THE VIOLET OPACITY IN THE RED PECULIAR STARS (I)

Spectral Analysis of the Cool Carbon Stars LW Cyg and Y Tau

O. ALKSNIŠ and L. ZAČS

Radioastronomical Observatory, Latvian Academy of Sciences, Riga, Latvia

(Received 25 June, 1993)

Abstract. Moderate dispersion (25–35 Å mm\(^{-1}\)) spectra were obtained from two carbon stars, LW Cyg and Y Tau, in a wide range of wavelengths (λλ 3400–6800 Å) with the 6 m echelle-spectrometer ZEBRA and two dimensional photon-counting system. Spectral feature identification was carried out from 3800 to 6300 Å. Most of the bands are due to C\(_2\), CN, and SiC\(_2\), however, atomic lines of the iron peak and s-process element also are represented. LW Cyg have intense isotopic carbon bands. The wavelengths and band-intensity were estimated.

1. Introduction

Carbon stars are peculiar red giant stars whose spectra are characterized by bands of the carbon-containing molecules. The visual spectrum is dominated by strong bands of the C\(_2\) Swan and CN systems, in contrast to the spectra of K and M giants, where oxides are strongest features. The spectral differences indicates that carbon in the atmospheres of carbon stars must be more abundant than oxygen (C/O > 1), whereas C/O < 1 in normal red giants. Cooler carbon stars have also been contaminated by s-process elements. It is believed that carbon star are asymptotic giant branch (AGB) stars with double shell-sources. The carbon and heavy element enhancement has been attributed to the addition of freshly nucleosynthesized material to the atmosphere.

The blue and violet flux in carbon stars appears to decrease more rapidly toward shorter wavelengths than does the flux in normal giant stars or black bodies. This flux deficiency is attributed to some atmospheric or circumstellar absorber, and the phenomenon is often referred to as “the violet opacity or depression”. Violet opacity is a significant feature in the optical spectra of a number of carbon stars. Two important sources can then be proposed in order to account for this opacity: SiC grains and C\(_3\) molecules (Bregman and Bregman, 1978). However Orletti (1987) showed that the source of the opacity could not be located in the outer layers of the atmosphere, especially in the circumstellar shell. Molecules of C\(_3\) and SiC\(_2\) were also rejected as basic sources of the depression. It is possible that some atoms play an important role in the creation of the depression. The search for this source was undertaken by Johnson and Luttermoser (1988) by comparing the observed energy distribution in the spectrum of TX Psc with a synthetic spectrum calculated for various sources of opacity including neutral metals. The uncertainty about possible violet opacity agents is due to the fact that opacity is observed not only in carbon
TABLE I
Stellar data for program stars

<table>
<thead>
<tr>
<th>Name</th>
<th>Stephens (1973)</th>
<th>*V Spectrum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y Tau</td>
<td>393</td>
<td>9</td>
</tr>
<tr>
<td>LW Cyg</td>
<td>3080</td>
<td>9</td>
</tr>
</tbody>
</table>

stars, but also in some SC, S, Ba II, and CH stars. A complete solution of the violet opacity problem is possible, basically, only by comparing the observed energy distribution and synthetic spectrum calculations of variety peculiar red stars.

2. Observations

Our program on the violet opacity include spectral investigations on the variety of the red peculiar stars with this phenomenon: carbon, S, Ba II, and CH stars. In this work are presented the first results of the spectroscopic analysis of two carbon stars. Spectroscopic data of the program stars were obtained using the 6 m telescope at the Special Astrophysical Observatory (SAO, Nizhnij Arkhiz, Russia) with the ZEBRA echelle spectrometer (Gazhur et al., 1990) and a two dimensional photon-counting system. The data were acquired in 1989. Each echelle region spanned 300–500 Å between λλ 3400–6800 Å and had a resolution of ~ 1.5–2.0 Å, and the signal-to-noise ratio was 40 or higher. Observers are G. Galazutdinov, V.G. Klochkova, V.E. Panchuk and L. Začs. Table I given the stellar data for the two stars included in this work.

3. Analysis

3.1. DATA REDUCTION

We did the data reduction with the DECH (Galazutdinov, 1992) package of programs installed on a PC in the Radioastrophysical Observatory of the Latvian Academy of Sciences. However, the main steps in the data reduction procedure: subtraction of the bias from the star spectrum and the collapse of the star spectrum to produce a one-dimensional spectrum were carried out in the Special Astrophysical Observatory. We used the DECH routines for continuum fitting and the determining of the wavelength dispersion relation. One-dimensional spectra were then used to identify the lines of interest and measure their equivalent widths. The equivalent widths for well-defined spectral features were computed using the integration of the profile in wavelength region of the spectral feature.