Ahmed Mukhtar Pasha, The Reform of the Calendar, translated by Sir J. W. Redhouse, K.C.M.G., presented by Sir J. W. Redhouse.

Photographs of the Moon taken with the Great Equatoreal of the Lick Observatory (3 original negatives and one glass positive). Photograph of the Total Solar Eclipse, 1889, Dec. 22, by J. M. Schaeberle (2 glass positives). Photograph of *Jupiter*, taken with the Great Equatoreal of the Lick Observatory, by E. S. Holden (glass positive — enlargement). Comparative photographs of the high Sun and low Sun spectra, presented by Mr. F. McClean. — Presented by the Lick Observatory.

On the Real and Apparent Variations of the Latitude of Greenwich.

By Professor F. Folie.

(*Communicated by the Astronomer Royal.*)

The real variations of latitude are, we know, given by the formula

$$r \cos (int + \beta).$$

The values of r given by Peters and Downing * are

$$0''{\cdot}079 \text{ and } 0''{\cdot}075.$$

The same value, determined by me from the diurnal variations in R.A., deduced from the observations of W. Struve at Dorpat in 1823–25, is:

1823	...	...	0·080″
1824	...	...	0·075
1825	...	...	0·086

The value of the constant β, determined by Peters, Nyrén, and Downing,† are, the last being brought back to Dorpat:

1842	...	...	341°·6
1850	...	...	224
1872	...	...	175

Astronomers have not yet been able to bring these values into accordance by assuming the adopted increase of 430° (about) yearly, corresponding to a period of 305 days.

Theoretical reasons, agreeing with my ideas as to the constitution of the central nucleus of the Earth, have made me doubt the

* I cannot use those of Nyrén, because they are too discordant.

† Peters (*A. N.*, xxii., 1845, 128). Nyrén (*St. Pétersbourg M* 1873, no. 10, pp. 37, 38). Downing (*M. N.*, xl., 1880, pp. 431, 432).

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accuracy of this period,* and I have tried to deduce it from the observations, after having found from those of W. Struve (cited above) that the value of 430° is considerably too large. Here are the values deduced from the observations, at April 1 of each of the three years:

1823	...	...	236° 43′	Mean 246°.
1824	...	...	247 23	
1825	...	...	254 6	

A series of observations by Preuss has given me for April 1, 1838, 310°. The difference, $310 - 246 = 64°$ divided by $1838 - 1824 = 14$ gives only 4°·5, or an increase of 364°·5 yearly, which is too small. I divide $360° + 64° = 426°$ by 14, which gives 30°·5 nearly, and 390°·5 for the annual increase.

Applying this to the observations, I find

			Residuals.
1824·0	151°	W. Struve	...
1838·0	$151° + 14 \times 30°{\cdot}5 = 218°$	Preuss, 221°	−3°
1842·0	$151° + 18 \times 30°{\cdot}5 = 340°$	Peters, 341°·6	−1°·6
1850·0	$151° + 26 \times 30°{\cdot}5 = 224°$	Nyrén, 224°	0
1872·0	$151° + 48 \times 30°{\cdot}5 = 175°$	Downing, 175° †	0

If I take 340° for 1842, or 224° for 1850, the same annual increase will naturally give no residuals for 1850 and 1872, or for 1872.

There is no doubt, then, that the constants determined by astronomers are in as great accordance as we can desire with the annual increase of 390°·5, corresponding to a period of 336·7 days instead of 305 days, the value which has hitherto been assumed. This last number is deduced from the value 0·00327 ascribed to $\frac{C-A}{A}$. This value is exact for the Earth considered as a whole solid body. The real value being smaller, 0·00296, we must admit in conclusion that we cannot consider the Earth as a solid body in the studies of variations of latitudes.

We can, from the above, assume with confidence, for the variations of latitude of Greenwich, the formula:

$$r \cos (205° + 390°{\cdot}5\, t),$$

in which $t =$ number of years from 1872·0 and $r = 0''{\cdot}078$, the mean of the values of Peters, Downing and Folie.

These are the results for the real variations of latitude, or the distance between the instantaneous pole and the geographical pole of the Earth. But the constant r is also, with a very slight

* See *Annuaire de l'Observatoire Royal de Bruxelles*, pour 1890, p. 299.

† Value referred to Dorpat.

difference, the constant of the *initial nutation* of the geographical pole, determined in obliquity and in longitude by the formula:

$$\Delta\theta = -r \sin[(1+i)\,nt+\beta]$$
$$\sin\theta\,\Delta\lambda = -r\cos[(1+i)\,nt+\beta],$$

whence we may deduce, as we know, $\Delta\alpha$ and $\Delta\delta$.

The apparent places of stars are, then, subject to variations of a period almost exactly diurnal, since $i = \frac{1}{336 \cdot 7}$ nearly, and no determination of latitude can be exact if not corrected for these variations. And Laplace is right in saying: "Si la valeur de r était sensible, on le reconnaîtrait par les variations journalières de la latitude,"* recognising, in fact, the correction to be applied to the latitude of Greenwich, deduced from two true consecutive zenithal distances of *Polaris*, at upper and lower transits.

If δ be the *true* declination of the star, as it is *calculated by the astronomers*, $\Delta_i\delta$ the initial nutation in declination, the true *real* declination will be $\delta+\Delta_i\delta$, and we shall have for the upper transit [z=true real zenithal distance, ϕ=colatitude].

$$z = \phi - \delta - \Delta_i\delta.$$

But we see immediately that after twelve sidereal hours the sign of $\Delta_i\delta$ must change and maintain almost the same value. We have, then, for the lower transit

$$z' = \phi + \delta - \Delta_i\delta.$$

From the two equations we deduce

$$\phi = \frac{z+z'}{2} + \Delta_i\delta$$

instead of

$$\phi = \frac{z+z'}{2}$$

the value given by astronomers.

This correction is by no means to be neglected, if we admit the coefficient $0''\cdot078$. It is for Greenwich

$$i = \frac{1}{336\cdot7} \text{ or } int = 390^\circ\cdot5 \text{ yearly};$$
$$t = \text{sidereal days from } 1872\cdot0;$$
$$nt = 360^\circ \text{ for a sidereal day};$$
$$\beta = 205^\circ;$$
$$\Delta_i\delta = \sin\alpha\Delta_i\theta + \cos\alpha\sin\theta\Delta_i\lambda$$
$$= -r\cos\{(1+i)\,nt+\beta-\alpha\},$$

which expression will change its sign after twelve hours, if we neglect the half degree for the increase of it, and the colatitude

* *Mécanique Céleste*, livre v., art. 4.

deduced from each pair of observations must be corrected by this quantity, as I have said above. Is it necessary to add that if we will take the hundredth of a second of arc in account, it is quite indispensable to correct the observations for initial nutation?

The expression in R.A. of the initial nutation is:

$$\begin{aligned}\Delta\alpha &= (\cot\theta + \sin\alpha\tan\delta)\sin\theta\Delta_i\lambda - \cos\alpha\tan\delta\Delta_i\theta \\ &= -r\{M\cos[(1+i)t+\beta] + N\sin[(1+i)t+\beta]\}.\end{aligned}$$

M and N being respectively $\cot\theta + \sin\alpha\tan\delta$ and $\cos\alpha\tan\delta$.

If r has the value given by the determinations of Peters, Downing and myself, this correction may attain to $0^s{\cdot}2$ of time for *Polaris*. But I think this value of r to be still doubtful, in spite of the accordance of those three determinations.

A very important consequence which arises in taking no account of the variations of latitude as also of the initial nutation, is its influence on the determination of the obliquity of the ecliptic.

If E_0 = mean obliquity determined as usual, the true expression for it, at the summer solstice, is

$$E_m = E_0 + \gamma\cos(int+\beta) + \gamma\sin[(1+i)nt+\beta],$$

the first term of the corrections arising from the variation of latitude, the second from the initial nutation.

At the winter solstice, this expression becomes

$$E'_m = E'_0 + \gamma\cos(int'+\beta) - \gamma\sin[(1+i)nt'+\beta];$$

the sign of the correction of the initial nutation is changed because, at the solstices, when the Sun's right ascension is 90° or 270°, the initial nutations in declination,

$$\Delta_i\delta = \sin\alpha\Delta_i\theta,$$

are equal and opposite in sign.

But, at the winter solstice, t is increased by an entire number j of sidereal days, taken as unity, and twelve hours more, so that

$$t' = t + j + 12^h$$

and

$$\begin{aligned}E'_m &= E'_0 + \gamma\cos(int'+\beta) + \gamma\sin(j+nt+int'+\beta) \\ &= E'_0 + \gamma\cos(int'+\beta) + \gamma\sin(nt+int\ +\beta),\end{aligned}$$

because j is a multiple of 360°.

The correction of obliquity at the summer solstice $E_m - E_0$ will be:

$$\Delta E = 2\gamma\cos\left(\frac{nt}{2} - 45^\circ\right)\sin\left(\frac{nt}{2} + 45^\circ + int + \beta\right)$$

and at the winter solstice

$$\Delta E' = 2\gamma\cos\left(\frac{nt}{2} - 45^\circ\right)\sin\left(\frac{nt}{2} + 45^\circ + int' + \beta\right).$$

These two corrections are not equal; the difference $\Delta E - \Delta E'$ will be:

$$\Delta^2 E = -4\gamma \cos\left(\frac{nt}{2} - 45^\circ\right) \sin in\frac{t'-t}{2} \cos\left(\frac{nt}{2} + 45^\circ + in\frac{t'+t}{2} + \beta\right)$$

as $t'-t$ is a half year,

$$in\frac{t'-t}{2}$$

will be equal to

$$\frac{390^\circ{\cdot}5}{4} = 97^\circ{\cdot}6\text{; its sin} = 0{\cdot}9915,$$

and we have then

$$\Delta^2 E = -3{\cdot}966\gamma \cos\left(\frac{nt}{2} - 45^\circ\right) \cos\left(\frac{nt}{2} + 45^\circ + in\frac{t+t'}{2} + \beta\right),$$

or, if we write

$$in\frac{t'+t}{2} = int + 97^\circ{\cdot}6,$$

and

$$\beta + 7^\circ{\cdot}6 = \beta'$$

$$\Delta^2 E = 3{\cdot}996\gamma \cos\left(\frac{nt}{2} - 45^\circ\right) \sin\left(\frac{nt}{2} + 45^\circ + int + \beta'\right).$$

We will apply the formula to the determination of obliquity for Greenwich 1872, and take for the equinox

$$\beta = 205^\circ + 0{\cdot}2163 \times 390^\circ{\cdot}5 = 289^\circ{\cdot}5\,;$$

$$\beta' = \beta + 7^\circ{\cdot}6 = 297^\circ{\cdot}0\,;$$

and

$$3{\cdot}996\gamma = 0''{\cdot}3.$$

From the equinox to the solstice t is increased by an entire number of days + 6 hours. So that $\frac{nt}{2}$ will be $= 45^\circ$.

The expression of $\Delta^2 E$ will then be

$$\Delta^2 E = 0''{\cdot}3 \cos(int + \beta') = 0''{\cdot}3 \cos(97^\circ{\cdot}5 + 297^\circ)$$
$$= 0''{\cdot}3 \cos 34^\circ{\cdot}5 = 0''{\cdot}25.$$

Such is the difference existing between the obliquity determined at summer and at winter solstices in 1872, at Greenwich, if we admit as exact the determination of the initial nutation made by Downing.

Moreover, if my period of 336·7 mean days is admitted as exact by astronomers, instead of the period of 305 days, adopted until now, and the great accordance between all the determinations compels this admission, it is certain, as I have said, that we cannot consider the Earth as a solid body, for which $\frac{C-A}{A}$ oscillates, at the most, between 0·00324 and 0·00328 (taking into account the exactness of the constants of precession and nutation), and, in consequence, the period between 304 and 306 days.

And if we cannot consider the Earth a solid body, the diurnal nutation, of which the period is half a sidereal day, certainly exists.

I estimate its coefficient to be twice as great as that of the initial nutation. It is, then, a new correction to be applied to the observations, if we will be sure of the hundredth of a second of arc.

And then, can we even be sure?

Brussels: July 5, 1890.

Preliminary Note on the Duplicity of α Lyræ. By A. Fowler.

(*Communicated by Professor J. Norman Lockyer, F.R.S.*)

A photographic study of stellar spectra has recently been commenced at Kensington, under the direction of Professor Lockyer, and one of the first results is the discovery that *α Lyræ* is a binary of the *β Aurigæ* and *ζ Ursæ Majoris* type. The principles of the method have already been fully stated by Professor Pickering (*Monthly Notices*, vol. L, p. 296), but it may be remarked that the evidence of duplicity depends upon the fact that when both components are travelling in opposite directions in the line of sight, the lines of the spectrum which are common will appear double, the spectrum of one being displaced towards the red and the other towards the violet. When the components are moving at right angles to the line of sight, the lines will be single. During a whole period, therefore, a given line will first appear single, let us say, then it will gradually double until a maximum is reached; it will then narrow and become single, widen to another maximum and again appear single.

In the spectrum of *α Lyræ* the principal lines are those of hydrogen, but these do not show the duplication because the separation is not greater than the thickness of the lines. A variation in width, however, amounting almost to doubling in the more refrangible lines, is very obvious. Next to the hydrogen lines the K line is strongest, and this is sufficiently fine and distinct to render the detection of duplication quite easy. The remaining lines are very faint and their duplication is not very apparent. They are only seen to be double in two or three photographs. Fourteen photographs have already been obtained, dating from October 3 to November 4, but, owing to unfavourable weather, there are long breaks in the series. There are sufficient data, however, to enable a provisional period of revolution and the probable form of the orbit to be determined.