MASS LOSS FROM HOT STARS BELOW THE MAIN SEQUENCE

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ABSTRACT

The evolutionary implications of mass loss from post-asymptotic giant branch stars is discussed, with reference to the UV observations of sdO's.

1. EVOLUTIONARY PROBLEMS OF POST-ASYMPOTIC GIANT BRANCH STARS

The evolutionary status of O subdwarfs (sdO's) is far from being definitely settled. It is probably a "mixed bag" containing low gravity stars crossing the normal evolutionary path to the white dwarf stage (commonly identified with the Planetary Nebulae Nuclei (PNN), stars evolving off the horizontal branch without reaching the Asymptotic Giant Branch (AGB) phase (Sweigart et al.,1974), and larger gravity stars almost close to the white dwarf region (Kruditzki,1976).

The post-AGB is an important phase in the evolution with mass loss of intermediate mass stars, which was recently upset by the recognition that among carbon stars in the Magellanic clouds the high luminosity stars are lacking. In the framework of the explanation of the carbon star phase with the "third dredge up" occurring during the thermal pulse phase (Iben and Truran,1978), the lacking stars would correspond to carbon-oxygen core masses between 0.8 and 1.4 M_o (e.g. Iben,1980). Their absence requires a non-naif modification of the whole stellar evolution through thermal pulses, as, for instance, a modification of the mass loss rates at large luminosity. One might hope to identify in the post-AGB phases the large core masses which are hidden (if they exist) during AGB.

The most important group of post-AGB stars are the PNN. But the appearence of a post-AGB star as PNN depends on the relative timescales of the evolution of the nucleus itself to white dwarf (t_{ev}), and the timescale of the PN expansion. These two rates must be comparable (i.e. $t_{ev} \simeq 10^4$ yr) to have a PNN (Renzini, 1978 and 1981), and this might happen

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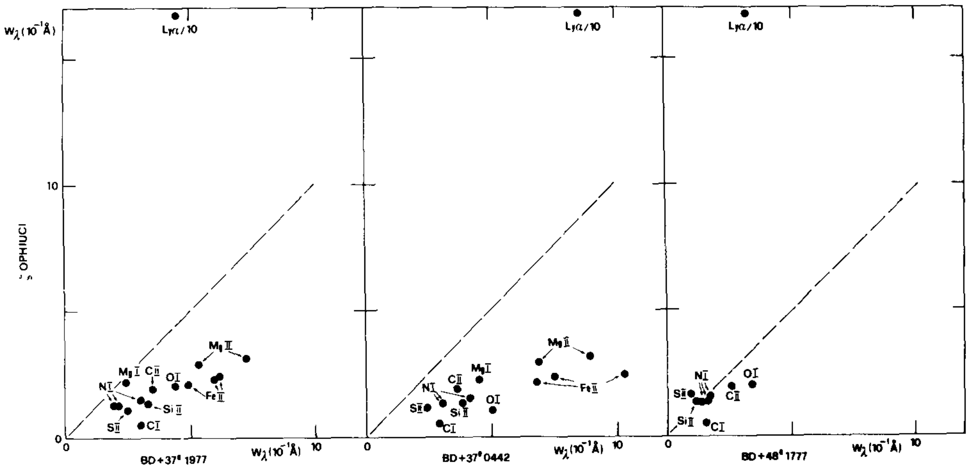

Fig.1 Interstellar line intensities in sdO's compared with ζ Oph.

only to some of the post-AGB stars. Furthermore, the most of PNN present mass loss (Benvenuti and Perinotto,1981), whose rates might be comparable with the rates of nuclear burning, dictating the evolutionary timescale. In this context, it is clear that the importance of understanding sdO's goes far beyond the limits of the group itself, as it is a step in the understanding of the post-AGB evolution.

The study of sdO's has known a considerable improvement in the recent years, with the advent of the UV observations with IUE (Darius et al.,1979, Simon et al.,1979, Rossi et al.,1980). Of these observations we report here two important aspects: the presence of strong circumstellar lines, and the existence of mass loss from a few sdO's.

2. THE CIRCUMSTELLAR LINES

Although it was already known that sdO's present strong anomalous "interstellar" lines (e.g. Wolff et al.,1974), many intense, saturated lines of non stellar origin have been revealed in the IUE spectra of all sdO's (Rossi et al.,1980) whose radial velocities are 30-50 Km/s more positive than the stellar ones. In fig.1 the i.s. line intensities are compared with those of the reddened star ζ Oph (Morton,1975). The concomitant absence of the 2200 i.s. absorption band, the weakness of i.s. Ly$_\alpha$ and the optical color indices suggest a small i.s. extinction and concur to the interpretation that we are in the presence of a circumstellar envelope. Therefore all sdO's have gone in the recent past through a phase of mass loss at low velocity. In the context of the preceding evolutionary picture, two possibilities may explain this feature: either these stars have recently been PN nuclei, and the circumstellar matter is a remnant of the PN,

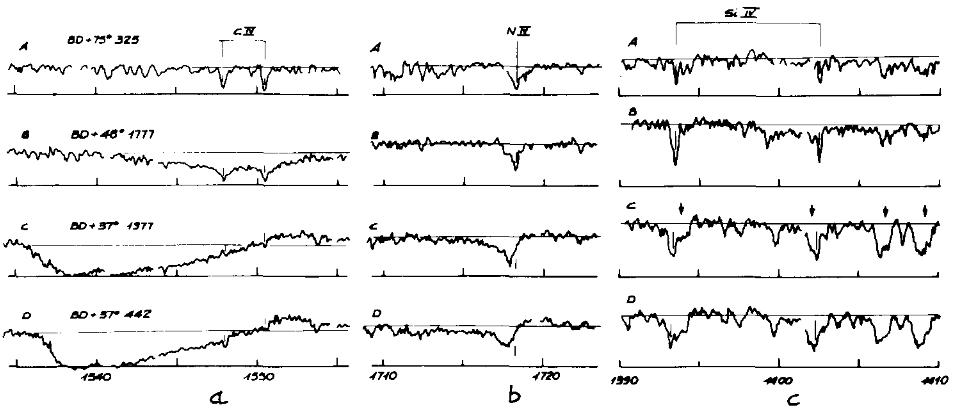

Fig.2 The high resolution IUE spectra of hot subdwarfs.

or they never have passed through a PN phase because they may have spent a lifetime long enough to dissolve the nebula in a stage too cool to excite it. In this latter case, we are sampling a group of post-AGB stars non homogeneous with the PNN sample, and consequently we may get different information on the involved masses, etc.

3. MASS LOSS FROM THE HOT SUBDWARFS

Four sdO's of a sample of 25 so far examined in the UV show evidence of mass loss (Darius 1980). In fig.2 a-c we compare the UV spectra of non mass losing (BD+75°325,+48°1777) and mass losing sdO's (BD+37°1977, +37°442). The latter ones show CIV and NV resonance lines with strong P Cygni profiles, having absorption components extending to about -2200 Km/s. Also the excited NIV λ1718 line clearly exhibits an asymmetrical profile (fig.2b), while the resonance SiIV lines seem to be normal (fig. 2c). The photospheric spectrum of all sdO's is characterized by high ionization absorption lines (CIV, OV, FeV, etc., Rossi et al. 1980) which appear broader in the mass losing stars. In fact, in these stars the line blending is more severe than in the non mass losing stars (arrows in fig.2c).

There is some indication that mass losing sdO's have smaller gravity than the non mass losing ones (Darius et al. 1979, Simon 1979, Kudritzki and Simon 1978, Kudritzki et al. 1980).Thus mass loss could be considered a purely atmospheric phenomenon, a conclusion supported by the presence of mass outflow in all the other groups of stars populating the same region of the H-R diagram (PNN, novae, normal main sequence O stars). On the other hand, the large variety of mass loss rates derived for PNN (Benvenuti and Perinotto 1980, Pottasch and Gathier 1980), and the fact that not every star presents the phenomenon force us to conclude that another parameter is playing a role, at least until one is not able to completely discriminate the mass losing objects in the (log g-logT_{eff}) plane. This parameter could be tentatively identified with the exact evolutionary stage, as in Section 1 we saw that the evolution through the region is dictated by the delicate interplay of a large number of parameters. Incidentally we notice that the exact evolutionary stage can be extremely important in determining the outer chemical composition on which the structure of the outer layers greatly depends. In particular the appearence and modality of convection depend very much on the helium content, larger convective velocities could in principle mean larger microturbulence in the atmosphere and possibly mass outflow. The broad profiles of the photospheric lines in mass losing sdO's would in this case find a consistent explanation.

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DISCUSSION

HAMANN: The Kiel group has also looked for mass loss from O subdwarfs Four objects were carefully analyzed in NLTE (1) HD 49798, (2) HD 128220B, (3) BD + 75°325, (4) HD 127493 . The T_{eff} and log g of (1) and (3) were already included in Viotti's table. We found mass loss (NV P Cygni profiles) in (1) and (2), but no mass loss in (3) and (4). The derived mass loss rates (or upper limits, resp.) agree well with the prediction of Andriesse's fluctuation theory.