Far-Ultraviolet Spectroscopy of Symbiotic Stars

Hans Martin Schmid
I. Appenzeller
J. Krautter
H. Mandel
Landessternwarte Heidelberg-Königstuhl, D-69117 Heidelberg, Germany

J. Barnstedt
M. Gölz
M. Grewing
W. Gringel
C. Haas
W. Hopfensitz
N. Kappelmann
G. Krämer
Institut für Astronomie und Astrophysik der Universität Tübingen, Waldhäuserstr. 64, D-72076 Tübingen, Germany

Abstract We present FUV spectra (900Å–1200Å) of several symbiotic binaries taken with ORFEUS (Orbiting and Retrievable Far and Extreme Ultraviolet Spectrometer).

1. Introduction

Symbiotic stars are binaries consisting of a cool red giant and a hot component. The hot component ionizes part of the giant's wind, which produces a strong emission line spectrum. The light curves of symbiotic systems are often very complex because they are the result of a combination of variability mechanisms, such as outbursts of the hot component, pulsations of the cool component, and orbitally-induced occultation and reflection effects (see, e.g., Kenyon 1986). For a better understanding of these systems, observations in all wavelength bands are required. We describe here spectra of symbiotic systems taken in the far-ultraviolet (FUV) between 900Å and 1200Å. Only a few observations have been made previously in this spectral range (e.g., Espey *et al.* 1995; Mikołajewska *et al.* 1995).

2. ORFEUS Spectroscopy

FUV spectra of symbiotic stars have been taken as part of the ORFEUS-I mission during the space shuttle flight STS 51 in September 1993. ORFEUS (Orbiting Retrievable Far and Extreme Ultraviolet Spectrometer) is a 1-m telescope for spectroscopic observations, and is a joint project between the Institut für Astronomie und Astrophysik, Tübingen, the Landessternwarte Heidelberg, and the Space Science Laboratory of the University of California, Berkeley.

The obtained spectra of the symbiotic systems RR Telescopii and AG Draconis in 910Å–1160Å are plotted in Figure 1. Both spectra show strong lines from the emission nebula and a very weak continuum from the hot component. The lines originate predominantly from highly ionized species, such as He II, O VI, Ne V, Ne VI, and S VI. By far the strongest emission is the O VI doublet at 1032Å, 1038Å.

3. O VI Raman Scattering

These observations are important for a better understanding of the O VI Raman scattering process in symbiotic binaries. In this process, the strong O VI lines are scattered inelastically by neutral hydrogen-producing broad Raman lines in the red spectral region at 6825Å and 7082Å. Spectropolarimetric measurements revealed that the Raman lines are strongly polarized (Schmid and Schild 1994; Harries and Howarth 1996). The properties of the Raman lines in symbiotic systems can be explained by a scattering geometry, where strong O VI radiation is produced in the ionized region near the hot component and converted by neutral hydrogen into Raman photons in the extended atmosphere and in the wind of the cool giant.

From a comparison of the line fluxes for the FUV O VI lines and the red Raman lines, we can determine the conversion efficiencies 1032Å → 6825Å and 1038Å → 7082Å for the Raman scattering process in symbiotic systems. These efficiencies are expected to be high, if the neutral scattering region (where Raman scattering takes place) is very extended, so that a large fraction of the emitted O VI photons can interact. A preliminary analysis for RR Tel and AG Dra suggests that about 10% of the O VI photons are converted to red Raman photons. This implies, according to the model simulations of Schmid (1996), that about 30%–50% of the emitted O VI photons must interact in the neutral scattering region. This in turn requires that the neutral regions in RR Tel and AG Dra are very extended to cover such a large fraction of the O VI-emitting region.

References

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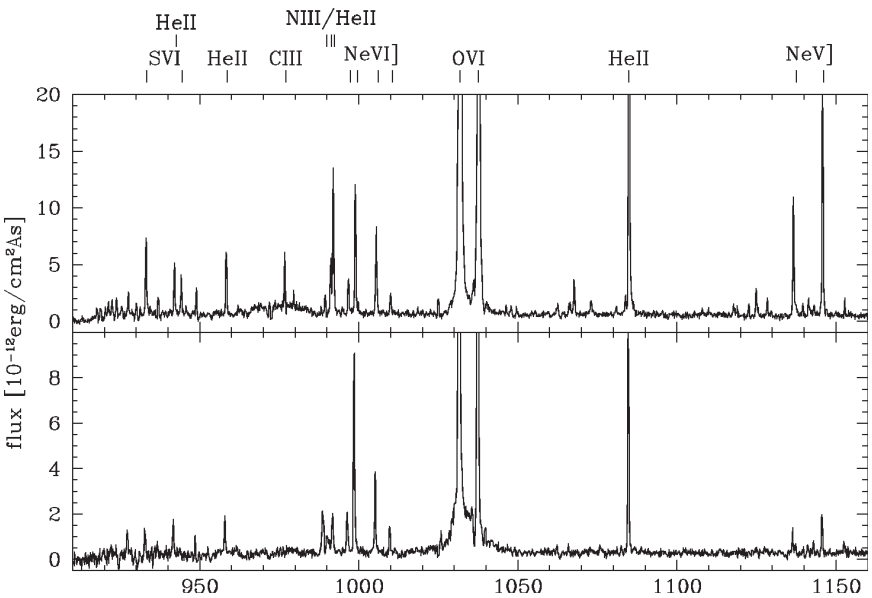

Figure 1. ORFEUS-I spectra of the symbiotic stars RR Tel (top) and AG Dra (bottom).