photosphere? If so, the northern parts of the sun would be more affected than the southern, for his proper motion has been concluded by various methods to be in north polar declination.

Should the existence of periodic vertical oscillations in the atmospheres of the earth and sun be demonstrated, then we may be enabled to account for the spots which occur on the planet Jupiter, and the periodicity lately attributed to them; also, the periodic variability of many of the stars, and even of certain nebulæ, H. II 278, and H. I–h 882, for instance, together with the curious alternation of visibility of a star and a connected nebula, as for example 80 "Messier's Catalogue of Nebulæ." There have also been cases in which nebulæ have only lately made their appearance, and instances of previously well-known nebulæ having entirely disappeared, the physical processes of which may be explained by vertical oscillations in elastic masses, which appear to be as universal in elastic media as gravity itself.

ART. VI.—*On the Permanency of Solar and Stellar Heat.*

By MARTIN CHAPMAN.

[*Read before the Wellington Philosophical Society, 10th October,* 1880.]

A FAVOURITE subject of speculation with physicists is the question of the manner in which the heat of the sun and other heavenly bodies of high temperature is maintained.

Various hypotheses are from time to time put forward, supported by speculations of more or less probability.

Some of these—as, for instance, the ingenious speculations of Mathew Williams ("Fuel of the Sun")—do not appeal to any processes of nature which we can see going on or put to any kind of test.

Professor Croll assumes the existence of dark, cold masses, whose velocity in space is vastly greater than that of any lucid orb. The collision of these generates heat by the conversion of molar motion. It is to be remarked of this hypothesis that the assumed velocities are such as we can never see on any lucid body; but Mr. Croll points out that this is only to be expected, as it is only by the destruction of this motion that the bodies can become visible. Such a source of heat would result in this:—that the heat generated would be gradually dissipated, so that the body would gradually cool down and become invisible.

Most of the received hypotheses assume molar collision of some kind, whether of large bodies or of meteoric rain on large bodies, the motion of translation being converted into heat.

The last-mentioned kind is by far the most favoured. The eminent astronomer, Secchi, expresses an opinion that only a very small portion of the heat of the sun can be derived from this source; but the reasoning on this point does not seem conclusive, and is not, so far as I am aware, acquiesced in by other physicists.

We see this process constantly occurring on our earth, small bodies constantly plunging into our atmosphere, becoming incandescent by the conversion of their motion, and showing their course by a more or less vivid streak of light. Following the opinion of more than one astronomer, I assume that the process indicated is not confined to the earth, but is common to the latter with all other heavenly bodies.

We have considerable reason for supposing that meteoric matter is distributed throughout space, being perhaps sparse in some parts, and moderately closely aggregated in other parts, more condensed in the neighbourhood of large centres of attraction than at a distance from such centres. Assuming this, it will follow that every body in its progress through space will be continually bombarded with meteoric particles.

The quantity each body will receive at any time will be proportioned—firstly to the richness of the meteoric field; secondly, to the transverse section of the body, and thirdly, to the attractive energy of the body, in other words to the mass.

The amount of heat generated by the impact of a given mass will be proportional to the mass of the attracting body.

It will thus be seen that the impact of say one pound on say Jupiter, will generate more than three hundred times more heat in that planet than a similar impact will generate on the earth, the masses of those planets being as more than 300 to 1.

It is true, that as there is more than three hundred times as much matter in Jupiter to be heated, the absolute rise in temperature of the whole mass will be the same in both instances; but a larger proportion of the heat generated will escape by radiation from the smaller body in a given time than from the larger—this is readily seen.

Taking approximate figures, the diameter of the earth being 1, the surface 1, and the mass 1; the diameter of Jupiter is 11, the surface 121, and the mass 300:—the amount of heat generated by the impact of a given mass will be on the earth 1, on Jupiter 300.

The amount of heat radiated away is proportional to the surfaces from which radiation takes place. In the case of the earth 1, in the case of Jupiter 121. So that while Jupiter receives three hundred times the amount of heat energy received by the earth, it loses in a given time one hundred and twenty-one times, leaving a residue of one hundred and seventy-nine times that amount. So that only in the time that the whole heat would be radiated from the earth, Jupiter would only lose $\frac{121}{300}$.

It is manifest from these considerations that even if the collisions on the earth are so infrequent that the heat generated is all radiated away, and would be so if the collisions were hundreds of times more frequent; still, even assuming collisions still less frequent on Jupiter, a residue of heat might be retained and continually accumulated.

Taking, however, probabilities into account, we should be inclined to infer that, considering the enormously greater bulk and mass of Jupiter, collisions are vastly more frequent on Jupiter, as well as being three hundred times more energetic than on the earth. We should, therefore, be led to suppose that, assuming that in the case of such bodies as the earth, moon, etc., all the heat generated is again dissipated, yet there is some magnitude at which we should find the generation and dissipation of heat balance, the planet being permanently maintained at the same temperature as the surrounding space.

All bodies larger than this, if started at zero, would have their temperature gradually rise to a point where, in consequence of increased radiation from increased heat, the temperature would be maintained uniform so long as the mass remained uniform; but the mass would, in fact, not remain uniform, but would continually grow by the addition of meteoric matter; the temperature would consequently also rise. Hence we see that all bodies will constantly increase in magnitude, and all bodies over a certain critical mass will constantly rise in temperature to a certain point beyond which the only fluctuations will be due to the body increasing in mass and periodically passing into relatively rich or poor meteoric fields, such as the August and November meteor streams, etc.

If we apply the foregoing considerations to those bodies which we know best, we find that some of the bodies, as the satellites of the primary planets —the Earth, Mars, the Asteroids, etc., appear all to be below the critical point of mass, and we find them to be cold bodies.

The larger bodies of the system—Jupiter, Saturn, Uranus, and Neptune, certainly the two former, and probably the two latter—are in a state of intense heat, and are, therefore, above the critical point of mass.

The largest body of all in our system, viz., the Sun, is maintained at a temperature estimated by Secchi at not less than 10,000 degrees cent., and perhaps many times that.

It would be interesting to ascertain if the fixed stars, which are regarded as the largest, are also the hottest, as they would be on the present hypothesis, So far as I can judge from a somewhat cursory examination of works on the spectroscope, it would appear that, when a variable or periodic star is at its maximum of brightness, its spectrum is the ordinary spectrum of the star with certain bright lines, those of hydrogen, added. Now in the stars placed by Secchi in his first class, such as Sirius, the spectrum consists also of a certain assemblage of bright and dark lines, with the characteristic lines of hydrogen superposed.

Art VII.—*Notes upon Mr. Frankland's paper, "On the Simplest Continuous Manifoldness of two Dimensions and of Finite Extent."**

By William Skey, Analyst to the Geological Survey of New Zealand.

[Read before the Wellington Philosophical Society, 26th June, 1880.]

It may be still in your mind that, some time ago, one of our members, Mr. F. W. Frankland, read a paper to us embodying a great deal of very remarkable matter, and entitled, "On the simplest continuous manifoldness of two dimensions and of finite extent."* Now, there is much in this paper which I took great exception to at the time, and still do; but I have hitherto refrained from informing you of this, as I had always the hope that a subject in itself so startling and profound, though possibly not new to you, would, as presented to us, and championed in this way, have elicited something more than a mere verbal discussion thereon; something more comprehensive and connected than such a discussion can well be; something commensurate with the importance of the matter treated, and which would possibly represent my ideas thereupon better than I may ever attempt to do.

My hope not being realized I can wait no longer, and I therefore beg your kind attention for a short time, so that I may, as best I can, acquaint you with the particulars of my dissent from the views in question, and my reasons for it; and if, in its turn, this paper should fortunately induce Mr. Frankland to answer the objections which he will here find stated, or to explain those parts of his paper which must appear somewhat obscure to others besides myself, I am sure that, for such a boon, you will cheerfully accord me the time and attention I ask for, and excuse all my shortcomings.

Ere I proceed with this, I will refresh your memory by a synopsis of Mr. Frankland's paper.

It commences by a statement of the well-known fact that some geometricians maintain that the axioms of geometry may be only approximately

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* See "Trans. N.Z. Inst.," Vol. IX., p. 272.