IS AS 431 A SUPERLUMINOUS WR STAR?

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The recent study by Caillault et al. (1985) has shown the emission-line star AS 431 (= WR 147) to be a strong X-ray source and moderately strong radio emitter. Combining optical, near-infrared and radio data, they deduced that its mass loss rate was ~ 4 x 10^{-4} $M_{\odot}yr^{-1}$, an order of magnitude greater than is normal for WR stars. They also suggested that it would show up in the IRAS survey and that such data would help to elucidate whether its extreme reddening had a significant circumstellar component. To investigate this possibility and to study the general properties of the object, we have raided the IRAS Point Source Catalogue.

Our reward was fluxes at 12 and 25 microns of 5.26 and 2.57 Jy respectively after colour correction; the background in the Galactic plane is too bright to permit 60 and 100 micron measurement. These data have been added to the ground-based (UBVRIJHK) photometry of Caillault et al., the narrow-band b, v and r measures of Massey (1984) and the radio and X-ray fluxes also presented by Caillault et al. The only other information to hand is the spectral type - given as WN8 by Caillault et al. and as WN7 by Massey. We have adopted the latter.

We have explored two methods of correcting for interstellar extinction. The first is based upon the assumption that AS 431 is a normal WN7 star and that a colour excess can be obtained from the observed b-v and the intrinsic index given by van der Hucht et al. (1981). The result, corresponding to A_V = 9.44 mag., led to an energy distribution quite unlike any single WR star and implies that the intrinsic index is, for some reason, inappropriate.

The other method, recognising that there may be free-free contamination even into the near infrared, relies upon a least-squares fitting of all the UBVR and bvr data to a 30000 K black-body energy distribution with the reddening, represented by the Savage and Mathis (1979) law, as the variable. A value for A_V of 12.0 mag. was found.

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Subtracting the hot black-body fluxes from the observed points permits any infrared excess to be recovered. There appears to be no marked excess at J, H or K that could be attributed to dust reemission. However, at 12 and 25 microns, there is an excess which can be linked to the radio flux on the assumption that it is due to free-free emission. The spectral index so determined α = 0.50±0.03, is close to that predicted for the models of Wright and Barlow (1975) for a spherically symmetric outflow with inverse-square decrease in density with radius: from 10 microns to 6 cm, the predicted index is 0.53 (Barlow et al. 1981). This is different from the value of about 0.76 found for other WR stars, implying that τ = 1 is reached in the constant velocity region of the wind of AS 431 for infrared as well as radio emission.

AS 431 lies in the direction of Cyg OB2, where strong and highly localised absorption is known to exist. If it is a member of that association and its distance is 1.8 kpc, then M_V = -9.7 mag., making it three magnitudes brighter than typical WN7 stars. With this distance we can also compute the mass-loss rate taking typical WN7 parameters from Barlow et al.; for both radio and IRAS excesses we deduce 3 x 10^{-4} $M_\odot yr^{-1}$, similar to the result obtained by Caillault et al.

The report of a strong flux of X-rays ($\geq$ 5 x 10^{-12} ergs cm^{-2} s^{-1}) can be compared with the other characteristics so far established. A value of L(x)/L(wind) = 2 x 10^{-6} is found which is not too dissimilar from that of HD 93162 (a Galactic WN7), while the L(x)/L(bol) for AS 431 is $\geq$ 10^{-7}, similar to that of O stars and again close to that of HD 93162, ie, 1.8 x 10^{-6} (Willis 1982). Thus we see that the present observations point to AS 431 being a super-WN star. Clearly we need more observations to see if this notion is tenable.

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