nebulæ, since these have been founded upon the supposed extent of remoteness at which stars of considerable brightness would cease to be separately visible in our telescope, must now be given up in reference at least to those of the nebulæ the matter of which has been established to be gaseous.

It is much to be desired that *proper motion* should be sought for in those of the nebulæ which are suitable for this purpose; indications of parallax might possibly be detected in some, if any nebulæ could be found that would admit of this observation.

If this view of the greater nearness to us of the gaseous nebulæ be accepted, the magnitudes of the separate luminous masses which the telescope reveals as minute points, and the actual intervals existing between them, would be far less enormous than we should have to suppose them to be on the ordinary hypothesis.

It is worthy of consideration that all the nebulæ which present a gaseous spectrum exhibit the *same three bright lines*; in one case only, 18 H.IV., was a fourth line seen. If we suppose the gaseous substance of these objects to represent the "nebulous fluid" out of which, according to the hypothesis of Sir Wm. Herschel, stars are to be elaborated by subsidence and condensation, we should expect a gaseous spectrum in which the groups of bright lines were as numerous as the dark lines due to absorption which are found in the spectra of the stars. Moreover, if the improbable supposition be entertained, that the three bright lines indicate matter in its most elementary forms, still we should expect to find in some of the nebulæ, or in some parts of them, a more advanced state towards the formation of a number of separate bodies, such as exist in our sun and in the stars; and such an advance in the process of formation into stars would have been indicated by a more complex spectrum.

My observations, as far as they extend at present, seem to be in favour of the opinion that the nebulæ which give a gaseous spectrum, are systems possessing a structure, and a purpose in relation to the universe, altogether distinct and of another order from the great group of cosmical bodies to which our sun and the fixed stars belong.

The nebulous star ι Orionis was examined, but no peculiarity could be detected in its continuous spectrum*.

III. "Further Observations on the Planet Mars." By John Phillips, M.A., LL.D., F.R.S., F.G.S., Professor of Geology in the University of Oxford. Received January 12, 1865.

The return of Mars to his periodical opposition with the sun has enabled me to offer a few observations on this planet, in addition to those which on a former occasion I had the honour to present to the Society †. Among

* Admiral Smyth appears to have always maintained that the results of telescopic observation on the nebulæ were insufficient to support the opinion that all these objects were probably of stellar constitution. See his 'Cycle of Celestial Objects,' vol. i. p. 316; and his 'Speculum Hartwellianum,' pp. 111–114.

† Proceedings of the Royal Society, 1863.

the subjects then suggested for consideration was the permanence of the main features of light and shade which had been recognized by many observers. Another question requiring attention referred to the fogginess or seeming cloudiness of the planet, also noticed by many observers, some of whom represented what might be thought effects of currents in the atmosphere round him. Again, it was a matter for further research whether the colours of what we suppose to be land and sea (the reddish hue of the land, and the grey aspect of the sea) were capable of explanation by any peculiarity of the soil or atmosphere, and whether, from the phenomena of snows visible about the poles and elsewhere, the climate of Mars could be estimated on trustworthy grounds.

My observations are too few to furnish answers for all these questions; but I have something to say in reply to some of them, though the distance of Mars from the Earth during the late opposition was too great to allow of such close scrutiny as in 1862.

First, then, in respect of the permanence of the main features of the planet. I submit several drawings* made between the 14th November and 13th December (both inclusive), the dates being marked on each, for comparison with others made in 1862, partly by Mr. Lockyer, partly by myself; from which it will immediately appear that no appreciable change has occurred in the main outlines of land and sea, in the longitudes observed. A certain fogginess has been noticed, especially on the 18th and 20th November, such as does not commonly occur with Jupiter or Saturn; but it seemed to be due to no essential circumstance of the planet, for it grew less and less as the observation approached the meridian.

The colour of the larger masses of land is the same as formerly observed, but fainter from distance; and the sea is grey and shadowy, but without the very distinct greenish hue which was noticed in 1862. Finally, the snows round the south pole appeared much less extensive than in 1862, and were not really observable with distinctness except on a few evenings. Snowy surfaces, scarcely more defined, but much more extensive, were observed in parts of the northern regions, not immediately encircling the pole (which was invisible), but in two principal and separate tracts estimated to reach 40° or 45° from the pole. On one occasion (30th November) two practised observers (Mr. Luff and Mr. Bloxidge) noticed with me one of these gleaming masses of snow, very distinct—so much so, that, as happened with the south polar snow in 1862, it seemed to project beyond the circular outline—an optical effect, no doubt, and due to the bright irradiation. This white mass reached to about 40° or 45° from the pole, in the meridian of 30° on my globe of Mars. Another mass was noticed on the 14th and 18th November, in long. 225°, and extending to lat. 50°. In each case the masses reached the visible limb.

The small extent of the snow visible at the further pole may be truly the effect of the position of the planet. If we remember that on this occasion the axis of Mars was nearly (within about 6° or 8°) at right angles

* Preserved for reference in the Archives; an equatorial projection is given in Plate II.

to the line of sight, while in 1862 it was oblique (about 26°), we shall perceive that though the snow about the south pole were really as extensive in 1864 as it appeared to be in 1862, it could not possibly appear even nearly so large, and in fact could barely be seen (as it was) under the very small angle which it would subtend on the limb. There may, however, have been really less snow round the south pole, in consequence of the longer action of the summer heat on Mars in 1864 than in 1862.

The ruddy tint of the surface of the broad tracts of land is so constantly observed in these parts as to claim to be regarded as characteristic of some peculiarity in them—some special kind of terrestrial substance for example *. On the other hand, the tint is so much like that of our evening clouds as to suggest the probability of its being due to the deep atmospheric zone which has been often ascribed to this planet, though perhaps, until of late years, on insufficient grounds †. On this head spectral analysis will probably enlighten us. If, however, there be such a deep covering of atmosphere, it might explain some facts regarding the climate which otherwise appear unaccountable. Some considerable amount of vaporous atmosphere there must be, to give origin to the beds of snow which alternately invest and desert the opposite poles, if indeed either pole be ever quite free from snow.

In different Martial years the extent of the snow appears nearly the same under nearly similar conditions. Compare, for instance, Herschel's drawing for August 16, 1830 ‡, with my sketch for September 27, 1862 §, and that now presented for November 20, 1864.

Snows appear to have been observed in mass as far from the south pole as lat. 40°. This occurred in April 1856, according to a drawing by Mr. De la Rue: snow in lat. 50° or perhaps 45° North is the result of my observations during this late opposition. Assuming this to be the geographical limit of the freezing mean winter temperature, we see at once that it differs but little from that of the earth, on which the isothermal line of 32° varies, according to local peculiarities, from the latitude of 40° to that of 60°. If the snows on the land of Mars be compared with those on the northern tracts of Asia and America, they will be found not to extend further. And as the snows, if they do not actually disappear, are reduced to small areas about either pole in *its* warm season, thus showing the mean summer temperature there to be not less than 32°, this confirms the general impression that the variations of the climate of Mars are comprised

* "In this planet we discern, with perfect distinctness, the outlines of what may be continents and seas. Of these, the former are distinguished by that ruddy colour which characterizes the light of this planet (which always appears red and fiery), and indicates, no doubt, an ochrey tinge in the general soil, like what the red sandstone districts on the earth may possibly offer to the inhabitants of Mars, only more decided. Contrasted with this (by a general law in optics) the seas, as we may call them, appear greenish."—Herschel's Astronomy (ed. 1833), p. 279.

† "It has been surmised to have a very extensive atmosphere, but on no sufficient or even plausible grounds."—*Ibid.* p. 279, note.

‡ Treatise on Astronomy (ed. 1833), pl. 1. § Proc. Roy. Soc. 1863.

within nearly the same thermic limits as those of the earth. In all the broad belt of 30° or 40° from the equator, the temperature seems to be such as always to allow of evaporation; between that limit and the pole, snows gather and disperse according to the season of the year, while for about 8° or 10° more or less round the pole, the icy circle seems to be perennial.

The relative mean distances from the Sun of Mars and the earth being taken at 100 and 152, the relative solar influence must be on Mars 100 to 231 on the earth; so that the surface of the more distant planet might rather be expected to have shown signs of being fixed in perpetual frost, than to have a genial temperature of 40° to 50°, if not 50° to 60°, as the earth has, taken on the whole. How is this to be accounted for? Of two conceivable influences which may be appealed to, viz. very high interior heat of the planet, and some peculiarity of atmosphere, we may, while allowing some value to each, without hesitation adopt the latter as the more immediate and effective.

To trace the effects in detail must be impracticable; but in the general we may remark that as a diminution of the mass of vaporous atmosphere round the earth would greatly exaggerate the difference of daily and nightly, and of winter and summer temperature, so the contrary effect would follow from an augmentation of it. Applying this to Mars, we shall see that his extensive atmosphere would reduce the range of summer and winter, and of daily and nightly temperature. It would, moreover, augment the mean temperature by the peculiar action of such an atmosphere, which, while readily giving passage to the solar rays, would resist the return of dark heat-rays from the terrestrial surface, and prevent their wasteful emission into space*. This effect obtains now on the earth, which is rendered warmer, as well as more equable in temperature, by the atmosphere than it would be without it. It is conceivable that it may obtain upon Mars to a greater degree, even without supposing the atmosphere to be materially different in its nature from that round the earth, or the surface of Mars to have any specially favourable or exceptional characters for the absorption and radiation of heat. It seems, however, requisite to suppose a greater communication of heat from the interior of the planet; for otherwise the additional vapour, to which the warming effect is in the main to be ascribed, could not probably be supported in the atmosphere. On the whole we may, perhaps, be allowed to believe that Mars is habitable.

Here, so far as direct observations upon the aspect of Mars are available, we may pause. The researches of the Radcliffe Observer, lately in Oxford, and formerly at Greenwich, have, however, brought into view a peculiarity in the constitution of this planet which deserves special notice. Its figure is spheroidal, as might be expected from the general laws of planetary form; but it is spheroidal in so high a degree as to be quite exceptional in this respect. Computing by the known rotation-velocity, and the admitted measures and mass of Mars, its ellipticity should be about $\frac{1}{300}$.

* Life on the Earth, 1860, p. 163–65. Tyndall's Researches, Proceedings of the Royal Society, February 1861.

Mr. Main's observations with the splendid Oxford Heliometer give as the most probable result, the large fraction of $\frac{1}{37{\cdot}59}$ for 1862. This excellent astronomer has continued his observations during the late opposition. My own attempts to obtain the ellipticity with the micrometer eyepiece reading to $0''{\cdot}2$ of arc failed to give satisfactory measures. The ellipticity, indeed, seemed to be small, and was merely observable, not really measurable or even to be approximately estimated by the help of this apparatus.

IV. "Notices of the Physical Aspect of the Sun." By JOHN PHILLIPS, M.A., LL.D., F.R.S., F.G.S., Professor of Geology in the University of Oxford. Received January 13, 1865.

PART I.

Frequently, during many years, the peculiarities of the physical aspect of the sun have arrested my attention, and induced me often to sketch and sometimes to measure; but until Mr. Cooke furnished me with the accurate and convenient equatorial which I now employ, there seemed little hope of my being able to draw correctly or observe systematically. During some late occasions I have endeavoured to obtain trustworthy representations not only of some of the darker tracts, denominated "spots," and the brighter parts which are near them, called "faculæ," but also of the general uneven groundwork of the sun's disk.

In tracing the path of a "spot" across the disk of the sun, I employ a Kellner (positive) eyepiece of about 50 linear, on which are engraved five transit-lines, at intervals of about $\frac{10}{117}$ of the sun's diameter, and therefore, near the centre of the disk, about equal to 10°. Having, with this eyepiece applied to the diagonal sun-glass, and the clock movement, determined the position of the spots, I replace the Kellner by ordinary (negative) eyepieces, whose powers range from 75 to 300, the latter being seldom beneficial except for objects near the limb, and in very favourable weather—which, in my experience, means a partially clouded sky, westerly winds, and morning hours by preference. Some of the clearest views which I have experienced were had in the intervals of storms and snow-clouds—the slowly drifting snow-flakes of those clouds being visible as dark spots in the field of view, when the eyepiece was adjusted to their very moderate distance *.

I present a diagram† showing the appearance of the sun's disk on the 29th of March, 1864, and other sketches of the bright and shady parts of the surface. From the variations in the appearance of the spots, faculæ, and ground surface, many suggestions arise; but I limit myself on this occasion to some inferences which appear justified by the observations of the least variable of them. So great is the diversity in the short

* I have occasionally employed the telescope to measure the distances and heights of clouds, employing for the purpose a well-known formula.

† Of the drawings accompanying this paper, which are referred to by numbers, Nos. 3, 4, and 5 are given in Plate III.; the rest are preserved in the Archives.