Nebulæ.

BY

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IF we turn a telescope towards the heavens we shall sometimes meet with the remarkable hazy cloudlike objects called Nebulæ. The word nebula means cloud and these bodies are so named because of their close resemblance to the clouds. They are all invisible to the naked eye except the one in Andromeda ; but one must know that it is there, otherwise it looks like one of the star-clusters. In some Star Charts no distinction has been made between star-clusters and nebulæ. But their true nature may be revealed by a telescope. The star-clusters are at once resolved into small stars, whereas a true nebula can never be so resolved, *i.e.*, separated into distinct stars.

The nebulæ have been classified into five classes according to their telescopic appearance. They are : (1) Irregular, (2) Ring nebulæ and elliptic nebulæ, (3) Spiral or whirlpool nebulæ, (4) Planetary nebulæ, (5) Nebulæ surrounding stars.

(1). The great nebula in Orion called the fish nebula is an example of irregular nebulæ. It is seen round the group of small stars called θ Orionis and is of a beautiful greenish white tinge and conveys to the mind the idea of a big conflagration. This nebula can be seen very easily with small telescopes. I have seen it with a 2·4″ refractor and the components of θ Orionis appear like two beautiful stars at the head.

(2). A beautiful example of the ring nebula is the one in the constellation Lyra. It suggests the idea of a vortex ring. This constellation cannot be seen with an ordinary telescope. The elliptic nebulæ are so called because of their appearance, and they are most probably ring nebulæ so tilted to our line of vision that they appear elliptical.

(3). Of the spiral nebulæ the finest is in the constellation Andromeda, visible with even an ordinary binocular. There are others in the constellations Coma, Ursa Majoris, Canes Venatici, but these are so small and faint that they are not visible with small power telescopes.

(4). Planetary nebulæ are so called because they shine with a planetary and often bluish light and are circular or slightly elliptical in form. 97M Ursæ Majoris is an example of this.

(5). The nebulæ surrounding stars. The stars thus surrounded are apparently like all other stars save of the presence of the nebula. (*i*) Orionis, 79M Ursæ Majoris belong to this class. The difficult nebulæ may be seen on certain clear nights but their shapes cannot be made out with small telescopes. I have myself seen some of them with a small telescope with a power of about 50. But in order to see them the eye must be seasoned as it were for some time. As there are lost, new and variable stars so there are lost, new and variable nebulæ. It is on record that a small nebula which was discovered in 1852 near a 10th magnitude star in Taurus disappeared in 1861 and the Star also became dimmer. In the next year the nebula again appeared and began to increase in brightness, but it was completely invisible from 1877 to 1880. There are other variable nebulæ; one is in the constellation Citus and another in Virgo. The reason for this variability has not yet been satisfactorily explained.

We come now to the distribution of the nebulæ. If we look at the heavens it does not take us long to detect that the Stars are more thick in and near the Milky Way than in any other part of the sky. But such is not the case with the nebulæ: it is something quite different with them. Generally they lie out of the Milky Way. In fact not only is the Milky Way the poorest in nebulæ, but the parts of the heavens furthest away from it are the richest. The recent application of photography to astronomy has shown that nebulæ are far more widely spread than was formerly supposed. With its help, nebulæ which were so far away or so dim as to be perfectly invisible even with powerful telescopes, have now been made visible. While studying these nebulæ one thing which struck me as peculiar is that those nebulæ that are in or very near the Milky Way are almost all irregular and those that are away from it are nearly all regular. These slides [*projected on the screen*] of Perseus, Orion, Cygnus and Saggitarius, illustrate nebulæ of the irregular type, while those of Andromeda, Ursa Major, Coma, Birnices and Canes Venatici illustrate nebulæ of the regular type.

The configuration of these nebulæ and the thickening of the stars towards the Milky Way suggests to one's mind the idea of motion, and it will be very easily understood from an analogy of a river. I do not mean to pose myself as a theorist. I only express what seems to me the probable explanation of these appearances. Suppose, then, that there are seeds floating in a river, and that a current is flowing along its middle, if you mark well you will not fail to note that those seeds that are flowing with the current will never have any regular form, while those that are at the sides of the stream will sometimes be drawn into eddies and give us the semblance of spiral nebulæ. These eddies are formed as you know either by two opposite currents or by currents one of which is approaching and the other receding. The nebulæ—and for the matter of that the Sun, the stars, the planets and all other heavenly bodies—may be considered as floating in space and consequently in ether which permeates the whole space, and I think it would be going too far if I positively assert that this all-pervading ether is in a state of constant motion: or the existence of some other substance more attenuated also in a state of constant motion, which is imparted to bodies which may be considered as floating in it. But we have some evidence of the existence of currents from the tendency of the stars to run in streams which is marked in Scorpio, Lyra, Cygnus, Taurus, etc., as was first pointed out by Mr. Proctor.

If the Milky Way is taken to be indicative of the main current these may be considered as side currents. The thickening of the stars in or near the Milky Way can also be explained by a similar method of argument. Suppose a boat is floating in the river—then if it is free to move it will be gradually drawn towards the main current; as it approaches the main current its momentum will increase and it will then follow a path which is the resultant of the two velocities: that of the current and its own and finally shoot over to the other side, owing to its inertia, when its progress will be checked and then it will again start on its return journey towards the main current, it will again shoot past and go on moving this side and that side for some time, until it will float smoothly along with the main current. In fact it will behave exactly like a pendulum which when once started from its point of rest never comes to that position all at once but does so after a few oscillations. I think that we have got an example of this in the big star Sirius. It was found out by means of the spectroscope that Sirius was receding from the Sun at the rate of 26 miles per second, and it is located in that part of the heavens from which the Sun is receding at the rate of nearly 12 miles per second. Professor Serviss some years ago calculated that at the rate at which Sirius was moving it will take it 10,000 years to cross the Milky Way. There is said to be a tradition that the men of the Stone Age saw Sirius on the other side of the Milky Way to that on which it is located now. Mr. Proctor writing about this star years ago remarked that "its rate of recession from us is diminishing, so that we may expect this to change into a motion of approach." It is interesting to learn that its motion away from us has not only been diminishing but is now actually gaining on us and overtaking the

Sun at the rate of 10 miles per second, notwithstanding the fact that the Sun is receding from it with the great velocity already mentioned. It is doing exactly what our boat or pendulum does. And this is most probably what is happening to the other stars.

I shall now pass on to the constitution of the nebulæ. A few years ago Sir Norman Lockyer expressed his opinion that the nebulæ are sparsed swarms of meteorites, and we shall briefly see what modern astronomy has to say about it. The irregular and regular nebulæ differ from each other not only in form but in character too, as has been demonstrated by the spectroscope. The spectrum of the irregular nebulæ proves to consist of a few bright lines due to hydrogen, helium and an unknown gas nebulium chiefly in the green, whence they are called green nebulæ. That of the spirals on the other hand is continuous and therefore white. Stars when examined through a spectroscope show continuous spectra from red to violet, as in the Sun's spectrum, though there may be some difference with respect to the presence of the dark and bright lines. Star-clusters also give the same kind of spectra as the stars resulting from the superposition of the individual stars in the clusters. Many of the nebulæ also give spectrums of this nature. The great nebula in Andromeda gives a spectrum of this kind.

A continuous spectrum not only indicates the presence of solid or liquid gases at high pressure, as was pointed out by Young, but also of gases at low pressure and high temperature under certain conditions. So it does not follow that the nebula in Andromeda is a cluster of ordinary stars. In fact it has defied all attempts to resolve it. A continuous spectrum of a nebula does not therefore imply that it is a cluster of stars. If on the other hand a nebulæ spectrum shows bright lines we can assume that gases at low pressure are present. Sir William Huggins examined about 70 nebulæ and found that about a third showed gaseous constitution. The planetary and many other nebulæ, among them those in Lyra and Orion, are of gaseous nature. Therefore Sir Norman Lockyer's theory should be taken cautiously. The subject is so vast that it is impossible in a paper like this to touch more than the shell. There is a saying in Sanskrit which means that "The Vedas are different and the Smritis are different for he is not a muni who has not got an independent opinion of his own." There are so many theories about the origin and constitution of the nebulæ that one feels like a blind man in a bamboo forest: you knock your head at every turn.