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Three new identifications of extended UV emission around AGB stars

M. A. Guerrero [1]★ and R. Ortiz [2]★
[1] Instituto de Astrofísica de Andalucía (IAA-CSIC), Glorieta de la Astronomía s/n, E-18008 Granada, Spain
[2] Escola de Artes, Ciências e Humanidades, USP, Av. Arlindo Bettio 1000, 03828-000 São Paulo, Brazil

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ABSTRACT

Asymptotic giant branch (AGB) stars experience heavy episodes of mass-loss through a slow stellar wind during the thermal pulse phase that form large, pc-scale structures around them. As the AGB stellar wind interacts with the interstellar medium (ISM), the otherwise isotropic ejecta gets distorted, resulting in asymmetric shapes, bow-shock structures and, in the case of fast motion relative to the surrounding ISM, extended wakes and tails as unexpectedly detected in *GALEX* ultraviolet (UV) images of *o* Cet, also known as Mira. Since that discovery, another fourteen AGB stars have been reported to exhibit extended UV emission around them. Here, we present the discovery of extended UV emission around another three AGB stars, namely R For, R Hor, and DM Tuc. The analysis of the overall properties of the regions of extended UV emission indicates that these are preferentially detected in closer AGB stars far away from the Galactic plane, i.e. sources less extincted. Faster AGB stars tend to have more elongated shapes, with bow-shocks and wakes or tails of material, while AGB stars farther away from the Galactic plane tend to be surrounded by larger regions of UV emission.

Key words: stars: AGB and post-AGB – *(stars:)* circumstellar matter – stars: mass-loss – ISM: bubbles – ultraviolet: ISM.

1 INTRODUCTION

Asymptotic giant branch (AGB) stars are the progeny of low- and intermediate-mass stars (0.8–1.0 $M_\odot$ to 8–10 $M_\odot$), before their short transit through the planetary nebula (PN) stage and their final evolution into white dwarf stars. AGB stars contribute significantly to the enrichment of the interstellar medium (ISM) through their massive and slow stellar winds. The heavy mass-loss can be modulated by different processes (thermal pulses, binary evolution, etc.), resulting in discrete episodes of enhanced mass-loss.

Observational evidence of the AGB ejecta has been provided by the detection of detached shells in CO radio line emission observations (Olofsson et al. 1996), infrared (IR) thermal dust emission in extended circumstellar regions or detached shells (van der Veen & Habing 1988), and even at optical wavelengths (González-Delgado et al. 2001). Spiral-like patterns have also been found around AGB stars (Mauron & Huggins 2006; Lykou et al. 2018; Doan et al. 2020), which are generally attributed to the modulation of the AGB mass-loss by a companion star (Mastrodemos & Morris 1999; Kim, Liu & Taam 2019).

A bit as a surprise, *GALEX*, the *Galaxy Evolution Explorer*, detected ultraviolet (UV) emission from a remarkable bow-shock feature and a 2° long tail associated with *o* Cet, a.k.a. Mira (Martin et al. 2007). These structures certainly result of the interaction of the stellar wind of this fast moving star with the local ISM, with the UV emission attributed to the excitation of molecular hydrogen by the turbulent mixing of cool molecular and shock-heated material. Since then, extended UV emission has been found around another fourteen AGB stars,[1] namely IRC+10216, CIT 6, U Hya, and R Dor (Sahai & Chronopoulos 2010; Sahai & Mack-Crane 2014; Sanchez et al. 2015; Ortiz & Guerrero 2023), and another ten recently reported by Sahai & Stenger (2023) (see Table 1).

The morphology of these UV structures generally supports the interaction of the AGB stellar wind with the surrounding ISM, as the bow-shock feature and trailing wake of material of IRC+10216. It is remarkable the 'jellyfish' appearance of some sources (e.g. EY Hya) with a 'bell-shaped head' and 'trailing tentacles'. On the other hand, there are cases of roundish hollow shell (bubble) morphology (e.g. U Hya and R Dor) that rather imply that this wind-ISM interaction is not present or a face-on orientation of the bow-shock. Sahai & Stenger (2023) associated more asymmetric shapes and one-sided brightness enhancements with the increasing relative velocity of the stellar wind of an AGB star moving through the ISM, identifying cases of wind–wind (w–w) interaction resulting in a symmetrical morphology, and mild (w-ISM) and strong (b-s, for bow-shock) interactions between the stellar wind and the ISM as their relative volcity increases resulting in asymmetric morphology and bow-shock structures. These follow the expectations of hydro-dynamical 2D (Villaver, García-Segura & Manchado 2003) and 3D (Wareing, Zijlstra & O'Brien 2007) simulations of the interaction of the wind of a moving AGB star with the ISM.

The spatial distribution of this UV emission can be compared to the varying morphology of the far-IR emission around AGB stars produced by thermal dust detected by Cox et al. (2012) using

[1] The point-sources of UV emission associated with a number of AGB stars (e.g. Ortiz & Guerrero 2016, and references therein) are not considered here.

★ E-mail: mar@iaa.es (MG); rortiz@usp.br (RO)