III. INSTABILITY IN THE LUMINOUS STARS OF EARLY TYPE

https://doi.org/10.1017/S0074180900018660 Published online by Cambridge University Press

13. ON THE ATMOSPHERES OF THE WOLF-RAYET STARS

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In 1945 we showed [1] from a study of six Wolf-Rayet stars that their spectrophotometric temperatures, when allowance is made for interstellar reddening, are still far below the temperatures as determined by the Zanstra method. It was demonstrated that these spectrophotometric temperatures (which are only slightly in excess of those of Ao stars) agree perfectly with N. Kosyrev's [2] theory of extended photospheres. Later Petrie [3] confirmed our observational results, though he did not compare the two sets of results for individual objects. This same result was recently obtained by Andrillat [4].

New plates which we obtained in 1946 in Abastumani lead to temperatures that are in good agreement with our former measurements. Four additional stars were studied with the same general result. Therefore the low spectrophotometric temperatures of the Wolf-Rayet stars are fairly well established.

It was natural to compare the conclusions concerning the extension of the Wolf-Rayet atmospheres obtained from these data with the hypothesis of outflow of matter due to Beals. The latter successfully explained the great width of the Wolf-Rayet spectral bands.

New facts accumulated during the last decade show that this hypothesis meets with some difficulties on account of the very large radii it predicts for the Wolf-Rayet atmospheres. Some of these difficulties were first noticed by O. Wilson [5], then by C. Beals himself [6], and have recently been summarized by M. Johnson [7]. The difficulties enumerated by the latter may be supplemented by the following:

(1) Notwithstanding the supposed intense outflow of atoms from the atmospheres of the Wolf-Rayet stars (except the dwarfs, which are nuclei of planetaries), as a rule these stars are not surrounded by visible nebulosities, and no forbidden lines are present in their spectra. (We would expect the ejected matter to form observable nebulosities after some lapse of time.)

(2) Many dwarf stars, such as the nuclei of planetaries and ex-novae, having very large gravity at their surfaces show the Wolf-Rayet characteristics in their spectra.

(3) The light pressure does not account for the observed motions of gases in the atmospheres.

(4) Appreciable variations of brightness are lacking. This is evidence against the importance of the role of irregular explosive effects in the atmospheres of the stars in question.

(5) A rapid loss of matter would result in a considerable dispersion of masses among the stars of this class, yet a large dispersion is apparently missing.

Therefore, attempts to find another explanation for the phenomena displayed in the Wolf-Rayet spectra are welcomed. The hypothesis of turbulence must, however, be abandoned since for the velocities required the turbulence will be equivalent to ejection.

Whether the physical explanation of the solar flares as discharges in an ionized gas is correct or not, it is possible that if large areas of the surfaces of the Wolf-Rayet stars are spotted by such flares, the scattering of the atomic emission in the flares by fast electrons could account for the large observed width of the Wolf-Rayet bands. If on the relatively quiet solar surface the width of the Hα line in flares amounts to 21 angstroms, there must exist stars in which this broadening is still larger and the flares more frequent and more numerous.

Such a hypothesis might be proven by an attempt to calculate theoretically the relative width and intensities of spectral bands due to different ions and atoms. These ought to be compared with the observed ones, which hitherto were interpreted in terms of stratification of atmospheres, although the latter can actually exist apart from prominent flares.

Estimates of the age of the Wolf-Rayet stars based on the rate of loss of matter will be meaningless in the case of a definite rejection of the expansion hypothesis.

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