RESIDUAL ROTATION OF THE FK5 FROM OPTICAL OBSERVATIONS OF THE PLANETS 1960-1994

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1. Observational basis

In the interval covering last three decades optical observations of the Sun and major planets have been produced with an unprecedented intensity. Most of the published world-wide observations of the Sun, Mercury, Venus and Mars made from 1960 to 1994 with transit circles, astrographs and astrolabes are incorporated here for investigation of the residual rotation of the stellar system with respect to the dynamical reference frame.

The transformation procedure of observations to the FK5-based stellar system presented in (Kolesnik 1995), henceforth Paper I, was applied to observations of the Sun and five major planets to convert them from the system based on standards IAU 1964 to that defined by the standards IAU 1976. The principal correction includes the transition from Newcomb's to Fricke's value of precession and elimination of the non-precessional rotation of the FK4. Residuals $(O-C)_\alpha$ and $(O-C)_\delta$ have been formed by comparison with DE200 ephemeris.

An independent normal system in the equatorial half of the sky (N70E) has been compiled on the basis of 37 modern catalogues made between 1958 and 1993 (Kolesnik 1996). FK3, FK4, GC and N30 catalogues were incorporated in addition to refine the system of proper motions. The mean formal accuracy of the N70E system in both α and δ is estimated to be around 4.5 mas for positions at the epoch 1970, and 15 mas/cy for proper motions. The overall orientation of N70E positions and proper motions is coincident with FK5 being consistent with the adopted equator and equinox J2000.0.The systematic differences N70E-FK5 have been applied to residuals α and δ of the Sun and planets.

S. Ferraz-Mello et al. (eds.), Dynamics, Ephemerides and Astrometry of the Solar System, 477–480.

2. Rotation of the FK5-based stellar system with respect to dynamical reference frame

Smoothed right ascension residuals $(O - C)_\alpha$ derived from 15 transit circle and astrolabe instrumental series for the Sun, 12 transit circle series for Mercury, 13 transit circle series for Venus and 30 transit circle, photographic and astrolabe series for Mars are shown in Fig.1a-d. Spectacular $1''$/cy positive secular drift of the Sun residuals is clearly manifested by the whole ensemble instruments. The similar drift can be noticed for Mercury and Venus as well, despite the clear phase effect. On the other hand, the positive trend is absent in the case of Mars. Solutions for the equinox correction ΔE and its secular motion $\Delta\dot{E}$ are given in Table 1. Conditional equations of Newcomb, for the Sun, and of Sveshnikov (1972), for Mercury Venus and Mars, have been used. The terms of secular variation of origin of the Earth's and planet's mean longitude were omitted in solution for Mercury, Venus and Mars in view of their strong linear correlation with this of equinox motion. Residual rotation of the stellar system and mean motions of the Earth and planets cannot be effectively separated in a LS solution with actual accuracy of optical observations, time interval covered by observations and conditional equations used. The derived quantity $\Delta\dot{E}$ might be interpreted, therefore, as the combined effect of the equinox drift and inaccurate inertial mean motions of the Earth and planets in the comparison ephemerides. The following hypotheses are analysed here to explain

TABLE 1. The equinox correction ΔE for the epoch 1975 (arcsec) and its secular variation $\Delta\dot{E}$ (arcsec/cy) derived from optical observations of the Sun, Mercury, Venus and Mars

		Sun	Mercury	Venus	Mars
Number	RA	10482	1988	6524	3232
of observ	DEC	8177	2017	6313	3892
ΔE		$+0.016 \pm 0.008$	$+0.056 \pm 0.052$	$+0.010 \pm 0.034$	$+0.045 \pm 0.066$
$\Delta\dot{E}$		-1.21 ± 0.08	-0.92 ± 0.22	-0.96 ± 0.14	$+0.56 \pm 0.12$

the $-1''$/cy correction : 1) inaccurate mean motion of the Earth in DE200; 2) inaccurate mean motions of Mercury and Venus in DE200; 3) constant error in FK5 proper motions caused by error in adopted value of luni-solar precession; 4) inadequacy of the procedure applied to transform the FK4-based observations to the FK5 system; 5) constant error in the FK5 proper motions of non-precessional origin appeared due to overestimated Fricke's correction $+1.27'' \pm 0.11''$/cy applied in the FK5; 6) unknown systematic

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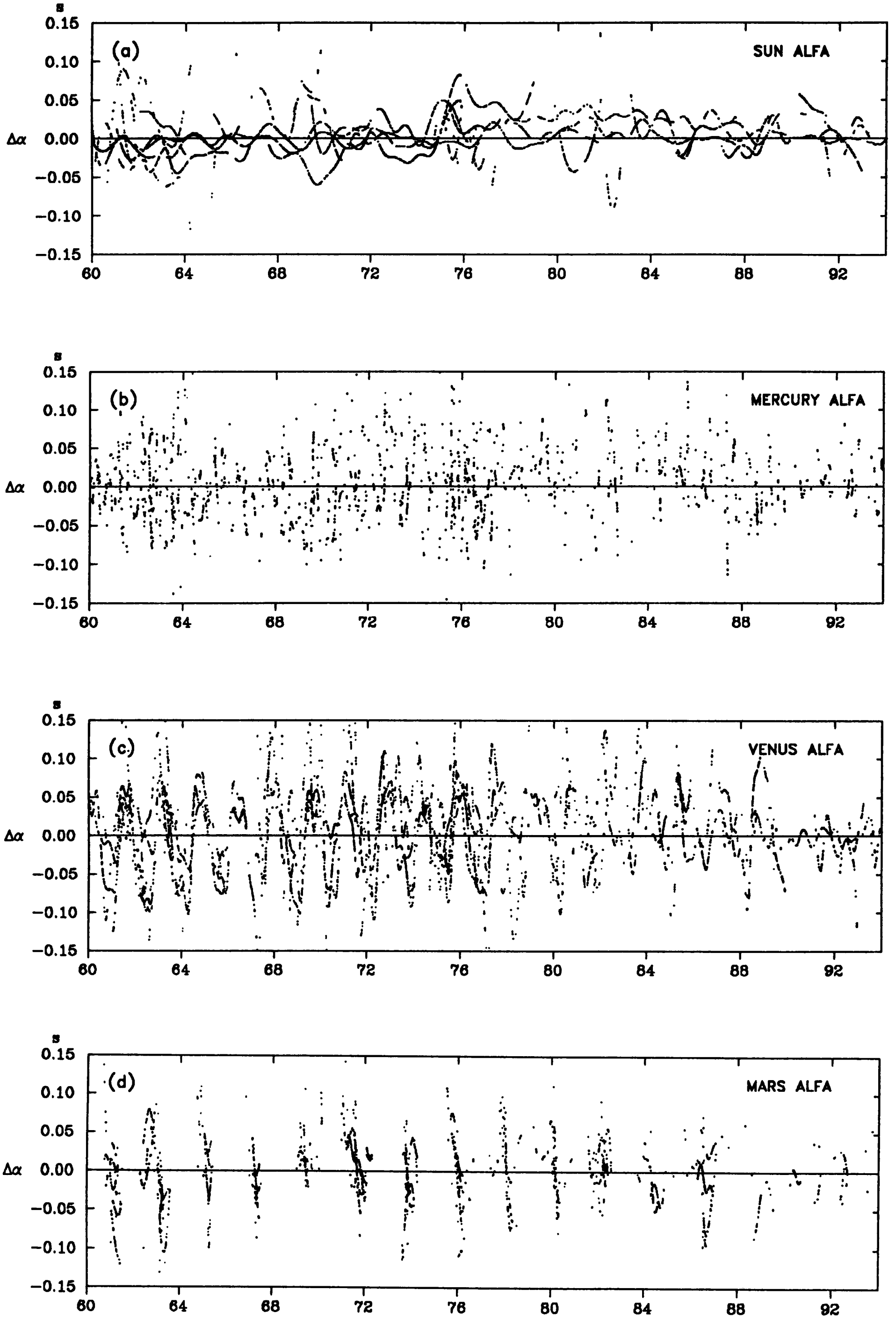

Figure 1. $(O-C)_\alpha$ residuals for the Sun, Mercury, Venus and Mars formed on the basis of modern optical obervations from 1960 to 1994

error in observations of daytime objects varying with time; 7) spurious effect of accidental combination of different instrumental series in a combined solution.

1) The mean motion of the Earth in DE200 cannot be erroneous by $1''/cy$ taking into consideration the investigation of Standish & Williams (1990).
2) To test how the inaccurate mean motions of planets with omitted terms in the conditional equations can affect results of the LS solution, a $1''/cy$ secular error in the origin of planet's longitude has been simulated and applied to the actual observations. Solutions for $\Delta\dot{E}$ with (O-C) computed in this way are $-1.08'' \pm 0.22''$ for Mercury, $-0.98'' \pm 0.14''$ for Venus, $-1.03'' \pm 0.12''$ for Mars, which are to be compared with the respective results in Table 1. It is seen that for Mercury, and especially for Venus, inaccurate mean motions of these planets (at least on the level of $1''/cy$) have a marginal effect on the solutions and cannot essentially affect estimates of given in Table 1. For the outer planets by contrast, in view of the significantly longer periods of revolution, the mean motions are dominant factors affecting the final results.
3) Determination of precession by lunar laser ranging and interferometric technique has shown that Fricke's value cannot have a $1''/cy$ error: see Fukushima (1991). The investigation of Schwan (1988) does not reveal any significant error in FK5 proper motions due to precession.
4) The same procedure has been applied to observations of the inner and outer planets. The latter ones do not manifest the positive trend in right ascension. Hence the $1''/cy$ drift cannot be attributed to an inadequacy of the transformation procedure.

Conclusion: the items 5), 6), 7) are recognized here to be the most probable explanation of the positive secular-like drift in right ascension residuals of modern observations of the Sun, Mercury and Venus.

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