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Infrared cavity surrounding T Pyxidis: evidence of a nova super-remnant?

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ABSTRACT

Nova super-remnants (NSR) are shell-like structures spanning tens of parsecs that are predicted to grow around all recurrent novae as a result of repeated ejecta sweeping up the surrounding material. After the first NSR was discovered in the Andromeda Galaxy around M31N 2008-12a, a number of Galactic NSRs have been uncovered, as has the first NSR in the Large Magellanic Cloud. Here we report an apparent infrared cavity surrounding the Galactic recurrent nova, T Pyxidis, which we suggest may be a nova super-remnant and discuss the implications.

Keywords: Recurrent novae (1366) – Stellar remnants (1627) – Interstellar medium (847)

1. INTRODUCTION

Nova super-remnants (NSRs) are substantial shells made up almost exclusively of interstellar medium (ISM) swept up by recurrent nova (RN) eruptions over millenia (Healy-Kalesh 2024). The prediction that NSRs should exist around all RNe (Healy-Kalesh et al. 2023) is now being validated: the prototype NSR associated with the Andromeda Galaxy RN M31N 2008-12a (Darnley et al. 2019) has been joined by NSRs hosted by the Galactic RNe KT Eridani (Shara et al. 2024a), T Coronae Borealis (Shara et al. 2024b), RS Ophiuchi (Shara et al. 2025) and V745 Scorpii (Healy-Kalesh et al. submitted), as well as the Large Magellanic Cloud RN, LMCN 1971-08a (Healy-Kalesh et al. 2025).

2. NOVA SUPER-REMNANT AROUND T PYXIDIS

T Pyxidis is one of the eleven known Galactic RNe (Darnley 2021; Shara et al. 2024a), with eruptions recorded in 1890, 1902, 1920, 1944, 1967, and 2011 (Darnley 2021). Such relatively quick-fire eruptions result from a combination of its high mass white dwarf ($\sim 1.33 M_{\odot}$; Schaefer 2026) and high accretion rate ($\sim 10^{-7} M_{\odot} \text{yr}^{-1}$; Schaefer 2026). Though, T Pyx is unusual in comparison to many other RNe on account of its short orbital period (1.83 hr; Patterson et al. 1998) and is unique as being the only RN hosting a persistent nova shell (Shara et al. 2015).

Schaefer (2026) proposed that the current RN cycle of T Pyx was triggered with a classical nova eruption in ~ 1866 and likely ended with the 2011 eruption, and that the nova will now enter a $\sim 13,000$ yr phase of quiescence. Orbital period variations across multiple eruptions may indicate that the T Pyx white dwarf (WD) is decreasing in mass (Schaefer 2026). Yet modelling of NSRs (Healy-Kalesh et al. 2023) indicates that neither of these properties of T Pyx would prevent the creation of an NSR.

3. INFRARED DATA OF T PYXIDIS SURROUNDINGS

Based on a suite of NSR simulations provided in Healy-Kalesh et al. (2023), it is predicted that (i) novae with high accretion rates similar to T Pyx ($\sim 10^{-7} M_{\odot} \text{yr}^{-1}$) are favourable for growing NSRs, with sizes ranging 20 – 200 pc; (ii) systems with eroding WDs can also grow NSRs (this effect was illustrated with a lower accretion rate); and (iii) systems with recurrence periods of ~ 3000 yr and $\sim 49,000$ yr are still capable of growing vast NSRs. Therefore, we predict that an NSR *could* be created by T Pyx and, if so, would have a size of the same order of magnitude as the NSRs around other Galactic RNe (~ 30 – 200 pc). In addition, previous searches for evidence of an NSR being present around other Galactic RNe (Healy-Kalesh et al. 2024a, Healy-Kalesh et al. submitted) were conducted using the new generation *Infrared Astronomical Satellite* (IRAS) catalogue, known as IRIS (Miville-Deschênes & Lagache 2005).

With the predicted approximate size and the success of previously identifying possible NSRs in IRIS data, we inspected the extended surroundings ($5^{\circ} \times 5^{\circ}$ FOV) of T Pyx within IRIS 60 μm imaging and identified a large cavity coincidentally aligned with the nova, with T Pyx centrally located, as shown in the left panel of Figure 1.

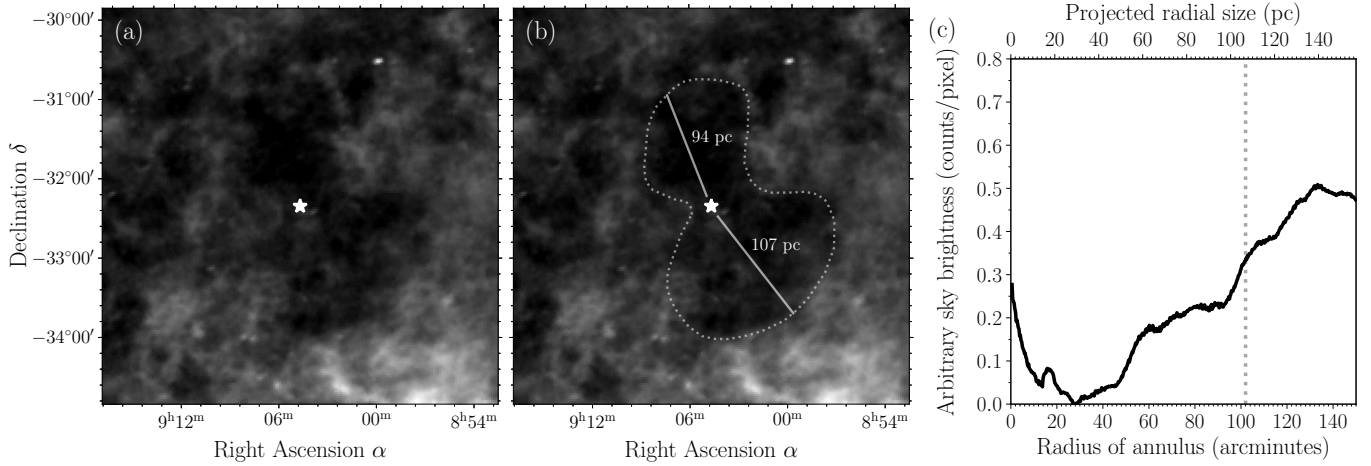


Figure 1. Panel (a) – $5^\circ \times 5^\circ$ IRIS $60\ \mu\text{m}$ far-infrared image of the surroundings of T Pyxidis, with the nova’s location indicated with a white star. Panel (b) – Same as panel (a) but with a boundary of the apparent cavity outlined with a dashed line for guidance. Panel (c) – Arbitrary surface brightness radial profile of the surroundings of T Pyxidis from annular photometry (see text). The largest extent of the apparent cavity at 107 pc is indicated with the dashed line.

4. DISCUSSION

The cavity appears to be bilobed (middle panel of Figure 1), with the larger southwest component spanning $\sim 102'$ and the smaller northeast component spanning $\sim 90'$. At the distance of $\sim 3.6\text{ kpc}$ to T Pyx (Schaefer 2026), the southwest and northeast component would have scales of $\sim 107\text{ pc}$ and $\sim 94\text{ pc}$, respectively, thereby conforming to the scale of known NSRs. Such an NSR with a bilobed structure is reminiscent of the NSRs (found through their $\text{H}\alpha$ emission) around T CrB (Shara et al. 2024b) and RS Oph (Shara et al. 2025).

In addition to the visual evidence of a cavity around T Pyx in the IRIS data, we also quantify this lack of emission. Using the method presented in Healy-Kalesh et al. (2024b), we performed annular photometry on the IRIS data by employing 500 circular annuli centred on the location of T Pyx with radii ranging from $0.375 - 150$ arcminutes, with the results provided in the right panel of Figure 1. As expected, this preliminary analysis reveals a general profile consisting of low levels of emission (cavity) bordered by higher levels of emission (surrounding medium). Further, the profile can be separated into varying components attributable to the structure seen in the data: moderately high levels of emission close to the nova ($\lesssim 8\text{ pc}$) before a drop to negligible levels between $\sim 20 - 45\text{ pc}$. The emission then increases at around 60 pc (likely due to the influence of the ‘pinched’ part of the cavity) before another substantial increase at around 100 pc , coinciding with the approximate edges of the two lobes.

We also note that the same cavity feature has been previously independently identified in van Loon (2008), though a much smaller diameter of $2'$ is specified. In this work, it was proposed that this cavity may have formed more than 10^4 years ago and “possibly built up during successive eruptions” (van Loon 2008). In light of the first NSR being discovered in M 31 in 2015 (Darnley et al. 2015, 2019) and subsequent development of both the theoretical and observational study of this phenomena, we corroborate the suggestion that the cavity seen around T Pyx was likely created through the excavation of local ISM by repeated nova eruptions in the form of an NSR, though we would suggest a longer evolutionary history based on studies of other NSRs (Healy-Kalesh et al. 2024c; Shara et al. 2024b, 2025).

With the existence of an infrared cavity revealing the location and extent of the possible NSR surrounding T Pyx, it would be fruitful to search the extended environs (up to $\sim 100'$) of the RN in other wavebands, particularly with a narrowband $\text{H}\alpha$ filter as NSRs have been shown to emit strongest in $\text{H}\alpha$ (Darnley et al. 2019; Shara et al. 2024a,b, 2025; Healy-Kalesh et al. 2025), to confirm the presence of an NSR around T Pyx. Furthermore, the implications of an existing NSR possibly cast doubt on the long-term past and future behaviour of T Pyx and suggest that (perhaps) it behaves more like the ‘typical’ RNe that has previously been proposed.

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