

The close agreement of the determinations of  $\sin \gamma d\theta$  is satisfactory.

The figures on p. 581 should be replaced by

$$\begin{aligned} N_1 M_1 &= 52^{\circ}6 & N_2 M_2 &= 40^{\circ}9 \pm 2^{\circ}5 \\ M_1 N_1 N_2 &= 121^{\circ}99 & M_2 N_2 N_1 &= 61^{\circ}72 \\ \text{and} & & N_1 N_2 &= 3^{\circ}66 \end{aligned}$$

Solving the triangles, the values found for the inclination, &c., are the same as those previously given.

3. The inclination of *Neptune's* equator to the plane of its orbit derived from these figures is about  $29^{\circ}$ .

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*The Meteors from Biela's Comet.* By W. F. Denning.

Undoubtedly the rich shower of *Andromedids* visible in the light of the nearly full moon on 1904 November 21 formed the most important meteoric event of the past year. The only observer of it in the United Kingdom appears to have been the Rev. W. F. A. Ellison, of Enniscorthy, who at 7<sup>h</sup> 25<sup>m</sup> G.M.T. saw eight meteors in fifteen seconds, and twenty-four altogether between 7<sup>h</sup> 25<sup>m</sup> and 8<sup>h</sup> 25<sup>m</sup>. Twenty-two others were observed between 8<sup>h</sup> 25<sup>m</sup> and 9<sup>h</sup> 25<sup>m</sup>, after which the numbers "fell off greatly." The radiant by eye estimation from forty or fifty tracks was at  $21^{\circ} + 50^{\circ}$ . The meteors generally were very brilliant, with trains, and a few of the more conspicuous objects were recorded as under :—

	G.M.T.			From	To
1905.	h	m			
Nov. 21	8	2	> 1	$308 + 47$	$280 + 39\frac{1}{2}$
"	8	49	♀	Low in W.	Andromedid
"	9	8	♂	$337 + 7$	$329 - 7$
"	9	16	♂	$354 + 30$	$348 + 18$
Nov. 26	7	35	♀	$52 + 27$	$64 + 8\frac{1}{2}$
28	8	50	> ♀	$215 + 50$	$215 + 46$

The display apparently continued until November 28.

It was also observed by K. Bohlin, of Stockholm (*Ast. Nach.* 3997), who says that the radiant of twenty-eight meteors (the paths of which he gives in his paper) recorded on 1904 November 21, 5<sup>h</sup> to 11<sup>h</sup> (mid-European time) was found by the method of least squares to be about  $3^{\circ}$  distant from  $\gamma$  *Andromedæ* at

$$26^{\circ} 2' + 44^{\circ} 10' (1900)$$

The meteors were of considerable brilliancy. The first

indications of the display were noticed on November 16, and it appeared to have ceased on November 22.

The occurrence of these *Andromedids* (sufficiently brilliant and abundant to attract special notice in strong moonlight) is remarkable, as there was a rich shower of them in 1899 November 24, so the interval is only five years, and the inference is that the meteors are being rapidly spread out along a considerable arc of the orbit.

The observed perihelia of Biela's Comet occurred 1772 February 19 and 1852 September 23, so that the mean period derived from twelve returns is 6.71 years.

The great meteoric showers of 1798 December 7 and 1885 November 27 comprise thirteen periods of 6.69 years.

The periodic time of the comet in 1846 was 6.617 years (Hind), and slightly greater than this according to the computed (but unverified) returns to perihelion in 1859 May 23, 1866 January 25-26, and 1872 October 6. By adopting a mean period of 6.68 years the observations of the meteoric displays, &c., seem fairly well satisfied.

P.P. of Biela. Period of 6.68 years.	Observed Meteoric Display.	Earth's Long.
1852 September 23	...	...
1859 May 30	...	...
1866 February 2	...	...
1872 October 9	1872 November 27	66.1
1879 June 14	...	...
1886 February 17	1885 November 27	65.8
1892 October 23	1892 „ 23	62.3
1899 June 28	1899 „ 24	62.3-6
1906 March 3	1904 „ 21	59.1

There will probably be a storm of these *Andromedids* in 1905 November 17-21; this, if realised, will give a mean period for sixteen returns (1798-1905) of 6.685 years.

The arc of true anomaly between 28 and P.P. being thirty days, the cometary material providing the meteoric showers must be in perihelion a month later than the observed displays.

If the periodic time of 6.68 years is correct the meteoric shower of last November took place about fifteen months before the comet reaches perihelion. The Earth is likely to intersect a part of the meteoric orbit much nearer the cometary nucleus of the swarm on November 17-21 next, and in view of recent developments the display will be awaited with great interest.

Planetary perturbation amply accounts for the removal of the shower to an earlier date than formerly. Bredichin pointed out that *Jupiter's* disturbing action in 1889.5-1891.5 brought about a reduction of 4° in the node, making the date November 23 instead of November 27, as in 1872 and 1885; and Dr.

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from Biela's Comet.

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Schulhof announced that there would occur another serious disturbance in 1901·2 from the same cause. Professor Abellmann, of Vienna, investigated the subject (*Ast. Nach.* 3516), and found that the node would be further affected to the extent of  $-6^{\circ}2$ , altering the shower-date to November 17 at the next maximum return in 1905 (*Observatory*, vol. xxi. p. 399). It appears that in 1901 March *Jupiter* approached the main group of *Andromedids* to within 0·5 of the Earth's mean distance from the Sun.

This particular system, from the shortness of its period, its liability to perturbation, and the great physical changes apparently affecting it, promises to give us a far clearer insight into the phenomena of meteoric streams and their cometary derivations than any other with which we are acquainted. The other prominent showers, correlated with known comets, and forming the *Lyrids*, *Perseids*, and *Leonids*, are probably of more ancient date and certainly of much longer period than the *Andromedids*. Many ages ago the former groups passed through the various gradations resolving them into annual showers with periodical maxima. No doubt, as a comet visible to human eyes, Biela's has vanished for ever. But its disintegration in 1846 and subsequent apparitions in the form of meteoric displays have added much to our knowledge of the subject.

In 1872 the *Andromedids* were confined to one night, and the stream was evidently a compact and narrow one. In 1885 the meteors were visible from November 25 to November 30, and it is probable that the particles are not only spreading out laterally, owing to repeated intersections by the earth, but that the group is lengthening out from year to year along the orbit, and will finally present an annual shower like the *Perseids*. Between the returns of 1892 and 1899 there were seven years, and between those of 1899 and 1904 only five years, so the dispersion of the meteors is evidently considerable.

Professor H. A. Newton pointed out as long ago as 1874 from a comparison of the positions of Biela's Comet at the times of the great showers of 1798, 1838, and 1872 that a "long, extended group of meteoric particles must accompany the comet in its periodic revolution, preceding it to a distance of 300 millions of miles (as in 1838) and following it to a distance of 200 millions of miles (as in 1872)" (*British Association Report*, 1875, p. 224). A further extension has probably taken place in more recent years, but the precise character of the changes effected remains to be determined by future observation.

An interesting point is that the *Andromedids* are now nearly contemporaneous with the *Leonids*. It appears likely that in ensuing years it will be possible to witness two notable meteoric displays in simultaneous action, one yielding objects having the greatest, the other the least, apparent velocity, while the green streaks of the rapid *Leonids* will contrast in a striking manner with the yellow trains of the slowly falling *Andromedids*.

Bishopston, Bristol :  
1905 May 12.

*The most Probable Position of a Point determined from the Intersections of Three Straight Lines.* By S. A. Saunder, M.A.

In the course of my work on the Moon I have frequently fixed the position of what may be termed a point of the second order by measuring its position angles from three points whose coordinates had been well determined. I have shown (*B.A.A. Memoirs*, vol. vii. pp. 61-65) that when the points are near the centre of the Moon's disc, and the distances between them are small, the errors involved by neglecting the effects of libration are also small, whilst the reduction of the measures is thereby much simplified.

In the course of these reductions I have had to consider what was the most probable position of a point so determined. I am not aware what is the practice of those who compute meteoric radiants, but a recent writer (*Monthly Notices*, vol. lxv. p. 238) has assumed that the radiant should be placed at the incentre of the triangle formed by these lines. As this can be correct only under very special circumstances, I have thought it might be worth while to call attention to the point.

Supposing the determinations of the lines to be of equal weight, the conditional equations should be so stated that equal residuals are equally probable, and this would seem to be effected, at all events in my work, by writing the equations in the form  $x \cos a + y \sin a - p = 0$ , so that the residuals represent the perpendiculars from the point finally determined upon the three straight lines. If a distant point were observed with a theodolite the equations would require to be differently weighted.

If we use trilinear coordinates, taking these straight lines as sides of the triangle of reference, these three residuals will be the coordinates  $\alpha$ ,  $\beta$ ,  $\gamma$  of the point, and we have to determine their values so that  $\alpha^2 + \beta^2 + \gamma^2$  may be a minimum.

A necessary condition is that

$$\alpha \delta \alpha + \beta \delta \beta + \gamma \delta \gamma = 0 \quad \dots \quad \dots \quad (1)$$

$$\text{and} \quad \alpha a + \beta b + \gamma c = 2\Delta \quad \dots \quad \dots \quad (2)$$

$$\therefore \quad \alpha \delta \alpha + \beta \delta \beta + \gamma \delta \gamma = 0 \quad \dots \quad \dots \quad (3)$$

$$\text{From (1) and (3)} \quad (ca - a\gamma)\delta\alpha + (c\beta - b\gamma)\delta\beta = 0$$

and as  $\alpha$ ,  $\beta$  are now independent this gives

$$\frac{a}{\alpha} = \frac{\beta}{b} = \frac{\gamma}{c} = \frac{2\Delta}{\alpha^2 + \beta^2 + \gamma^2} \quad \text{by (2)}$$

If  $u \equiv \alpha^2 + \beta^2 + \gamma^2$  it is easily shown by actual differentiation that

$$r = \frac{\partial^2 u}{\partial \alpha^2} = 2 + 2 \frac{a^2}{c^2}, \quad s = \frac{\partial^2 u}{\partial \alpha \partial \beta} = 2 \frac{ab}{c^2}, \quad t = \frac{\partial^2 u}{\partial \beta^2} = 2 + 2 \frac{b^2}{c^2}$$