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U Antliae — A Dying Carbon Star

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Abstract. U Antliae is one of the brightest carbon stars in the southern sky. It is classified as an N0 carbon star and an Lb irregular variable. This star has a very unique spectrum and is thought to be in a transition stage from an asymptotic giant branch star to a planetary nebula. This paper discusses possible atomic and molecular line identifications for features seen in high-dispersion spectra of this star at wavelengths from 4975 Å through 8780 Å.

1. Introduction

U Antliae (U Ant = HR 4153 = HD 91793) is classified as an N0 carbon star with a visual magnitude of 5.38 and $B-V$ of +2.88 (Hoffleit 1982). It also is classified as an Lb irregular variable with small scale light variations. Scattered light optical images for U Ant have been made and these observations are consistent the existence of a geometrically thin (∼3 arcsec) spherically symmetric shell of radius ∼43 arcsec. The size of this shell agrees very well with that of the detached shell seen in CO radio line emission. These observations also show the presence of at least one, possibly two, shells inside the 43 arcsec shell (González Delgado et al. 2001). In this paper, absorption lines in the optical spectrum of U Ant are tentatively identified for this bright cool carbon star.

2. Observations

The European Southern Observatory has created a web site for astronomers to access a library of high-dispersion spectra of stars obtained at the UVES Paranal Observatory (http://www.sc.eso.org/santiago/uvespop/). The UVES Paranal Observatory Project (POP), is an on-going program of acquisition, reduction, and public release of stellar spectra obtained with UVES. All of the spectra in the library were obtained in two instrument modes, *Dichroic 1* and *Dichroic 2*, in order to cover almost completely the wavelength interval from 3000 to 10,000 Å. The spectral resolution is about 80,000 and typical S/N ratios are 300 - 500 in the V band for most of the spectra in this library (Bagnulo et al. 2003).

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3. Analysis

An initial list of tentative identifications was first compiled by WPB. He used 8909 measurements of wavelengths and central intensities from $\lambda\lambda$4975 to 9998. These identifications are made by noting the number of coincidences of absorption features with species listed in the multiplet tables. In this first pass, the two most abundant features result from Ti I and Zr I absorption. The zirconium lines suggest that U Ant may actually be a CS star instead of a standard carbon star. The next stage of line identifications involve the technique of wavelength coincidence statistics (WCS, see Hartoog et al. 1973) by CRC. WCS supports the following identifications at the 0.05 significance level (95% confidence), or better: N I; Mg I; Ca I, II; Sc I, II; Ti I; V I; Cr I, III (though III is likely spurious); Fe I, III (though III is again unlikely); Co I; Ni I; Ga II (this identification may be unlikely); Y I, II; Zr I; Nb I; Rh I; In II (once again, unlikely); I I (yes, iodine one); Ce I, II; Nd II; Ho I; Yb I; and Th I.

Regarding molecular species, the initial pass produced 87 neutral diatomic species identifications, with CN, C_2, TiO, ZrO, VO, and CO having the largest number of features, respectively, though there may be many cases of chance coincidences for those species with few absorption features. For the expected molecules, there seem to be coincidences with 15 or more species. These molecular identifications are based on wavelengths of rotational lines of molecules from the Rowland Tables (Moore et al. 1966) and the molecular data tables of Pearse & Gaydon (1976).

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