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Ultraviolet emission from main-sequence companions of AGB stars

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ABSTRACT

Although the majority of known binary asymptotic giant branch (AGB) stars are symbiotic systems (i.e. with a white dwarf as a secondary star), main-sequence companions of AGB stars can be more numerous, even though they are more difficult to find because the primary high luminosity hampers the detection of the companion at visual wavelengths. However, in the ultraviolet the flux emitted by a secondary with $T_{\rm eff} > 5500 \sim 6000$ K may prevail over that of the primary, and then it can be used to search for candidates to binary AGB stars. In this work, theoretical atmosphere models are used to calculate the UV excess in the *GALEX* near- and far-UV bands due to a main-sequence companion. After analysing a sample of confirmed binary AGB stars, we propose as a criterium for binarity: (1) the detection of the AGB star in the *GALEX* far-UV band and/or (2) a *GALEX* near-UV observed-to-predicted flux ratio >20. These criteria have been applied to a volume-limited sample of AGB stars within 500 pc of the Sun; 34 out of the sample of 58 AGB stars (~60 per cent) fulfill them, implying to have a main-sequence companion of spectral type earlier than K0. The excess in the *GALEX* near- and far-UV bands cannot be attributed to a single temperature companion star, thus suggesting that the UV emission of the secondary might be absorbed by the extended atmosphere and circumstellar envelope of the primary or that UV emission is produced in accretion flows.

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

1 INTRODUCTION

Binarity has long been suggested as a mechanism to shape bipolar planetary nebulae (PNe) (e.g. Corradi & Schwarz 1993; Soker 1998). Observations have confirmed that a significant number of PNe indeed have binary central stars (De Marco et al. 2013). Since binarity precedes the formation of the PN, it is paramount to detect it along previous phases of stellar evolution before the PN formation, particularly at the asymptotic giant branch (AGB) phase. An unbiased comparison among the binarity occurrence rates during the main sequence, AGB and PN phases can help to reinforce a causality relationship between binarity and the formation of aspherical PNe and to assess the evolution of binary systems (e.g. Ivanova et al. 2013; Staff et al. 2016)

Binary or multiple systems including AGB stars have been often observed as symbiotic systems. They are identified by their spectra, which includes features characteristic of the red giant as well as emission lines arising from the wind-driven atmosphere of the giant, which is ionized by the UV photons of the secondary white dwarf (WD). The latest catalogue of symbiotic systems contains about 200 objects, including confirmed and suspected objects (Belczynski et al. 2000).

The discovery of hot companions of AGB stars is somewhat straightforward where they compose symbiotic systems, but the detection of low- and intermediate-mass main-sequence (hereafter MS) companions is not simple. The detection of the secondary in direct images is difficult because the high brightness contrast between them hampers the detection of the secondary, except in the cases where the components are well resolved (Karovska, Nisenson & Beletic 1993; Karovska et al. 1997; Prieur et al. 2002). Indeed, the recent advent of new generation adaptive optics systems has allowed the detection of late-type, close companions of AGB stars (Beuzit et al. 2008; Fusco et al. 2014), but this method still remains restricted to a few near objects (Kervella et al. 2015). Other methods to detect binary AGB stars include asymmetries in their circumstellar envelopes (Mayer et al. 2013), proper-motion variations (Pourbaix et al. 2003), and the identification of features attributed to the secondary in the visual spectrum (Castelaz & McCollum 1995; Danilovich et al. 2015).

As a rule, the shorter the wavelength, the higher the relative contribution of the hot component to the spectrum because the flux emitted by an AGB star decreases abruptly beyond ~2800 Å. Therefore, UV space observatories (*FUSE*, *GALEX*, *HST*) have greatly

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