THE ULTRAVIOLET TO INFRARED SPECTRUM OF THE LARGE MASS LOSS LMC SUPERGIANT S22 = HD 34664[+]

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S22 is a peculiar supergiant in the Large Magellanic Cloud whose optical spectrum is characterized by numerous emission lines including FeII and [FeII] (Muratorio 1978). A detailed study performed by Friedjung and Muratorio (1980) led to two main conclusions: (a) A wind with a velocity of 70 km s^{-1} and a mass loss rate between 4×10^{-6} and $5\times10^{-5} M_\odot\,yr^{-1}$ is suggested by the examination of the Balmer line P Cygni profiles. (b) The FeII and [FeII] emission lines come from a different region which is optically very thick in the permitted lines. Emission line curve-of-growth methods indicated that the region of line formation has a surface area perpendicular to the line of sight equal to that of a disk perpendicular to this direction with a radius between 3×10^{13} and 3×10^{14} cm.

S22 was observed with IUE at low resolution in both the long and short wavelength ranges, while infrared photometry was also performed at ESO. Except for an IR excess longwards of 2 μ probably due to dust emission, the continuum when dereddened for E(B-V)=0.17 (determined by Friedjung and Muratorio 1980) with the standard galactic extinction law shows a smooth distribution without a depression at 2200 A (Figure 1). A short

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[+] Based on observations by the International Ultraviolet Explorer collected at the Villafranca Satellite Tracking Station of ESA, and on observations made at the European Southern Observatory, La Silla.

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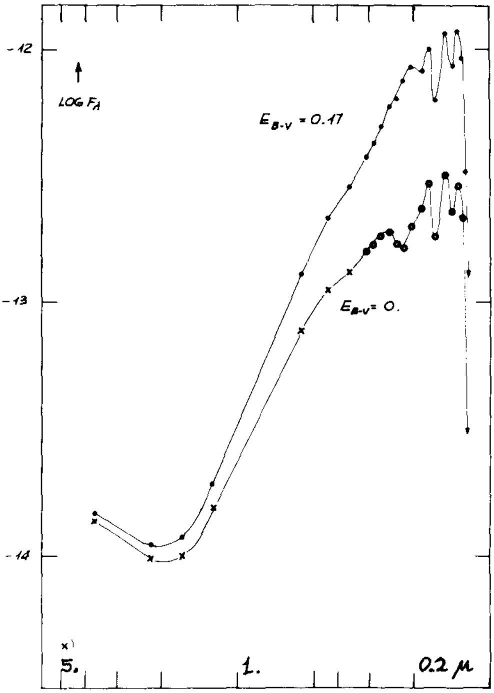

Fig.1 The energy spectrum of S22, HD 34664.

wavelength cutoff is present at about 1250 A. The energy distribution is nearly a power law with $F_\lambda \propto \lambda^{-2.2}$ in the steepest parts. To explain as due to optically thin f-f emission an electron temperature of $\geqslant 3\text{x}10^5$ °K would be required, but this is contradicted by the absence of the helium recombination lines in the optical spectrum. An accretion disk model though still speculative has some attractive features. Using the theory of Bath et al.(1980) the total luminosity and an estimate of the disk inner edge temperature from the observed short-λ maximum, a very large accretion rate of $4\text{x}10^{-3} M_\odot yr^{-1}$ is obtained, assuming for S22 $M_* = 40\ M_\odot$, corresponding to the mass of a main sequence star with the same radius as the estimated inner disk radius. There is no evidence that the star is binary, but it occurs in an association, so it may be young and still accreting from the i.s. medium via a disk. In this case we may be seeing a massive star in a very short lived phase of 10^4 years. Whatever be its origin the outer parts of such an accretion disk would be a good place for those emission lines without a P Cyg profile, FeII etc., to be formed while the inner disk could give the broad emission wings of the earlier Balmer lines. The high mass loss could be a byproduct of the accretion.

Preliminary identification of the UV features suggests the presence of many FeII lines. We therefore decided to try to synthesize the FeII contribution to the spectrum between 2100 and 3100 A using the upper term relative populations derived by Friedjung and Muratorio (1980) and taking

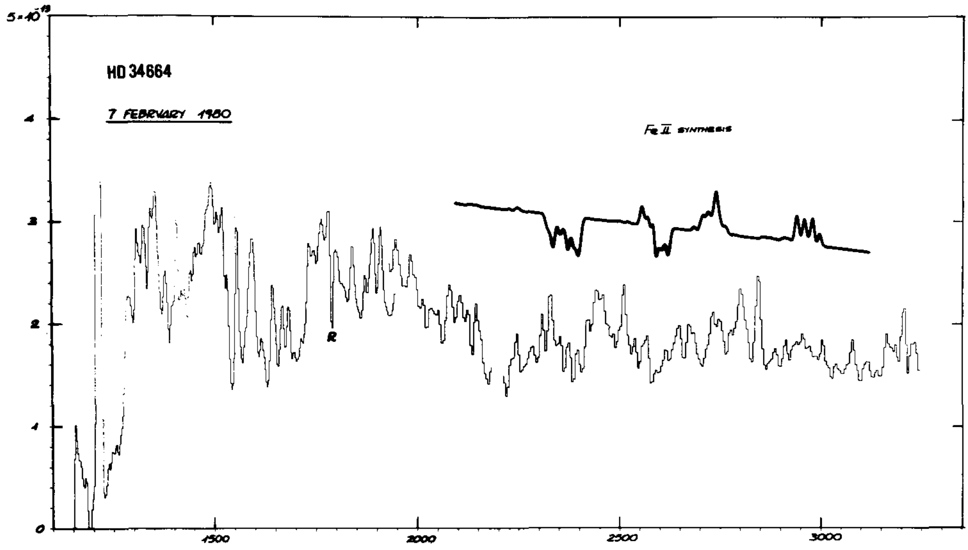

Fig.2 The ultraviolet spectrum of S22 and the FeII synthetic spectrum.

for the lower terms a Boltzmann distribution at 5060°K. A good fit to many features is obtained (see figure 2) if all lines are in emission, but there is absorption for lines with lower excitation potential $\lesssim 0.4$ eV. The absorption components were assumed optically very thick with equivalent widths proportional to $\lambda^2 \sqrt{gf}$, while a mean emission line self absorption curve was used as in Friedjung and Muratorio. One can suppose the emission lines formed in the same region as the FeII lines seen in the optical spectra, while the absorption could be due to P Cyg components formed in the wind. If all iron was once ionized and abundances were cosmic, a hydrogen column density of $6\text{x}10^{21}\,\text{cm}^{-2}$ is derived.

REFERENCES

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DISCUSSION

MENDEZ: I would like to know how many spectrograms you have and if you have searched for variations in radial velocity?

VIOTTI: In an old paper (Caputo and Viotti 1970) we found large variations of the radial velocity of the P Cygni absorptions from -100 to about -200 km s^{-1} which should be related to variations of the stellar wind.

FRIEDJUNG: What is the ultraviolet energy distribution like? Does it resemble that of a more "normal" star? Would you require a more exotic model?

VIOTTI: The continuum gradient in UV is rather hot and similar to that of P Cygni, maybe slightly cooler than P Cygni itself.

ANDRIESSE: Do you know something about the stellar mass? Could it be some 50 $M_\odot$?

VIOTTI: Yes. On the basis of the large mass loss rate, low terminal velocity, high luminosity and maybe also the considerable mass of the ring nebula, one must infer that AG Car is a massive star.