of translation in the visual direction of some portions of the nebulous matter within the nebula, which might be found by comparing the different parts of a large and bright nebula.

Sir William Herschel states that "nebulæ were generally detected in certain directions rather than in others, that the spaces preceding them were generally quite deprived of stars, that the nebulæ appeared some time after among stars of a certain considerable size and but seldom among very small stars, that when I came to one nebula I found several more in the same neighbourhood, and afterwards a considerable time passed before I came to another parcel"*.

Since the existence of real nebulæ has been established by the use of the spectroscope, Mr. Proctor† and Professor D'Arrest‡ have called attention to the relation of position which the gaseous nebulæ hold to the Milky Way and the sidereal system.

It was with the hope of adding to our information on this point that these observations of the motions of the nebulæ were undertaken.

In the following list the numbers are taken from Sir J. Herschel's 'General Catalogue of Nebulæ.' The earth's motion given is the mean of the motions of the different days of observation.

No.	h.	H.	Others.	Earth's motion from Nebula.
1179	360	..	M. 42	7 miles per second.
4234	1970	..	Σ. 5	12 ,, ,,
4373	..	IV. 37.	..	1 ,, ,,
4390	2000	..	Σ. 6	2 ,, ,,
4447	2023	..	M. 57	3 ,, ,,
4510	2047	IV. 51.	..	14 ,, ,,
4964	2241	IV. 18.	..	13 ,, ,,

III. "On the Annual Variation of the Magnetic Declination." By J. A. Broun, F.R.S. Received February 11, 1874.

The first observations which seemed to show that the mean position of the declination-needle followed an annual law were those of Cassini, made, more than eighty years ago, in the hall of the Paris Observatory and in the *caves* below it (90 feet under ground). It cannot be said, however, that Cassini's result has been confirmed by subsequent observations, either as regards the direction or amounts of movement from month to month.

The extensive series of observations made in different parts of the

* Philosophical Transactions, 1784, p. 448.
† Other Worlds than Ours, pp. 280–290.
‡ Astronomische Nachrichten, No. 1908, p. 190.

world in modern times have given results so different that we must conclude either that the magnetic needle obeys different annual laws at each place, or that the differences are due to instrumental errors. The consequence has been that, after long, laborious, and expensive researches, it is still a question whether the magnetic needle obeys an annual law or not.

The results obtained at some observatories have made it very probable that, if an annual law exist, the range of the oscillation must be very small. It is therefore essential, in questioning any series of observations for this law, to be assured that the errors (instrumental or others) are neither considerable nor systematic.

I have concluded, from several series of observations made with suspension-threads bearing unmagnetic or slightly magnetic weights, that the systematic errors due to varying temperature or humidity are very small when the suspension-threads are carefully constructed with fibres from which the original torsion has been removed. Dr. Lloyd has concluded that threads with fibres differently twisted may produce comparatively large annual variations in different directions, according to the direction of the twist. There is little doubt, however, that the greatest errors are due to the unequal stretching and rupture of the different fibres which form the suspension-thread.

When the instrumental errors may be so considerable compared with the variations to be observed, it cannot be supposed extraordinary that instruments in different places give different results; and it appears essential so to eliminate the sources of error that two instruments in the same place may tell the same story before we attempt to announce the existence of any law.

If at sea two or more chronometers are necessary in case one may be affected by error, it seems not less necessary in scientific researches requiring continuous observations for years, where errors are so difficult of detection and elimination, that two or more instruments should be observed. These considerations induced me to establish at Trevandrum two declination-magnetometers of different construction, placed under considerably different atmospheric conditions; and it is to the results of sixteen years' comparative observation from these two instruments that I desire to draw the attention of physicists.

Both instruments had suspension-threads made with the utmost care. One, Dr. Lloyd's instrument, made by Mr. Grubb, of Dublin, with a magnet weighing nearly a pound, was placed in the large room of the Trevandrum Magnetic Observatory, which was always more or less open to the external air; and, although covered by a cotton-wadded hood and a series of boxes, it was much more liable to any errors due to atmospheric actions than the other. Its chief source of error was, however, connected with small movements of the telescope wire, although that was made to coincide, at varying intervals of time, with the transit-mark five miles distant.

The second instrument, made according to my own designs by Mr. P. Adie, of London, had a magnet weighing only about one sixth of the other; it was suspended under a glass bell from which the air was exhausted, and which was covered with two hoods—one with gilt surfaces, the other with cotton wadding. This instrument was placed in a closed room without windows or external openings, and with a terraced ceiling below the observatory roof. Observed from without (within the large room of the observatory), the diurnal variations of temperature in the instrument were not more than three tenths (0·3) of a degree Fahrenheit, while the annual variation was under 5° Fahr.*

The compared mean positions of the two magnets for each day, derived from hourly observations of both instruments during eleven years, and from eight daily observations during the remaining five years, will be found with all other details in the volume referred to in the note to the preceding paragraph. It will be sufficient for the purposes now in view to give here the chief conclusions from these means.

The monthly mean declinations having been freed from the secular movement, and the means for three groups of years having been taken, these means are represented very nearly by the following equations of sines ($\theta=0$, Jan. 15):—

Years.		
1854 to 1859	Adie.	$y=0'{\cdot}033 \sin(\theta+135°)+0'{\cdot}069 \sin(2\theta+299°)$.
	Grubb.	$y=0'{\cdot}030 \sin(\theta+150°)+0'{\cdot}078 \sin(2\theta+300°)$.
1860 to 1864	Adie.	$y=0'{\cdot}190 \sin(\theta+178°)+0'{\cdot}070 \sin(2\theta+324°)$.
	Grubb.	$y=0'{\cdot}099 \sin(\theta+211°)+0'{\cdot}062 \sin(2\theta+319°)$.
1865 to 1869	Adie.	$y=0'{\cdot}171 \sin(\theta+181°)+0'{\cdot}104 \sin(2\theta+342°)$.
	Grubb.	$y=0'{\cdot}062 \sin(\theta+228°)+0'{\cdot}122 \sin(2\theta+322°)$.

In the years 1854 to 1859 the movements of Grubb's telescope were very small, the daily mean declinations from both instruments differing rarely more than 0'·1 throughout the whole six years. It will be seen that the equations for these years agree very nearly. In spite of the greater movements of the telescope in following years (affecting chiefly the coefficient of sin θ), the epochs of maxima and minima derived from the two instruments differ but little, and all the principal deviations from the *mean* law for *any* year are confirmed by both instruments.

When the means for the whole sixteen years are taken, and the equi-

* Experiments with suspension-threads carrying slightly magnetic weights of nearly one pound, showed that the effect of a change of 1° Fahr. on the position of Grubb's magnet amounted to about 0'·003 (=0''·18)—a result deduced from the changes of temperature from hour to hour, as well as from those from day to day. I must refer to the first volume of the 'Trevandrum Observations,' now in the press, for the details of these experiments.

valent equations of sines are carried to four terms, the following results are obtained:—

1854 to 1869.

Adie. $y = 0'{\cdot}120 \sin(\theta + 175^\circ) + 0'{\cdot}076 \sin(2\theta + 323^\circ) + 0'{\cdot}011 \sin(3\theta + 299^\circ) + 0'{\cdot}022 \sin(4\theta + 181^\circ).$

Grubb. $y = 0'{\cdot}056 \sin(\theta + 209^\circ) + 0'{\cdot}095 \sin(2\theta + 315^\circ) + 0'{\cdot}012 \sin(3\theta + 293^\circ) + 0'{\cdot}022 \sin(4\theta + 197^\circ).$

From these equations we deduce the following epochs of maxima and minima:—

	Minima.	Maxima.
Adie.	January 26 and May 19.	March 14 and October 1.
Grubb.	January 13 and May 23.	March 18 and September 29.

The confirmation of the results from Adie's instrument by those from Grubb's, in spite of the errors of the latter, is so marked in each year and group of years, that we can affirm that at Trevandrum, in the south magnetic hemisphere, the magnetic needle obeys an annual law producing a double oscillation, having a minimum towards the end of May, the principal maximum near the end of September, another minimum in January, and a secondary maximum in the middle of March. Or, taking the results from Adie's instrument as most free from all error, the principal minimum occurs about a month before the June solstice, and the secondary minimum about a month after the December solstice; while the principal maximum occurs about a week after the September equinox, and the secondary maximum about a week before the March equinox.

In the result obtained by me from four years' observations (1843 to 1846) at Makerstoun, in Scotland, the greatest easterly position was attained in the end of April or beginning of May, and the greatest westerly (or least easterly) position in September. If that result, derived from a single instrument, can be accepted*, it would appear that the movements of the north end of the needle, in the annual variations, are in opposite directions at Trevandrum and Makerstoun at the same period of the year. This result agrees with that which I have found for the decennial inequality, or that in the south magnetic hemisphere; the law for the south end of the magnet is the same as that for the north end of the magnet in the north magnetic hemisphere: but it is opposed to the result obtained by me for the twenty-six day period, in which the easterly and northerly magnetic forces have their maxima at the same time in both hemispheres.

It follows that the results which are connected with the sun's rotation on its axis are the same in both hemispheres, while those related to

* I have always considered this result a near approximation to the truth, but it was not confirmed by the very limited series of observations made in the three subsequent years, years of great disturbance.

the earth's revolution round the sun appear opposite in the two hemispheres.

It might be supposed, as was done for the diurnal variation of magnetic declination, that the directions of motion being opposite in the two hemispheres, the amount of motion should diminish, and perhaps altogether disappear, at the magnetic equator. This does not seem to be the case for the annual law more than for the diurnal law, the range of the mean oscillation from four years' observations at Makerstoun being about 1'·0, which is little different from that found for Trevandrum (0'·33), the difference of the directive forces being considered.

The Society then adjourned over the Easter Recess to Thursday, April 16th.

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Transactions.

Berlin:—Konigl. Preussische Akademie der Wissenschaften. Monatsbericht. February to December 1873. 8vo. The Academy.

Florence:—R. Comitato Geologico d'Italia. Bollettino. Anno 1873. No. 5–8, 11, 12. 8vo. *Firenze.* The Institution.

London:—Society of Antiquaries. Archæologia. Vol. XLIII. Part 2; Vol. XLIV. Part 1. 4to. 1873. The Society.

Nijmegen:—Nederlandsche Botanische Vereeniging. Nederlandsch Kruidkundig Archief. Verslagen en Mededeelingen. Tweede Serie. Deel I. Stuk 3. 8vo. 1873. The Society.

Vienna:—Anthropologische Gesellschaft. Mittheilungen. Band III. Nr. 1–9. 8vo. *Wien* 1873. The Society.

Reports, Observations, &c.

Calcutta:—Geological Survey of India. Memoirs. Vol. X. Part 1. 8vo. 1873. Palæontologia Indica. Cretaceous Fauna of Southern India. Vol. IV. 3, 4. Jurassic Fauna of Kutch. Vol. I. 1. 4to. 1873. Records. Vol. VI. Part 1–4. 8vo. 1873. The Survey.

Copenhagen:—Universitet. Undersögelser over de Nebulose Stjerner i Henseende til deres spektralanalytiske Egenskaber, af H. d'Arrest. 4to. *Kjöbenhavn* 1872. The University.

Japan:—Second Annual Report of the Director of the Imperial Mint, Osaka, Japan, for the year ending 31st July, 1873. 8vo. *Hiogo* 1873. The Director.

Königsberg:—Königliche Universitäts-Sternwarte. Astronomische Beobachtungen, herausgegeben von E. Luther. Abtheilung XXXVI. folio. *Königsberg* 1870. The Observatory.