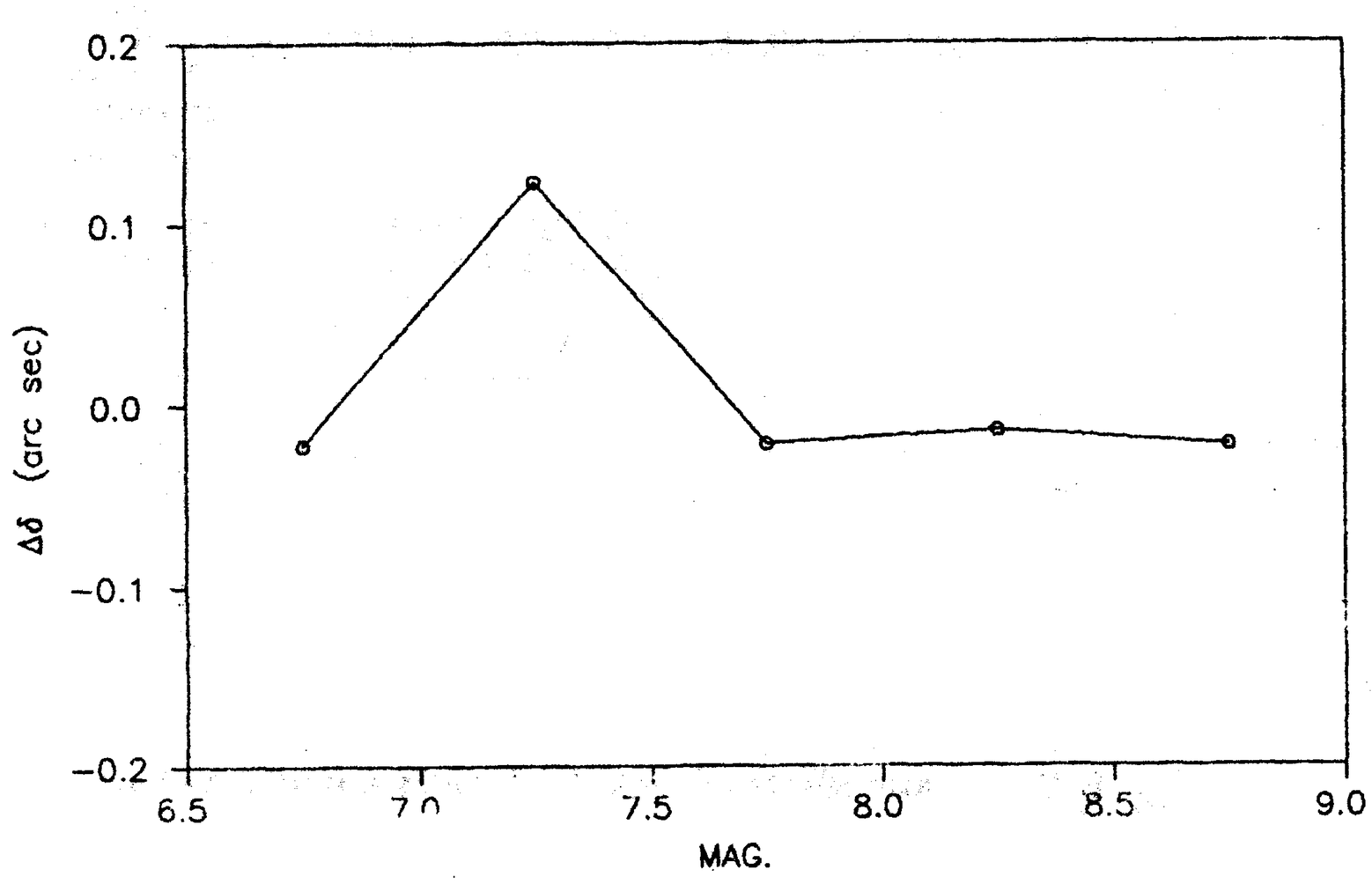

Fig. 2. Systematic effects of the $\Delta\delta_m$ type.

The values $\Delta\alpha_\alpha$ vary from $-0^s.009$ to $+0^s.007$ and $\Delta\delta_\alpha$ vary from $-0''.15$ to $+0''.09$ in individual segments of the sky. The mean value of $\Delta\alpha_\alpha$ resp. $\Delta\delta_\alpha$ over the 4 hours zones follows a sinusoid form.

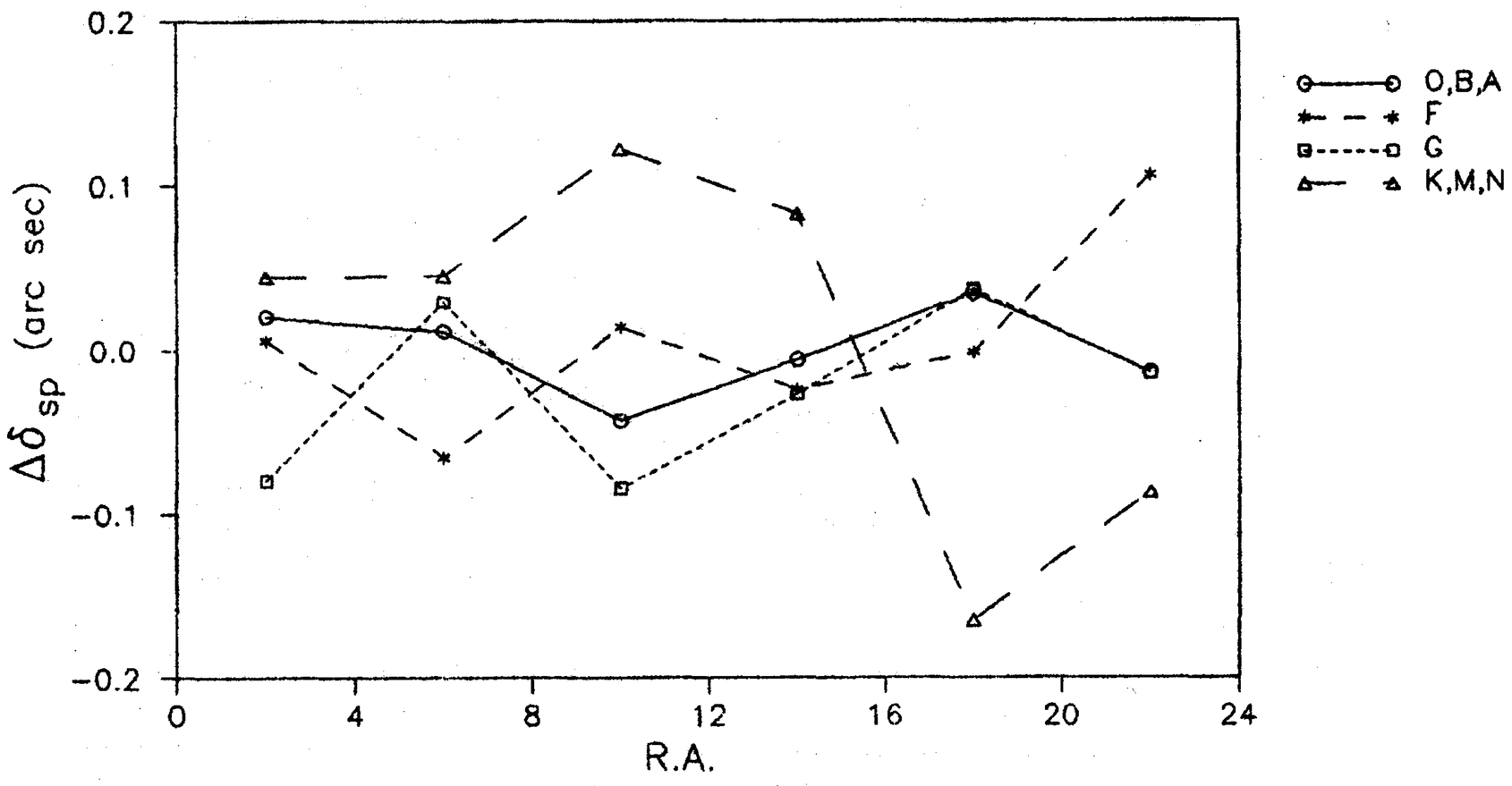

Fig. 3. Systematic effects of the $\Delta\delta_{sp}$ type as a function of α.

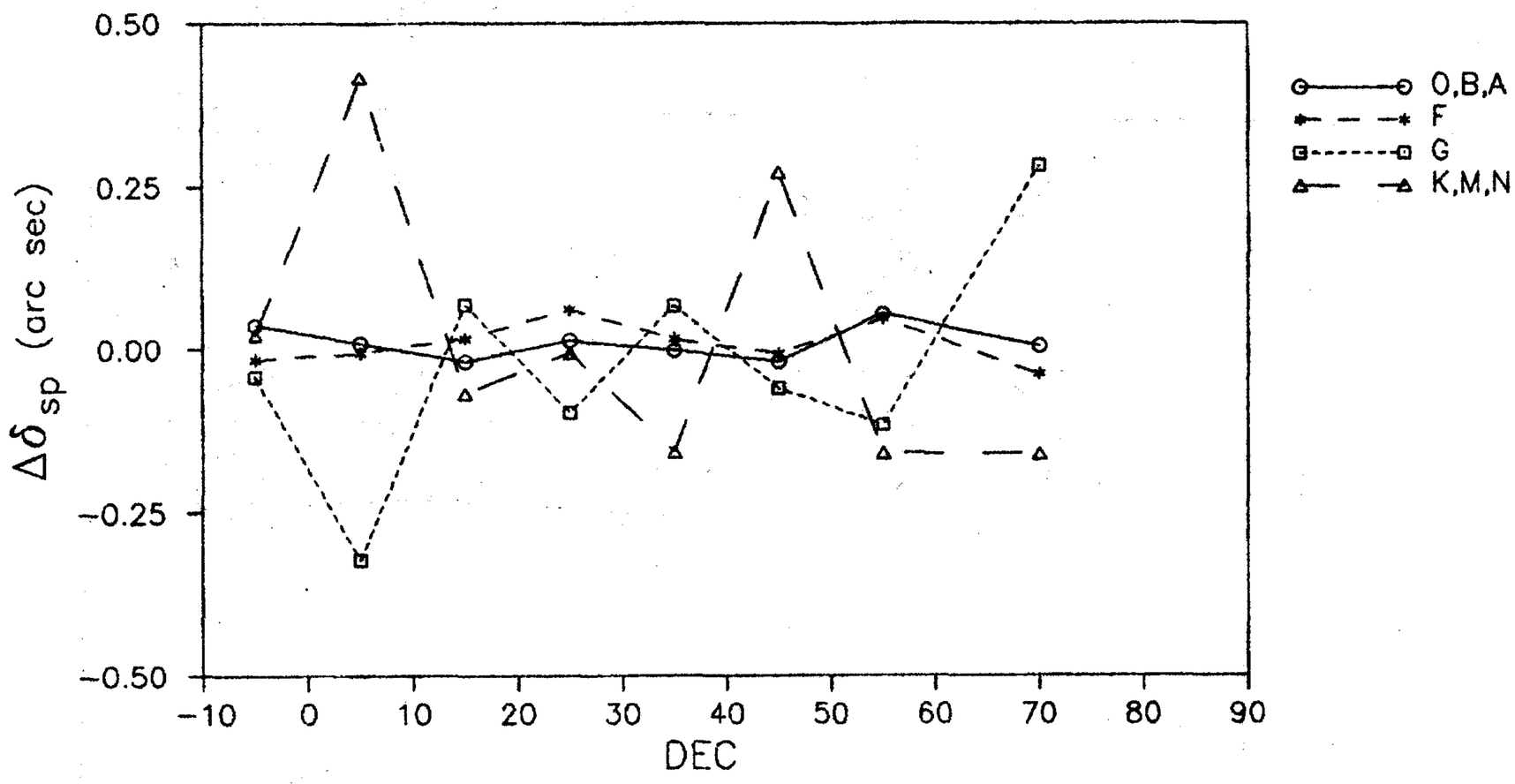

Fig. 4. Systematic effects of the $\Delta\delta_{sp}$ type as a function of δ.

On the basis of the foregoing we can draw the following conclusions:

1. The maximum divergence appears in those areas of the sky in which the measurements were made in the period $0^h < \alpha < 12^h$, which covers the winter period (evening hours).

2. The values for the northern and southern zones point to the possibility of the existence of local anomalies in refraction or, which is more likely, that a certain measured element, which is significant in the calculation, is unreal. It is possible that the measurements of the air temperature in the pavilion were not adequate.

3. The minimum divergencies and the intersections of curves for the zones in the farthest north and farthest south fall in the warmer period, when the observational conditions are more favourable and the number of clear nights higher.

4. Considering that in the observations for BCDS the screen grids were used, the search for systematic effects of the type $\Delta\alpha_m$ and $\Delta\delta_m$ is justifed (see Figs.1 and 2).

5. The obtained $\Delta\delta_{s,p}$ values are grouped by spectral type (see Table 1) as follows:

A - stars of the spectral type A0 to A9, including also some stars of the spectral type B and O;

F - stars of the spectral type F0 to F9;

G - stars of the spectral type G0 to G9;

K - stars of the spectral type K0 to K9, including also some stars of the spectral type M and N.

The analysis of $\Delta\alpha_{s,p}$ and $\Delta\alpha_{s,p}$ shows that the stars of different spectral types have different deviations (see Figs. 3 and 4).

The curves $\Delta\delta_{s,p}$ according to α for the spectral types O, B, A and G (Fig.3) have a cosine trend with low amplitudes $\pm 0''.25$ whereas the corresponding curves for the spectral types F, K, M and N have high amplitudes and opposite curving.

The curves presenting the values $\Delta\delta_{s,p}$ as function of declination (Fig.4) demonstrate a very good agreement for the early- spectral-type stars (O, B, A, F) and a large scattering for the late spectral types (G, K, M, N).

Since the rays of longer wavelengths have lesser refraction angles during their penetration through the atmosphere, the stars of spectral type A will be more strongly apparently shifted towards zenith than the K stars.

On the basis of the available data obtained in this analysis the results indicate that in such kind of examinations of the systematic errors of $\Delta\alpha_{s,p}$ and $\Delta\delta_{s,p}$ types it is necessary to study atmospheric processes in the surroundings of the instrument, as well as the instrument itself.

3. CONCLUSION

On the basis of the above said, we may say that the systematic effects of the types $\Delta\alpha_\alpha$ and $\Delta\delta_\alpha$ and $\Delta\alpha_\delta$ and $\Delta\delta_\delta$ are real and, most probably, they result from:

1. seasonal systematic errors;
2. possible systematic errors in proper motions;
3. systematic errors resulting from observations made by zones;
4. systematic effects $\Delta\alpha_{s,p}$ and $\Delta\delta_{s,p}$ exist and most probably they result from inaccurate refraction value and chromatic qualities of the object-glass.

Acknowledgments – This work has been supported by Ministry for Science and Technology of Serbia through the project "Physics and Motions of Celestial Bodies".

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СИСТЕМАТСКИ УТИЦАЈИ БЕОГРАДСКОГ КАТАЛОГА ДВОЈНИХ ЗВЕЗДА

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УДК 524.38(083.8)
Оригинални научни рад

Поређење Београдског Каталога Двојних Звезда са Прелиминарним Изведеним Каталогом Двојних Звезда извршено је по ректасцензији, деклинацији, магнитуди и спектралном типу. Уочава се постојање систематских грешака $\Delta\alpha$ и $\Delta\delta$ за све типове звезда. Овај утицај се вероватно може објаснити разликом у атмосферској рефракцији за различите спектралне типове. То зависи од квалитета одређивања ректасцензија и деклинација изведених из посматрања звезда на неким опсерваторијама.