OPTICAL AND UV INVESTIGATION OF THE ENVELOPE OF AG CARINAE

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The galactic LBV object AG Car is unique for assembling several interesting features: (i) a light curve typical of Hubble-Sandage variables, (ii) a largely variable P Cygni-type spectrum, (iii) a strong IR excess, and especially (iv) a small ring nebula. Caputo and Viotti (1970) found that during 1949-59 the AG Car spectrum varied between A1 and B0 equivalent spectral types. A dramatic evolution occurred in recent years, when the visual magnitude gradually faded from V=6 in 1981 to V=8 in 1985, followed by a rise of the line excitation from Aeq in 1981 (Wolf and Stahl 1982), to Beq in 1983 (Viotti et al. 1984), and to Ofpe/WN9 in January 1985 (Stahl 1986). This behaviour has represented a unique chance to follow a LBV in different spectral ranges during its major photometric and spectral changes. In the following we present the results of a long term monitoring of the star and of its nebula in the optical and UV. We propose that AG Car evolved in recent times from a red supergiant phase, and that the present LBV phase is characterized by a critical structure of the stellar atmosphere.

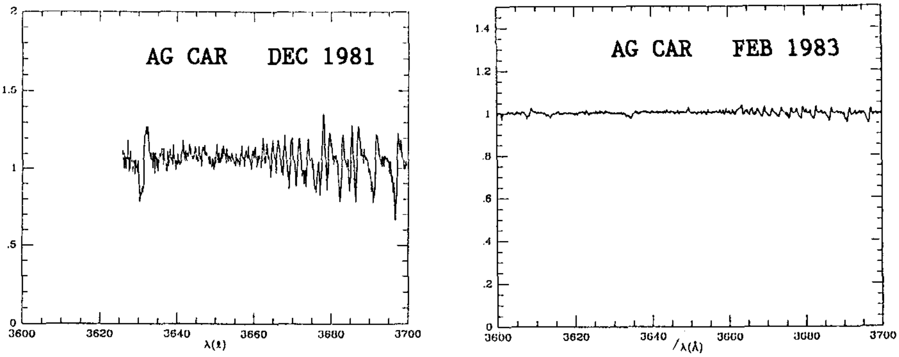

Fig.1. The spectrum of AG Car near the Balmer discontinuity in 1981-83.

K. Davidson et al. (eds.), Physics of Luminous Blue Variables, 268–270.

1. THE OPTICAL SPECTRUM. Coude' spectra of AG Car were obtained in November and December 1981, and during the fading phase in February 1983 (Fig.1). The 1981 spectra show strong Balmer and FeII emissions with P Cygni profile, and no HeI lines, while in February 1983 H and FeII faded and HeI appeared with weak P Cygni profile. In 1981 the Balmer series and the strong FeII lines of multiplet 42 show broad emission wings (Wolf and Stahl 1982). If produced by electron scattering they imply a Tel=9500-15000 K and τe=1.0 for the Balmer lines, and Tel=7000 K and τe=0.5 for FeII 5018 A. We have analyzed the 1981 FeII emission lines with the Self Absorption Curve method (Friedjung and Muratorio 1987), and derived a nearly Boltzmann-type FeII level population with an excitation temperature of 7200+/-350K. From a comparison with theoretical curves, we found that FeII is formed in a high velocity accelerated wind. Hα in Feb.1984 displayed a P Cygni absorption with a sharp edge at -138 km/s, and a narrow emission with wide wings (FWHM=27 A). At minimu in 1987 Hα appeared as a broad emission (Bandiera et al. 1988). The radial velocity of the i.s. CaII appears negative as found by Caputo and Viotti (1970), in agreement with the distance estimate of 2.5 kpc.

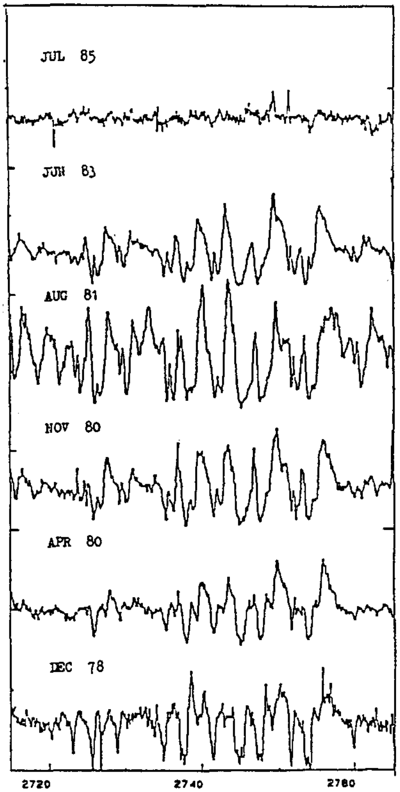

Figure 2. High resolution UV spectra of AG Car in 1978-85.

2. THE UV SPECTRUM. The long lifetime of IUE allowed the study of the UV spectrum of AG Car during its recent major variations. At high resolution the spectrum generally appears rich of FeII lines which strongly affect the energy distribution (Fig.2). The line intensity is variable according to the luminosity phase, and is larger at maximum. A double structure of the absorption component is clearly present during 1980-1983. From a study of UV to IR energy distribution, Viotti et al. (1984) and Viotti (1987) found that the large variations of AG Car occurred at almost constant bolometric magnitude, perhaps due to change of the envelope structure resulting in different energy distributions.

3. THE NEBULA. AG Car is surrounded by a ring nebula, closely resembling the classical Planetary Nebulae, except for the unusual fact that the central nucleus is a luminous P Cygni star! We have monitored the optical and UV spectrum of the nebula, and found at maximum a low excitation spectrum including FeII emissions. The Balmer decrement, when compared with case B, is in agreement with a reddening of about E(B-V)=0.6. Viotti et al. (1988) found that the nebula/star flux ratio is nearly constant. This result, and the

surface brightness distribution suggest that scattering by dust particles in the nebula should be the main source of the observed UV radiation of the nebula.

4. AG CAR AS LBV PROTOTYPE. The study of the recent light and spectroscopic history of AG Car can provide important constraints on the LBV phenomenon, as discussed in the following.

During recent times the effective temperature of AG Car (whatever be the physical meaning of this term) changed from less than 10000 K to more than 30000 K in a few years, whereas Mbol remained nearly the same. The effective radius of unit opacity has correspondently largely decreased. But this does not mean that the star has 'shrinked'! Viotti (1987) suggested that the structure of the atmosphere of AG Car is probably critical, so that small changes of the mass outflow could produce large opacity variations (for instance as a result of ionization of FeII to FeIII) followed by large changes of the 'effective radius' and energy distribution, but without large luminosity variations. Obviously the star has only apparently moved in the HR diagram.

The presence of dust in the nebula is putting severe constraints on the possible evolutionary models for AG Car. If the star is not binary, dust should be produced by AG Car itself. The easiest explanation is that some 10^3-10^4 years ago the star was a red supergiant with intense mass loss and dust formation in the wind. The star should thus have recently moved from this M-supergiant phase to the present LBV phase.

Finally, we would like to note that according to our estimate of the bolometric magnitude (about -8.5 mag) the star is underluminous with respect to most of the known LBVs. Although the distance estimate could be subject to large revision in future, we do not consider at present this result not acceptable, in view of the poor statistics of galactic (and extragalactic) LBVs, and the still poor knowledge of the origin of the variations. From our point of view AG Car is a peculiar luminous star which needs be studied individually, rather than as a member of a class of star. Thus we consider it non-physical to try to force the observations in order to have the 'correct' (i.e. model expected) luminosity.

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