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The effect of pulsation on the near-ultraviolet spectrum of AGB stars

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ABSTRACT

Pulsating and non-pulsating asymptotic giant branch (AGB) stars exhibit a variable near-ultraviolet (near-UV) spectrum, which suggest that mechanisms other than pulsation may affect their near-UV spectrum. In this work, we analyse the near-UV spectra of two groups of AGB stars: (1) regularly pulsating and (2) irregular, small-amplitude stars. Near-UV and blue spectra were obtained for 27 stars distributed into these two groups with the Isaac Newton Telescope (La Palma, Spain). Additional near-UV spectra were taken from the IUE library. The occurrence of Fe II lines depends mainly on the intensity of the stellar continuum: as it increases, Fe II lines are gradually hampered. Balmer emission lines are pulsation driven, as they appear only among the large-amplitude pulsating stars of our sample, between $-0.10 < \phi < 0.50$. Among the regularly pulsating stars, the intensity of the Mg II λ2800 doublet is driven by pulsation, with its maximum between $0.20 < \phi < 0.35$. On the other hand, this feature is also highly variable among small-amplitude, irregularly pulsating stars. This suggests that, besides pulsation, other mechanisms may participate in the formation of this line. The spectral slope between $3000 < \lambda(\text{Å}) < 3200$ is approximately constant among small-amplitude stars, but it shows a strong correlation with the phase of the pulsation in the other group, which indicates that the origin of the continuum is chromospheric. Different phase lags between the Mg II λ2800 and the slope of the continuum suggests that this line and its neighbouring continuum might be formed in distinct places in the chromosphere or its surroundings.

Key words: stars: AGB and post-AGB – binaries: general – circumstellar matter – ultraviolet: stars.

1 INTRODUCTION

Asymptotic giant branch (AGB) stars show a variety of features in their ultraviolet (UV) spectra, and various mechanisms have been proposed to explain their characteristics. The *IUE* satellite (Sonneborn et al. 1987) revealed a multitude of metallic emission lines, especially Fe II (Carpenter & Wing 1979) between 1200 and 3200 Å. AGB stars with intense far-UV emission and high-excitation emission lines have been suggested to be binaries (Sahai et al. 2008, 2018; Ortiz & Guerrero 2016), whereas the correlation between the NUV *GALEX* magnitude and the visual light curve of Mira-type stars indicates that their near-UV emission follows the stellar pulsation and is thus 'intrinsic' to the star (Montez et al. 2017).

The majority of the near-UV emission lines are collisionally excited and stellar pulsation has been suggested as the main mechanism of excitation of metallic ions, with shock waves propagating from the bottom of the chromosphere upwards (Judge & Jordan 1991; Judge & Cuntz 1993). Schrijver (1987) noticed that there might be two distinct mechanisms responsible for the chromospheric heating: (1) a basal component, fundamentally non-magnetic, which depends only on fundamental stellar parameters, such as effective temperature and gravity, and (2) a 'magnetic' component, which depends on the stellar rotation and the properties of convection zones. The matter is controversial, and eventually Judge & Carpenter (1998) demonstrated that acoustic heating mechanisms, i.e. non-magnetic, are not able to produce the chromospheric heating necessary to explain the observed UV flux.

The UV emission of AGB stars is highly variable, and to date only Mira-type variables have been analysed in detail (Fox, Wood & Dopita 1984; Johnson & Luttermoser 1987; Wood & Karovska 2000; Montez et al. 2017), whereas a significant fraction of AGB stars are irregulars or small-amplitude pulsators. The slope of the near-UV continuum of AGB stars between 3000 and 3200 Å and the intensity of the Mg II λ2800 doublet has been recently analysed by Ortiz, Guerrero & Costa (2019): three non-regularly pulsating stars (BD Cam, TW Hor, and TX Psc) shows the F_{3200}/F_{3000} flux ratio to be anticorrelated with the intensity of the Mg II λ2800 doublet, whereas the Mira *o* Cet shows additionally that the minimum of the F_{3200}/F_{3000} flux ratio occurs approximately at the same phase as the intensity of the Mg II λ2800 doublet peaks.

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