A&A, 693, A203 (2025)
https://doi.org/10.1051/0004-6361/202451715

Astronomy & Astrophysics

Y Gem, a symbiotic star outshone by its asymptotic giant branch primary component

M. A. Guerrero[1,⋆], D. A. Vasquez-Torres[2], J. B. Rodríguez-González[2], J. A. Toalá[2,⋆⋆], and R. Ortiz[3]

[1] Instituto de Astrofísica de Andalucía, IAA-CSIC, Glorieta de la Astronomía S/N, Granada 18008, Spain
[2] Instituto de Radioastronomía y Astrofísica, Universidad Nacional Autónoma de México, Morelia, Michoacán, Mexico
[3] Escola de Artes, Ciências e Humanidades, USP, Av. Arlindo Bettio 1000, 03828-000 São Paulo, Brazil

Received 30 July 2024 / Accepted 21 November 2024

ABSTRACT

Context. A considerable number of asymptotic giant branch (AGB) stars exhibit UV excess and/or X-ray emission that indicates a binary companion. AGB stars are so bright that they easily outshine their companions. This almost prevents their identification. Y Gem has been known for some decades to be an AGB star that is bright in the far-UV and X-rays, but it is unclear whether its companion is a main-sequence star or a white dwarf (WD) in a symbiotic system (SySt).
Aims. Our goal is to uncover the true nature of Y Gem, which will help us to study the possible misidentified population of SySts.
Methods. Multiwavelength IR, optical, UV, and X-ray observations were analyzed to investigate the properties of the stellar components and the accretion process in Y Gem. In particular, an optical spectrum of Y Gem is presented here for the first time, while X-ray data are interpreted by means of reflection models produced by an accretion disk and material in its vicinity.
Results. The optical spectrum exhibits the typical sawtooth-shaped features of molecular absorptions in addition to narrow recombination and forbidden emission lines. The emission lines and the analysis of the extinction-corrected UV spectrum suggest a hot component with $T_{\rm eff} \approx 60\,000$ K, $L = 140\,{\rm L}_\odot$, and $R = 0.11\,{\rm R}_\odot$ that very likely is an accreting WD. The late component is found to be an $1.1\,{\rm M}_\odot$ AGB star with $T_{\rm eff} = 3350$ K and $R = 240\,{\rm R}_\odot$.
Conclusions. Using IR, optical, UV, and X-ray data, we found that Y Gem is an S-type SySt whose compact component is accreting at an estimated mass-accretion rate of $\dot{M}_{\rm acc} = 2.3 \times 10^{-7}\,{\rm M}_\odot\,{\rm yr}^{-1}$. At this accretion rate, the accreting WD has reached the stable and steady burning phase in which no recurrent events are expected.

Key words. stars: AGB and post-AGB – binaries: symbiotic – ultraviolet: stars – X-rays: binaries

1. Introduction

Planetary nebulae (PNe), the short-lived descendants of low- and intermediate-mass stars after the asymptotic giant branch (AGB), exhibit a high occurrence of axisymmetric morphologies, with bipolar, highly collimated, and point-symmetric shapes (Frew & Parker 2010). The axisymmetric morphology of PNe would be naturally explained by the influence of a companion star during the late AGB phase (Balick & Frank 2002; Jones & Boffin 2017). Searches for companions of central stars of PNe (CSPNe) are difficult, but have resulted in a growing sample of binary CSPNe (Miszalski et al. 2009; De Marco et al. 2013; Jacoby et al. 2021).

The search for the stellar companions that shape PNe might also be carried out among their precursor AGB stars. These are expected to be UV faint (Sahai et al. 2008) and X-ray quiet as they cannot support a corona (Linsky & Haisch 1979). Therefore, the detection of UV excess and/or X-ray emission was proposed to be evidence of binarity. In particular, Ortiz & Guerrero (2016) and Sahai et al. (2022) proposed that AGB stars with a far-UV counterpart, (the so-called fuvAGB stars), high near-UV excess (i.e., $Q_{\rm NUV} > 20$, which is the observed-to-predicted near-UV flux ratio), or $F_{\rm FUV}/F_{\rm NUV} > 0.06$ were most likely in a binary system. Similarly, AGB stars with X-ray counterparts (the so-called X-AGB stars) in excess of a few times $10^{29}\,{\rm erg\,s}^{-1}$ (Soker & Kastner 2003; Sahai et al. 2015; Ortiz & Guerrero 2021) are most likely members of binary systems. So far, about 40 fuvAGB stars (Sahai et al. 2008; Ortiz & Guerrero 2016) and 50 X-AGB stars (Guerrero et al. 2024, and references therein) are known.

One of the most astounding far-UV and X-ray AGB star is Y Gem, a semi-regular SRb variable with a visual magnitude between 10.4 and 12.3 within a period of 160 d (Samus' et al. 2017). The detection of strong far-UV emission (Sahai et al. 2008) was soon followed by the discovery of variable UV and strong and variable X-ray emission (Sahai et al. 2011, 2015; Ortiz & Guerrero 2021) that was attributed to accretion onto a companion star or to an accretion disk around it. The flickering of its UV continuum on timescales <20 s strongly supports the presence of an active accretion disk around a companion star, whereas high-velocity absorption and emission components arise from a fast outflow and infalling material from the giant onto the disk (Sahai et al. 2018).

The nature of the companion star of Y Gem, however, is disputed. Sahai et al. (2018) favored a main-sequence companion based on the amount of its UV excess, the relatively low-outflow velocity, and the lack of narrow-band optical emission lines typical of symbiotic stars (SySts), such as H I, He II, and [O III] (see also Sahai et al. 2011). The X-ray and UV properties of Y Gem were also used to suggest that Y Gem is actually an SySt (Yu et al. 2022), in which a WD in a wide binary orbit accretes material from a cool giant companion, an AGB star in this particular case, in the wind Roche-lobe overflow scenario.

⋆ Corresponding author; mar@iaa.es
⋆⋆ Visiting astronomer at the IAA-CSIC as part of the Centro de Excelencia Severo Ochoa Visiting-Incoming programme.