SYMBIOTIC STAR UV EMISSION AND THEORETICAL MODELS

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Observations of symbiotic stars in the far UV have provided important information on the nature of these objects. The canonical spectrum of a symbiotic star,e.g. RW Hya, Z And, AG Peg, is dominated by strong allowed and semiforbidden lines of a variety of at least twice ionized elements. Weaker emission from neutral and singly ionized species is also present. The Mg II doublet is usually very strong and may be associated with the M giant primary. A continuum may or may not be present in the 1200 - 2000 A range but is generally present in the range 2000 - 3200 A range, the latter arising from free-free and bound-free emission in the same nebula that is responsible for the UV line emission (CI Cyg, RW Hya, RX Pup). The suspected hot subdwarf continuum is seen in some cases in the range 1200 - 2000 A (RW Hya, AG Peg, SY Mus). High resolution observations of lines are important because they yield information on densities, temperatures and sizes of the line emitting region(s); in general, however, such observations are difficult and time-consuming to obtain with "IUE". Densities are found to range from a low of $\sim 10^{6}$ cm^{-3} in R Aqr and V1016 Cyg through typical values of 10^{8} - 10^{9} cm^{-3} in RW Hya to a high of $\sim 10^{11}$ cm^{-3} in Z And. Sizes range from $\sim 10^{11}$ in the resonance line emitting region in Z And to $\sim 10^{14}$ - 10^{15} cm in the more extended regions of R Aqr and V1016 Cyg. Temperatures are generally $\lesssim$ 20,000 K. High resolution profiles generally show single component nebular emission (RW Hya, SY Mus, AG Peg, V1016 Cyg). Complex profiles showing multiple velocity structure present in rings and/or streamers have been detected in RX Pup. Continua, which very often are flat, are harder to interpret but it seems that line blanketed models of B, A and F-type stars generally fail. A combination of different sources of continua seems ro be required: nebular emission (particularly for $\lambda \gtrsim 2000$ A); hot subdwarf continuum; and/or continuum arising in an accretion disk. The presence of an accretion disk is difficult to demonstrate and to this date the best candidate for accretion to a main sequence star remains CI Cyg. A number of equations have been derived by the author that can yield the accretion parameters from the observable quantities. Boundary layer temperatures $\sim 10^{5}$ K and accretion rates $\gtrsim 10^{-5}$ $M_{\odot}$/yr are required for accreting main sequence companions. To this date, though, most of the symbiotics may only require the presence of a $\sim 10^{5}$ K hot subdwarf.

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DISCUSSION ON THEORETICAL MODELS

Chairman: I want to recall the audience that we must decide if the Symbiotic Stars are binary or not, otherwise we cannot go on to Session IV which is devoted to the binary evolution.

Slovak: CH Cygni = HD 182917 has been extensively studied by Hack, Wallerstein and many others, but there is no convincing evidence for the binary nature of this system. Admittedly, it is an extreme example of a symbiotic star (very low excitation, latest spectral type secondary, displays rapid variations), but it still remains a troublesome case which cannot be ignored.

Boyarchuk: I have some arguments against the single star hypothesis of the nature of symbiotic stars.
First if we propose that a symbiotic star is a cool star with a hot corona or chromosphere, in this case we must remember that the luminosity of the corona would have to be 10^6 times larger than the solar one in order to observe it in total light in the visual spectral region.
It means that the bolometric luminosity of such a corona will be even more intense than the bolometric luminosity of the photospheric radiation. Under such conditions it is impossible to keep the surface temperature cool enough. As a result we will not have a symbiotic star.

Secondly, if we propose that a symbiotic star is a hot star with a hot nebula, and that TiO-bands and other absorption features are formed in other parts of this nebula, we should note that in the spectra of many symbiotic stars we observe the absorption line of CaI λ 4227. This line has very extended "wings" which is normal for a cool star spectrum. But, if we calculate the column density which is needed to produce such wings in a nebula, and multiply by the surface of the nebula which is huge, then we will obtain the mass of the absorption envelope that is equal to several solar masses. It is difficult to understand how such envelope could exist.

The main argument in favour that the symbiotic stars are single stars is a lack of strong evidence for the binary nature of some symbiotic stars. But this argument is not sufficient. It is necessary to give the arguments that a single star can produce the symbiotic phenomenon.

Hack: The model you discussed (hot star and cool envelope) cannot work in the case of CH Cygni. In fact this star in a period of relative quiescence lasting several years, had a normal M 6 III spectrum.

The blue-UV continuum appearing during outburst is due to a semi-transparent layer, because the TiO bands are always visible (also in the blue part of the spectrum). The temperature indicated by the blue continuous energy distribution is not very high (less than about 10^4°K), and the blue continuum lasts a few months or years, and is surely not sufficent to heat the photosphere of the M giant.

Slowak: The lack of magnetic fields, at least as determined by conventional Zeeman studies in symbiotic stars, argues against the single star model proposed for a red star, which is analogue of the flare star model.

Michalitsianos: A kilogauss magnetic field measured on an average magnetic field for a symbiotic star would imply local field strengths of enormeous values. It is likely that high energy processes would occur under such circumstances, which is contrary to observations; for example soft X-ray emission is not present.

Kwok: One important element in our understanding of the nature of symbiotic stars is their division into type S and type D (Allen 1979), which correlates well with the type I and type II of Paczynski and Rudak (1980). Since only type D (or type II) objects have clear evidence for an M-star wind, one might wonder whether the presence of such a wind is in fact the cause of the slow nova phenomenon,through their abilities to transfer mass in spite of a wide binary separation.

Rudak: As I understood, Bath applied geometrically thick ($z/r=0.5$) accretion disk in his calculations to reproduce the observed light curve. I don't know how the distribution of surface temperature on the disk was calculated. The way to do that in the case of an α-disk, which gives us a very bright boundary layer dominatingthe disk and a temperature of disk decreasing outwards, is not proper for considerably thick disks.
And the reason is that in geometrically thick disks, the energy generated due to accretion is not transferred entirely to the point on the surface which lies directly above the point inside the disk, where this generation take place. We will expect the effective influence of energy generation in one place giving surface temperature in other places. Similar problems are considered for example in thick accretion disks around massive black holes and give some QSO-characteristics.

Kafatos: About the theoretical attempts to fit the optical continua (by Bath) or the more recent ones to fit the IUE UV continua (by S. Kenyon) they go, in my opinion, in the wrong direction or are - at least - incomplete. The reason for this is that we have a lot of information about the nature of the ionizing radiation from the UV lines, and that

information has to be incorporated in any self-consistent disk model. The continua in the long wavelength region of IUE seem in most cases to arise from the same optically thin nebuale that give rise to the UV lines and there is no need to invoke disks.
The only continua that are left are in the short wavelength UV region of IUE (1200-2000 A). This is, in my opinion, too small a region to try to fit accretion disk continua which are in any case highly uncertain.
Until someone has looked at the ionizing radiation responsible for the line forming region, how that radiation arises in a self-consistent disk model, and how this radiation escapes from the inner regions of the geometrically thick disks of Bath, the disk models of symbiotics remain I think incomplete.

Hack: I wish to say that also IUE observations indicate that probably the physical conditions in chromosphere-corona of late dwarf stars are different from those in giants and supergiants. Only the dwarfs show hot chromospheres, while cool giants and supergiants present low excitation features.

Kwok: From the paper of Dr. Kafatos, it seems that the characteristic densities of D-type objects are lower than that of S-type objects. Again, it points to D-type objects as having wind-like nebulae, whereas S-types do not.