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Article

Understanding High-Energy (UV and X-ray) Emission from AGB Stars—Episodic Accretion in Binary Systems

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Abstract: X-ray surveys of UV-emitting AGB stars show that ∼40% of objects with FUV emission and GALEX FUV/NUV flux ratio $R_{fuv/nuv} \gtrsim 0.2$ (fuvAGB stars) have variable X-ray emission characterized by very high temperatures (Tx∼35–160 MK) and luminosities (Lx∼0.002–0.2 $L_{\odot}$), indicating the presence of accretion associated with a close binary companion. However, the UV-emitting AGB star population is dominated by objects with $R_{fuv/nuv} \lesssim 0.06$ (nuvAGB stars), and we do not know whether the UV emission from these is intrinsic to the AGB star or extrinsic (i.e., due to binarity). In order to help distinguish between intrinsic and extrinsic models of the puzzling high-energy emission of cool AGB stars, we report results from two studies—(i) XMM-Newton X-observations of two nuvAGB stars, and (ii) simple chromosphere modeling. In study (i), we detect the one which has the lower FUV/NUV ratio, with a total Lx = 0.00027 $L_{\odot}$, and a spectrum best fitted with a dominant component at Tx∼10 MK, most likely coronal emission from a main-sequence companion. Therefore, a significant fraction of nuvAGB stars may also be binaries with active, but weak accretion. Study (ii) shows that chromospheres with temperatures of ∼10,000 K can produce $R_{fuv/nuv} \lesssim 0.06$; higher ratios require hotter gas, implying active accretion.

Keywords: circumstellar matter; binaries (including multiple): close; stars: evolution; stars: AGB and post-AGB; stars: mass loss; wavelengths: UV; X-ray

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1. Introduction

Stars in the 1–8 $M_{\odot}$ range expel half or more of their masses at rates up to $\sim 10^{-4}$ $M_{\odot}$ yr^{-1} (e.g., Decin 2021 [1], Olofsson 2008 [2]), as they evolve from the asymptotic giant branch (AGB) to the preplanetary nebula (PPN) and planetary nebula (PN) evolutionary phases. This mass loss dramatically alters the course of stellar evolution, enriches the interstellar medium (ISM) with nucleosynthetically enriched material and thus plays a key role in the chemical evolution of galaxies. AGB stars also eject copious quantities of dust grains into the ISM, which are crucial ingredients for the birth of new Sun-like stars and solar systems. Young PNe (YPNe) represent the bright end-stages of these stars and provide valuable diagnostics on their demise. However, YPNe formation and the phase of extreme mass loss at the end of the AGB phase is very poorly understood—although the mass ejection in the latter is generally spherical, producing extended circumstellar envelopes (CSEs) expanding at speeds of 10–20 km s^{-1}, all observed PPNe and most YPNe are observed to have bipolar, multipolar or elliptical shapes (e.g., Sahai and Trauger 1998 [3] [ST98], Sahai et al. 2007 [4], Sahai et al. 2011 [5] [SMV11]). Collimated high-speed outflows ($\gtrsim$(50–100) km s^{-1}) are ubiquitous during the PPN phase (Bujarrabal et al. 2001 [6]).

Morphologically unbiased HST imaging surveys have observationally bracketed the evolutionary phases that cover the transition from the spherical to aspherical morphology.