it is easy to see from the energy principle that

$$U_1 = \frac{U_N+3U_H+U_2}{2}$$

and cannot be estimated before all these quantities are known.

For a chemical reaction of the type

$$Ti+O_2=TiO_2+U,$$

the equation of chemical equilibrium is given by the formula

$$\log \frac{P^2x^3}{(1+2x)^2(1-x)} = -\frac{U}{2{\cdot}30RT}+\frac{\Sigma\nu C_p}{R}\log T+\Sigma\nu C,$$

which redues to

$$\log \frac{P^2x^3}{(1+2x)^2(1-x)} = -\frac{U}{2{\cdot}30RT}+3\log T+C_{Ti}+2C_o-C_{TiO_2},$$

if, in accordance with the kinetic theory of specific heat, we put $(C_p)_{TiO2} = \frac{9R}{2}$.

This class of chemical reaction is likely to have wide application in the treatment of the spectra of sun-spots, for a large number of spot-lines were identified by Fowler, Hale, and Olmsted with the band-lines of MgH_2, TiO_2 and, CaH_2 (tri-atomic compounds)[20].

It appears that no attention has yet been paid to the study of the spectra of the faculae, which are believed, on the basis of very sound physical arguments, to be regions of higher temperature than the photosphere. Supposing the temperature of the faculae to range between 8000°K and 9000°K, their spectra are likely to show very important differences from the spectra of the ordinary photosphere, and to be similar to the spectra of the F_0 to F_5G classes of stars, just as the spectra of sun-spots are similar to those of the Antarian stars (K-class). At any rate, the subject seems to offer a very rich field for investigation.

If the necessary data be available, these questions will be taken up in a future communication.

I have much pleasure in recording my best thanks to my students of the Post-graduate classes in physics for much useful help in preparation of this paper.

University College of Science, Calcutta.
May 22, 1920.

[20] Pringsheim, *Physik der sonne*, pp. 211 to 217.

14. ON THE PROBLEM OF NOVA AQUILA III

(*Jour. Astr. Soc. Ind.*, **10**, 36, 1920)

The spectrum of Nova Aquila III has been studied in its various stages by many astrophysicists, all over the world, and has yielded a crop of extremely interesting results. It appears to me that in view of these results, it is now possible to seek for a plausible physical cause underlying this singular phenomenon. The results are fairly concordant and may thus be briefly summarised:

The spectrum of the Nova is a composite one and consists of four superposed spectra due to 4 distinct bodies. The first spectrum consists of bright-line emission bands of Hydrogen, Nebulium (?), Titanium, and other gases. The centres of the bands are displaced towards the red and are of enormous width. The spectrum reminds one forcibly of a pressure-shift, as mentioned by Father Cortie, (M. N. R. A. S., January 1919) and is most probably due to emission by the gases aforesaid under enormous pressure (Vide Rossi's work in Proc. Roy. Soc. Lond., Vol. 83).

Superposed upon this are three continuous spectra having dark absorption-lines. Prof. Newall[1] finds that these spectra can be identified with that of the Star Cygni, when velocities of amounts,—1650 Km. per sec, and—2797 Km per sec are impressed upon that star. (These results are practically identical with those obtained by Evershed[2] and Lunt[3]; i.e. in other words, we are witnessing here the emission from three distinct gaseous bodies of the type of Cygni, but moving respectively with the enormous velocities of—1650 Km per sec.,—2291 Km per sec. and—2797 Km per sec. in the line of sight, but these three gaseous masses, if they really existed, had very transient existence, because none of them were recorded on Father Cortie's plate exposed on June 30th, while the emission spectrum is of much longer duration, though undergoing changes all the while.

Now I should particularly emphasise upon a point

[1] M.N.R.A.S, 1919, December.
[2] *Nature*, Vol 102, p 105.
[3] Lunt, *The Observatory*, 1918, November.

which has been brought forward in a very lucid manner by Prof. Newall (M. N. R. A. S., December 1918). Newall compares the displacements of 50 absorption lines on a plate taken on June 13, and though they belong to elements widely differing in atomic weight, they give the same two sets of identical velocities of approach, viz., 1654 Km per sec., and—2449 Km per sec. The same may be said of the plate taken on June 15th; only here, we have evidence of three velocities of approach (—2767, —2291, —1691 Km per sec.). These observations make a very strong case for the view that we are, in this case, witnessing the emission from three distinct luminous masses of the Alpha Cygni type, which fade away to an inert non-luminious state within less than 15 days of their birth.

As stated by Dr. Lindemann (The Observatory, 1919) these huge velocities are inexplicable on any theory of explosion, while the conclusion that lines due to elements widely differing in atomic weight are displaced by amounts which can be represented by the same velocity factor is not favourable to the view of Evershed that the phenomenon has analogous features to those of eruptive solar prominences (*Nature*, Vol 102, Page 105).

It appears to me that the results obtained by Newall and supported to a large extent by Dr. Lunt in the case of Nova Germinorum (M.N.R.A.S., Feb. 1919), justify us in reviving in a modified form, the collision theory associated with the names of Huggins and Vogel. The choice of the name "Collision theory" is rather an unfortunate one. A much better appellation would be "the meteoric-flash theory". By this is meant that we are in this case witnessing a phenomenon similar to the sudden flashing up of meteorites, across our own sky—only repeated on an infinitely larger scale. It would have saved us a great deal of discussion, if we could have a consistent previous history of the star which flashed up as Nova on June 8. But this is not available. All that is known is derived from the Heidelberg and Harvard plates.

They have shown that previous to the eruption, the nova was represented by a star of 10·5 magnitude of unknown(?) parallax and spectral type, which showed rapid increment in emissive power, from June 6. No spectra seem to have been taken previous to the eruption, or shortly after the eruption was discovered (June 8. 8h. G.M.T.)

We have, accordingly, to build our hypothesis on the results of the spectra obtained during the declining stages of the Nova.

Let us suppose that the star, which represented the nova previous to the eruption, was of a compact composition (like the red carbon stars) and enveloped in a dense atmosphere. Let us suppose that the critical velocity of escape for a particle on the surface of the star was some 2500 Km. per sec. (This is not an over-estimate, when we remember that the same quantity for our sun is some 616 Km per sec.—only it will mean a star of the same diameter but 4 times as dense). Now let a planetoid suddenly plunge into its atmosphere with a velocity equalling or exceeding the critical velocity. What would happen? A meteor, when it plunges into our own atmosphere, moves with a radial velocity of 20 to 42 Km per sec, and is heated by friction with our atmosphere through a range of more than 3000°C (from absolute zero to the temperature of the arc). Now, in the case before us, the range of temperature will be much larger. Considering the magnitude of the quantities involved, it may not be an overestimate that the outlying crusts of the planet would be heated to an incandescent gaseous mass of the Cygni type, at the same time, the planet may be torn to fragments travelling in different directions with different velocities (a sort of Roche's effect). But these luminious fragments would have a very transient existence. It appears that in the case of the Nova Aquila, the meteoric flash lasted for not less than 10 or 12 days, but it is difficult to say whether the lumionous matter was left behind or whether it was carried along with any solid planetary kernel which might have survived the catastrophe. If left behind, it would diffuse through the stellar atmosphere in a short time; while if carried along with the kernel, it would be quickly reduced to the inert stage, owing to the smallness of the mass involved. At any rate, its career as a luminous body of the Alpha Cygni type could not last long. What would happen to the Star? As the planet approached it, huge tidal forces would be set up in it, causing the liberation of large amounts of gas, and as the planet flashed across, the temperature would be increased to a large extent. The star is now enveloped in a very dense atmosphere of incandescent gas, which would be responsible for the spectrum with the emission bands of enormous width.

It has been shown by Adams and Pease that Nova Auriga and Nova Persei finished up as Wolf-Rayet stars after a short nebular stage. It will be interesting to see how the Nova Aquila finishes up. At present, all the theories about the spectral types of stars are in melting pot. But if the Nova Aquila finishes up as Wolf-Rayet, I do not consider that it will be difficult to adapt the aforesaid theory to the explanation of this stage. But we must wait for the further results of spectrographic examination of the Nova in its various stages.