On the Proper Motion of Sirius in Declination. By Truman Henry Safford, Assistant at the Observatory of Harvard College.

It is well known that *Sirius* exhibits irregularities of proper motion, both in Right Ascension and Declination. Bessel (*Ast. Nach.* Nos. 514–16), and Dr. C. A. F. Peters, in a Memoir, "Ueber die eigene Bewegung der *Sirius* (Habilitationsschrift), Königsberg, 1851," also republished in vol. xxxii. of the *Astronomische Nachrichten*, have investigated the variations of proper motion in Right Ascension. The hypothesis which these distinguished astronomers have adopted is, that the motions are performed around some centre of gravity, which is not at *Sirius* itself. This involves the idea of a dark body of considerable mass, whose attraction is exerted to draw *Sirius* from its hypothetical motion in a straight line. Dr. Peters does not, as I understand, insist that the dark body is of greater mass than *Sirius* itself; so that it may (possibly) be of planetary character.

The object of the present discussion is merely to show the character of the irregularities in Declination, and to examine whether they are reconcilable with the results derived from the Right Ascensions. The quantity which I have used in this investigation is the deviation of *Sirius* in Declination from the *Tabulæ Regiomontanæ*, less mean of the corresponding deviation for the four stars *Spica*, a^2 *Libræ*, *Antares*, and a^2 *Capricorni*. These have the advantage over absolute declinations, that there is thus a possibility of avoiding a portion of the systematic errors to which most astronomical determinations are exposed. The mean of the Declinations of the four comparison stars is very nearly that of *Sirius*.

Bessel's Declinations are (it is well known) more than a second further south than other determinations, at a South Declination equal to 16°; and in a matter of such delicacy it becomes necessary to scrutinise the observations quite closely.

Without a new reduction of Piazzi's and Pond's observations, it would be difficult to use them as fully authentic. The chief cause of disturbance seems to be the fact that Piazzi and Pond both used Bradley's factor for the thermometric variation of the refraction; and this value is largely erroneous. If *Sirius* is observed at a mean temperature different from that at which the four stars above mentioned are observed, an error is thus introduced. The refraction being large, it becomes of too great influence.

The effect (probably) of this error in the factor of the thermometric correction may be seen on comparing Olufsen's reduction of Pond's observations of 1822 with Pond's own. As a^2 *Capricorni* is not contained in Pond's reduction, we will (at

this period) omit it in considering Olufsen's. We find that by Pond's own reduction of his observations of 1822, *Sirius* is 1″·68 further north than the *Tabulæ Regiomontanæ* make it; that *Spica*, a^2 *Libræ*, and *Antares*, are (in the mean) 4″·55, and, therefore, that *Sirius* is 2″·87 too far south, as compared with these three stars. But, by employing Olufsen's reduction, *Sirius* is shown to be 0″·33 too far north, and the three other stars in the mean 0″·95; so that *Sirius*, as compared with these three, is 0″·62 too far south.

The comparisons here given have been taken from Bessel's table (*Ast. Nach.* No. 73, p. 7).

The numbers which have been used are as follows, nearly:

			q′.
Bradley	1755		−0·7
Piazzi	1805		(−0·5)
Pond	1813		(+0·6)
Bessel	1820		−0·4
Pond	1822	(Olufsen)	−1·5
Struve	1824		−1·6
Pond	1826		(−2·1)
Argelander	1830		−1·0
Taylor*	1832		−1·7
Pond	1833		(−2·6)
Henderson*	1833		−1·5
Airy	1834		−2·4
Maclear*	,,		−1·7
Henderson	1837		−0·8
Airy	1838		−0·4
Busch	,,		−0·4
Bessel	1843		+1·1
Airy	1844		+1·9
,,	1850		+2·1
Moesta*	1855		+0·8
Airy	1856		+1·5

* From observations near and south of the equator.

It may seem singular that the position of the *Fundamenta* for 1755, and Bessel's for 1820, should seem to differ at all from the *Tabulæ Regiomontanæ*, when the latter were calculated from the former. The numbers given above, for those Catalogues, are merely the corrections necessary, on account of the alteration in mutation, rendered necessary by more modern observations. Corrections have been applied also to Olufsen's reduction of Pond (−0″·26), to Argelander (+0″·40), and to Busch (−0″·39); these being the excess of the correction

taken from Table IV. on p. xxvi. of Struve's *Positiones Mediæ* for *Sirius* over the similar correction for the four stars compared.

Our table includes, then, the deviation from the *Tabulæ Regiomontanæ* of the Declination of *Sirius*, as observed by different observers, with (in general) different instruments, less the mean of the similar corrections for *Spica*, a^2 *Libræ*, *Antares*, and a^2 *Capricorni;* corrected in the cases above specified for error of mutation.

On referring to Dr. Peters' memoir, we shall at once find that, if his hypothesis be adopted, the numbers given above will be represented by the formula

$$q' = b' + f' + c'(t - 1800) + g' \cos u + h' \sin u,$$

where b' denotes the correction of the Declination for 1800 of the centre of gravity of the system, c' the correction of Annual Proper Motion; each of these quantities to be applied to the *Tabulæ Regiomontanæ* values for *Sirius* itself, to get declinations in general accordance with Bessel's other declinations; g', h', being constants depending on the elements of the orbit of *Sirius* around the centre of gravity, and $f' = -g'e$, where e is the excentricity; u being also the excentric anomaly of *Sirius* in its orbit.

If, then, we adopt Peters' Elements V.,

Passage of the Lower Apside	1791·431
Mean Yearly Motion	7°·1865
Excentricity (e)	0·7994

we shall have

$$u - e \sin u = 7^\circ{\cdot}1865\,(t - 1791{\cdot}431),$$

t being the date in years, and the predicted values of $\sin u$ $\cos u$ can be easily computed. But, in the first place, it must be seen whether any hypothesis of uniform motion will represent the observations, excluding Bradley's of about 1755. It is found that a correction $-4''{\cdot}18 + 10''{\cdot}30\left(\frac{t-1800}{100}\right)$ will materially lessen the errors. This correction, however, requires that Bessel's Bradley's place for 1755 be erroneous by $8''{\cdot}7$; and that this is impossible is shown by the near agreement of Lacaille's and Mayer's places for 1750 and 1756 with the *Tabulæ Regiomontanæ*.

But the actual formula deduced from the observations by the substitution of Peters' hypothesis is

$$-0''{\cdot}56 + 0''{\cdot}0202\,(t - 1800) + 1''{\cdot}47 \sin u + 0''{\cdot}51 \cos u,$$

and this leaves, as residual errors,

			C—O.	
			″	
Bradley			0·0	
Piazzi	1805		(+0·8)	
Pond	1813		(−0·6)	
Bessel	1820		−0·6	
Pond	1822	(Olufsen)	+0·3	
Struve	1824		+0·4	
Pond	1826		(+0·8)	
Argelander	1830		−0·5	
Taylor	1832		+0·2	
Henderson	1833		0·0	
Pond	1833		+1·1	(14 observations.)
Airy	1834		+1·0	
Maclear	1834		+0·3	
Henderson	1837		−0·4	
Airy	1838		−0·5	
Busch	1838		−0·4	
Bessel	1843		+0·5	
Airy	1844		0·0	
,,	1850		−0·4	
Moesta	1855		+0·5	
Airy	1856		−0·4	

There can be hardly any doubt, then, that Bessel's and Peters' hypothesis does actually represent the observed Declinations of *Sirius*, although the evidence on which it has been previously urged depends entirely on the Right Ascensions.

It may be noticed that Calandrelli's statement, that the *Greenwich Twelve-Year Catalogue* for 1845 (1844) is materially in error, is at once refuted by the almost perfect agreement given above. The phenomena which *Sirius* presented about 1841, that being according to Peters (confirmed by the results above) the time of the passage of the lower apside, are sufficiently remarkable; rapid variations both in Right Ascension and Declination were then taking place.

Extract of a Letter from Mr. A. Auwers to the Rev. R. Main, dated Königsberg, 1862, February 21, on the Irregularity of the Proper Motion of Sirius, and on a Missing Nebula.

(*Communicated by the Rev. R. Main.*)

For some months I have been attempting to represent the observed Declinations of *Sirius* from 1755 to 1859, in which a