convex side is screened off, so as to let the light shine only on the concave, continuous rotation is produced at the rate of one revolution in 6·95 seconds, the concave side being apparently attracted. These experiments show that the repulsive action of radiation on the convex side is about equal to the attractive action of radiation on the concave side, and that the double speed with which the fly moves when no screen is interposed is the sum of the attractive and repulsive actions.

14. *Radiometer.*—A two-disk, cup-shaped, aluminium radiometer, lamp-blacked on the concave surfaces. In this instrument the usual action of light is reversed, rotation taking place, the bright convex side being repelled, and the black concave attracted. When the light shines only on the bright convex side, no movement is produced; but when it shines on the black concave side, this is attracted, producing rotation.

15. *Radiometer.*—A cup-shaped radiometer similar to the above, but having the convex surfaces black and the concave bright. Light shining on this instrument causes it to rotate rapidly, the convex black being repelled. No movement is produced on letting the light shine on the bright concave surface, but good rotation is produced when only the black convex surface is illuminated.

16. *Radiometer.*—A multiple-disk, cup-shaped, turbine radiometer, bright on both sides, working by the action of warm water below and the cooling effect of the air above.

17. *Radiometer.*—A four-armed, metallic radiometer with deep cups, bright on both sides.

18. *Radiometer.*—A four-armed radiometer, the vanes consisting of mica cups, bright on both sides.

19. *Radiometer.*—A four-armed radiometer having clear mica vanes, the direction of motion being determined by the angle formed by the mica vanes with the inner surface of the glass bulb.

IV. "On the Inferences to be drawn from the Appearance of Bright Lines in the Spectra of Irresolvable Nebulæ." By William Huggins, D.C.L., LL.D., F.R.S. Received April 26, 1877.

In a paper recently read before the Royal Society, Mr. Stone attempts to show that the fact that the spectra of some of the irresolvable nebulæ consist mainly of bright lines does not warrant the inference that these bodies are of a constitution different from our sun and the generality of the fixed stars, and consist mainly of glowing gas, so far, at least, as the light-giving portion of them is concerned.

Waiving for the present the objections which may be urged against Mr. Stone's reasoning, let us consider the question in the light of the results afforded by actual observation.

There are not found in the spectra of different nebulæ the differences of relative brightness of the bright lines and of the continuous spectrum which would be expected on Mr. Stone's hypothesis.

The star-clusters which are just within the resolving-power of the largest telescopes do not give, even faintly, a spectrum of bright lines.

The same bright lines appear to be common to all the nebulæ which give a bright-line spectrum. On Mr. Stone's view, differences in the constitution of the enclosing atmospheres of different star-groups would be probable.

On this point I may be permitted, perhaps, to add the following sentences from my paper "On the Spectra of some of the Nebulæ"*:—

"It is indeed *possible* that suns endowed with these peculiar conditions of luminosity (giving bright-line spectra) may exist, and that these bodies are clusters of such suns. There are, however, some considerations, especially in the case of planetary nebulæ, which are scarcely in accordance with the opinion that they are clusters of suns. Sir John Herschel remarks of one of this class, in reference to the absence of central condensation:—'Such an appearance would not be presented by a globular space uniformly filled with stars or luminous matter, which structure would necessarily give rise to an apparent increase of brightness towards the centre, in proportion to the thickness traversed by the visual ray. We might therefore be inclined to conclude its real constitution to be either that of a hollow spherical shell, or of a flat disk presented to us (by a highly improbable coincidence) in a plane precisely perpendicular to the visual ray'†.

"This absence of condensation admits of explanation without recourse to the supposition of a shell or flat disk, if we consider them to be masses of glowing gas. For supposing, as we probably must do, that the whole mass of the gas is luminous, yet it would follow, by the law which results from the investigations of Kirchhoff, that the light emitted by the portions of gas beyond the surface visible to us would be in great measure, if not wholly, absorbed by the portion of gas through which it would have to pass; and for this reason there would be presented to us a luminous surface only"‡.

It appears, therefore, that the results of observation do not accord well with Mr. Stone's theory.

But the theory itself appears open to grave objections. It is obvious (and was strongly insisted upon by Prof. Stokes in remarks made when the paper was read) that in a star-cluster in which the stars are surrounded by self-luminous atmospheres, the *proportion between the sum total* of the light from the stars and the light from the atmospheres will be independent of the distance of the cluster from us. Unless, then, we sup-

* Phil. Trans. 1864, p. 443.

† 'Outlines of Astronomy,' 7th edit. p. 646.

‡ See also Sir William Herschel, Phil. Trans. 1811, pp. 314, 315.

pose that the light received from our own sun is but a fraction of the total light received from a supposed atmosphere of enormous extent surrounding him (a supposition which needs only to be stated to be rejected), instead of constituting the main portion of the total light, it follows that the total light received from a distant cluster formed of stars at all resembling our own sun must mainly come from the stars themselves. If, then, it be true, as it undoubtedly is, and as Mr. Stone has urged, that at a sufficient distance the light from any individual star is insignificant, while that from the cluster as a whole (both stars and atmospheres) is not, this can only be by the distance being so great that the small but finite solid angle subtended by a small portion of the slit employed in the investigation is nevertheless sufficient to take in a considerable number of the stars; and if this be admitted, Mr. Stone's reasoning falls to the ground.

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