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# Optical Depth Constraints on the Supernova Impostors SN 1954J and SN 1961V

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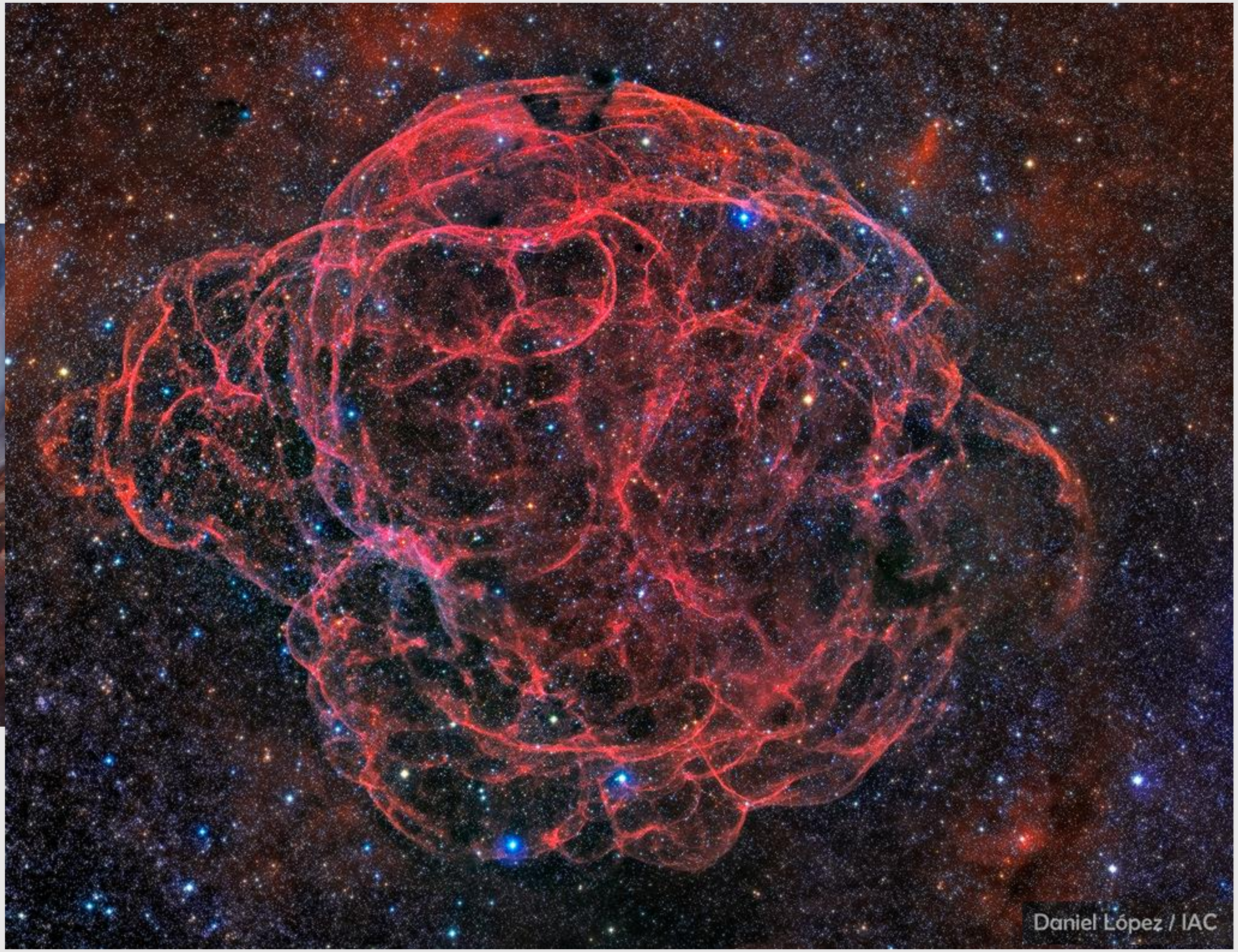
Midwest Workshop on Supernovae and Transients
26 February 2019

Image: NASA APOD

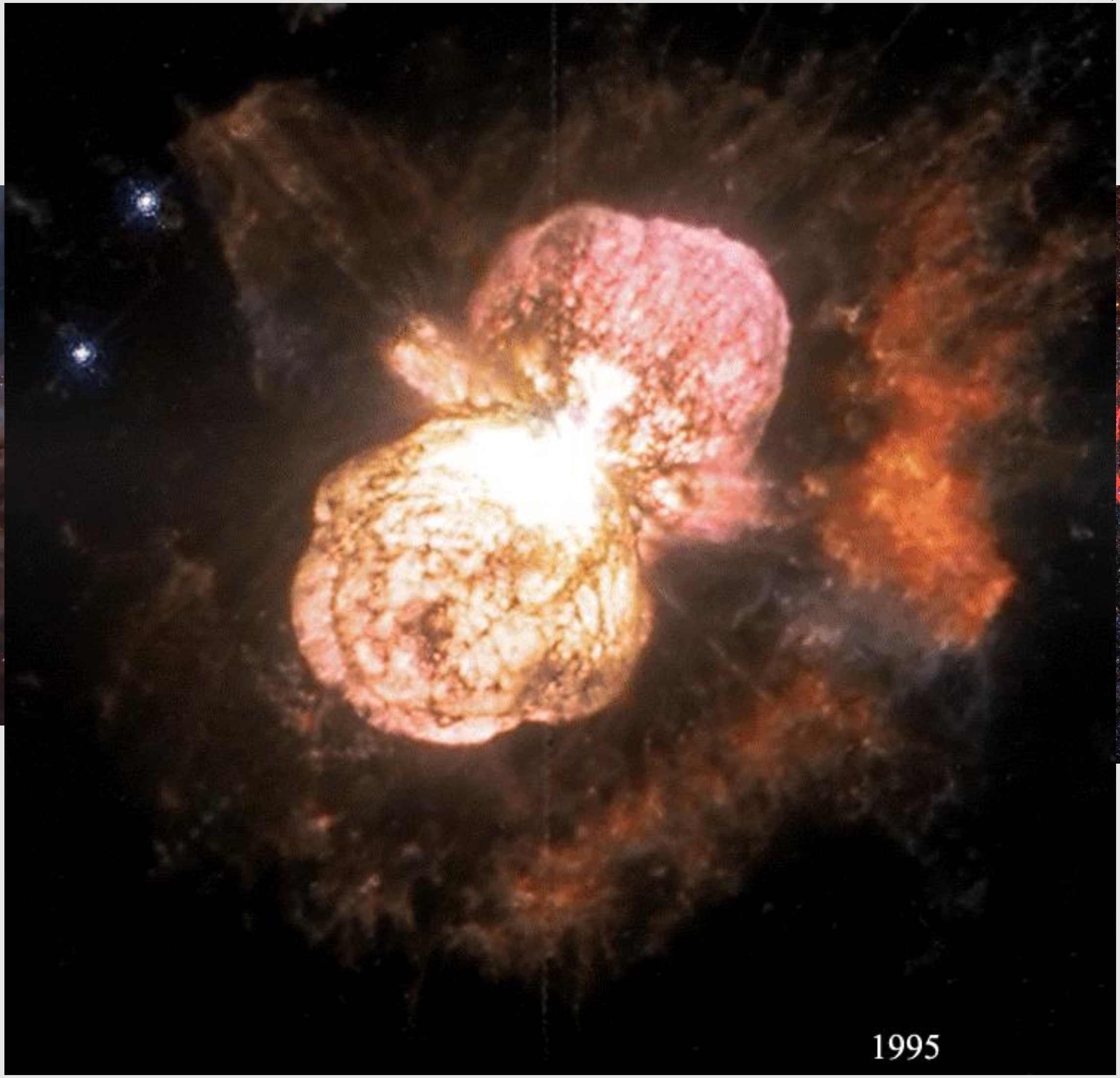


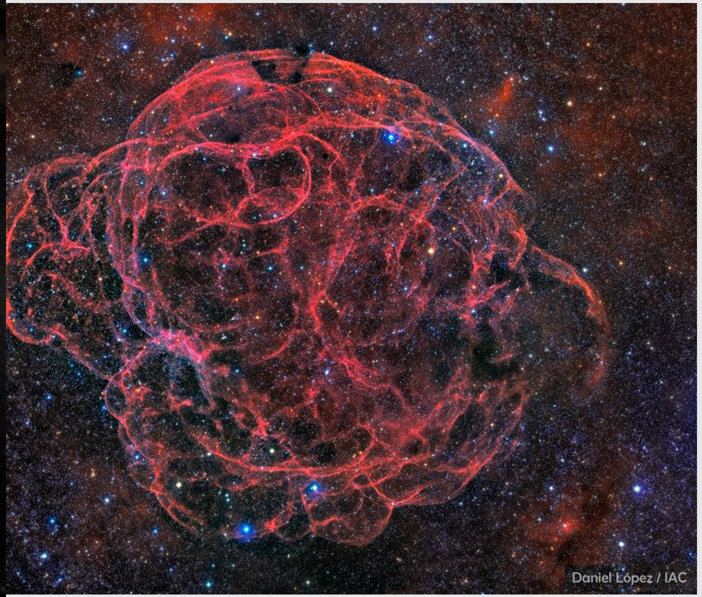

Images: NASA APOD

3-10 million years

Birth

Death




Images: NASA APOD

# Supernova Impostors: What are they and why do we care?

High energy eruptions are not cleanly separated from low energy core collapse supernovae.

Driving mechanism: unknown

There are no clear trends among the known impostors.

**Correctly identifying the impostors is critical to understanding the eruption mechanism.**

| Supernova Impostors |
| --- |
| Eta Carinae |
| **SN 1954J** |
| **SN 1961V** |
| SN 1997bs |
| SN 1999bw |
| SN 2000ch |
| SN 2001ac |
| SN 2002bu |
| SN 2002kg |
| SN 2003gm |
| SN 2008S |
| NGC 300-OT |

Kochanek+ 2012

# Probes of Dust Optical Depth: SED fits

- 4 HST filters: 2 optical, 2 NIR
- Corrections for distance and Galactic extinction
- 2 model fits: DUSTY, simple MCMC

$$\chi^2 = \sum_i \frac{(\log \mathrm{L_i} - \log \mathrm{L_i^{mod}} + 0.4 R_\lambda\, \mathrm{E(B-V)})^2}{\sigma^2}$$

- Reports best fit L, T, E(B-V)

**Not sensitive to:** gray dust, cool dust

# Probes of Dust Optical Depth: Photometric Variability

- Compare new and archival photometric data (10-20 year baseline)

- Ejecta expansion places limits on the dust optical depth

$$\frac{L_{obs}(t_1) - L_{obs}(t_0)}{L_{obs}(t_0)} = e^{\tau_0(1-(t_0/t_1)^2)} - 1$$

**Sensitive to:** all types of dust, independent of composition

**Not sensitive to:** continuous outflows

# Probes of Dust Optical Depth: Hα Luminosity

- Assumes photoionized ejecta mixed with dust

$$L_{H\alpha} = \frac{M^2 \alpha_{H\alpha} E_{H\alpha}}{4\pi \Delta R^3 m_p^2}$$

$$\tau = \frac{M\kappa}{4\pi R^2}$$

$$\tau = 0.07\, \kappa_2 t_{50}^{-1/2} v_3^{-1/2} L_{36}^{1/2} \Delta_{0.1}^{1/2}$$

**Sensitive to:** continuous outflows, all types of dust

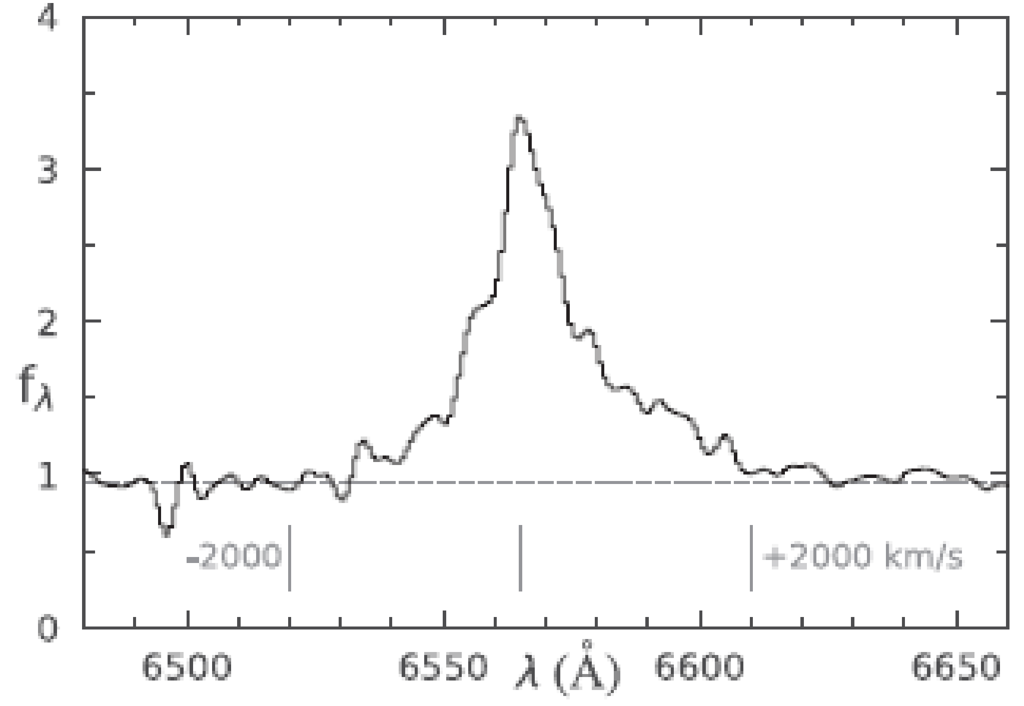
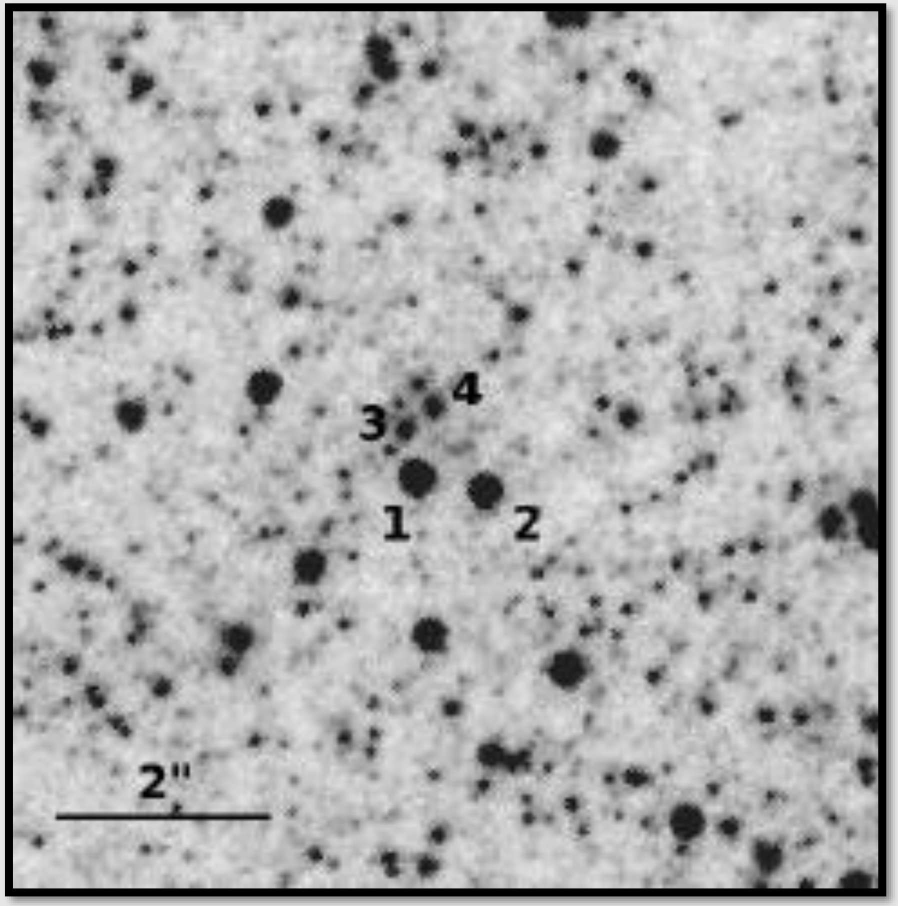



**Figure 7.** Flux calibrated Hα profile of V12 in 2017 January. The units for $f_\lambda$ are $10^{-17}$ erg $cm^{-2}$ $s^{-1}$ $A^{-1}$.

Figure 7 from Humphreys+ 17

# SN 1954J in NGC 2403




Star 4 preferred candidate survivor due to Hα emission

# SN 1954J in NGC 2403

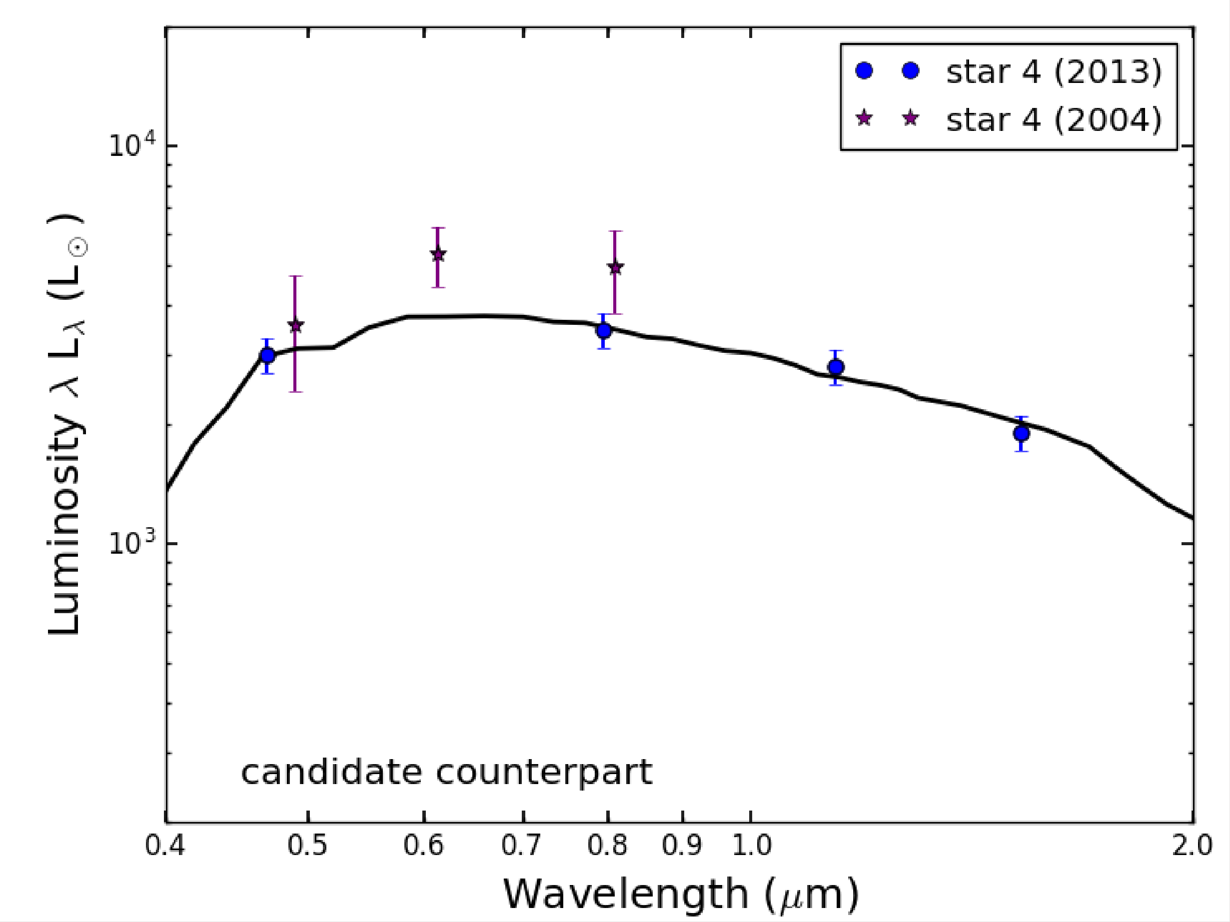
The post-eruption light curve is a full magnitude fainter than pre-eruption

Hα line has asymmetric wings consistent with a dense outflow (Humphreys+ 17)

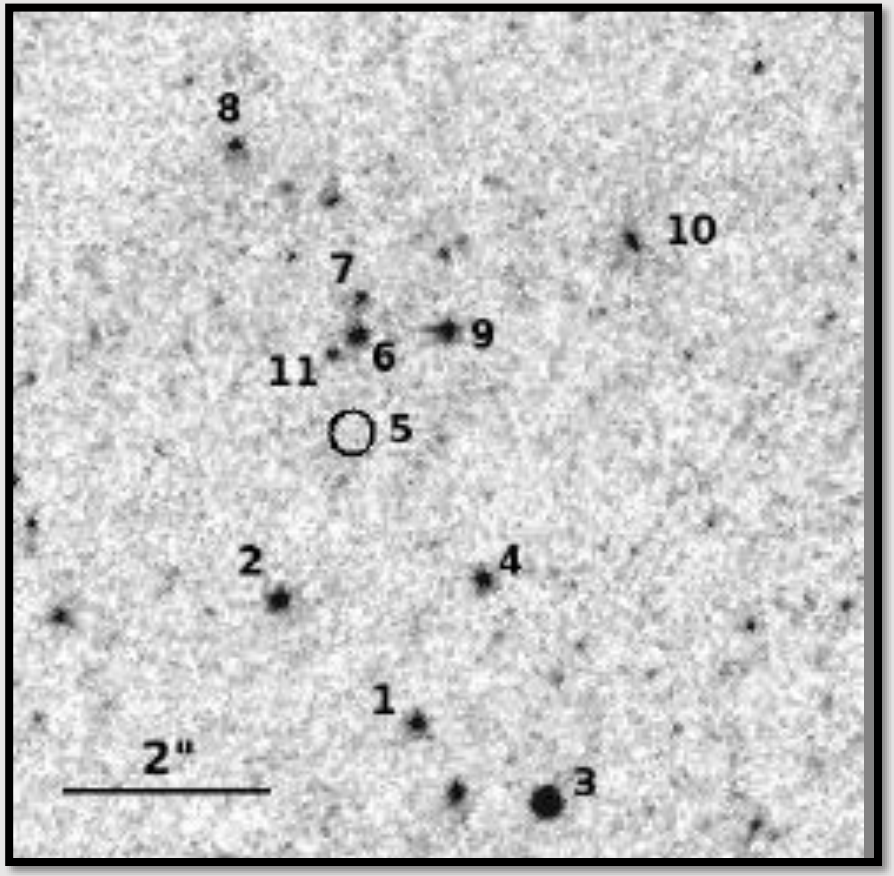
SED fits prefer 5000 – 6000 K star with log L = 3.7-4

From photometric variability: $\tau < 0.60$

From Hα luminosity: $\tau < 0.07$



# SN 1961V in NGC 1058




Star 7 preferred candidate due to Hα emission and proximity to SN location

# SN 1961V in NGC 1058

Contaminated IR data prevents SED modeling

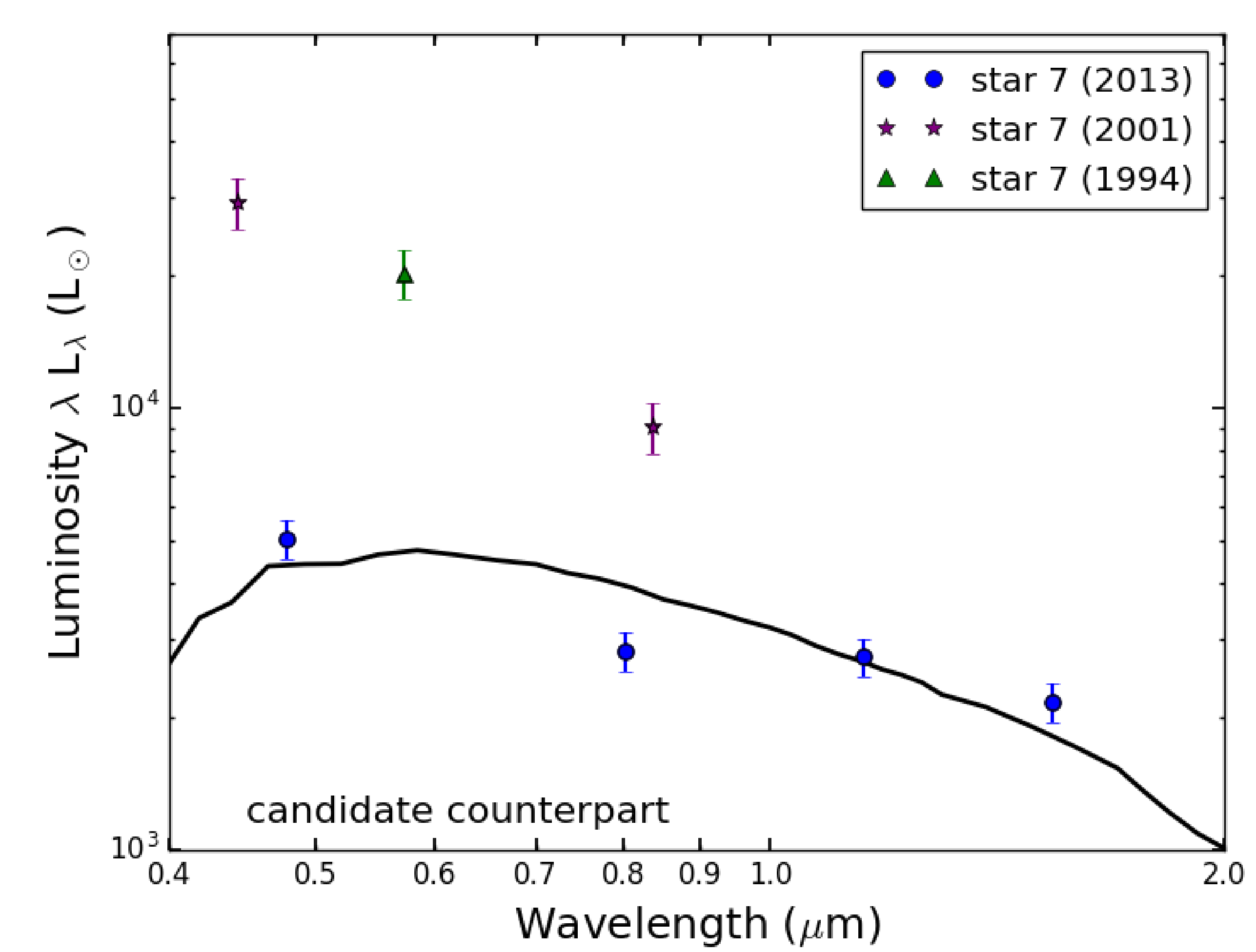
Star 7 cannot regain progenitor luminosity

1.7 mag of fading since 1994

- requires change in $\tau$ of 1.74

From photometric variability: $\tau < 1.02$

From Hα luminosity: $\tau < 0.19$



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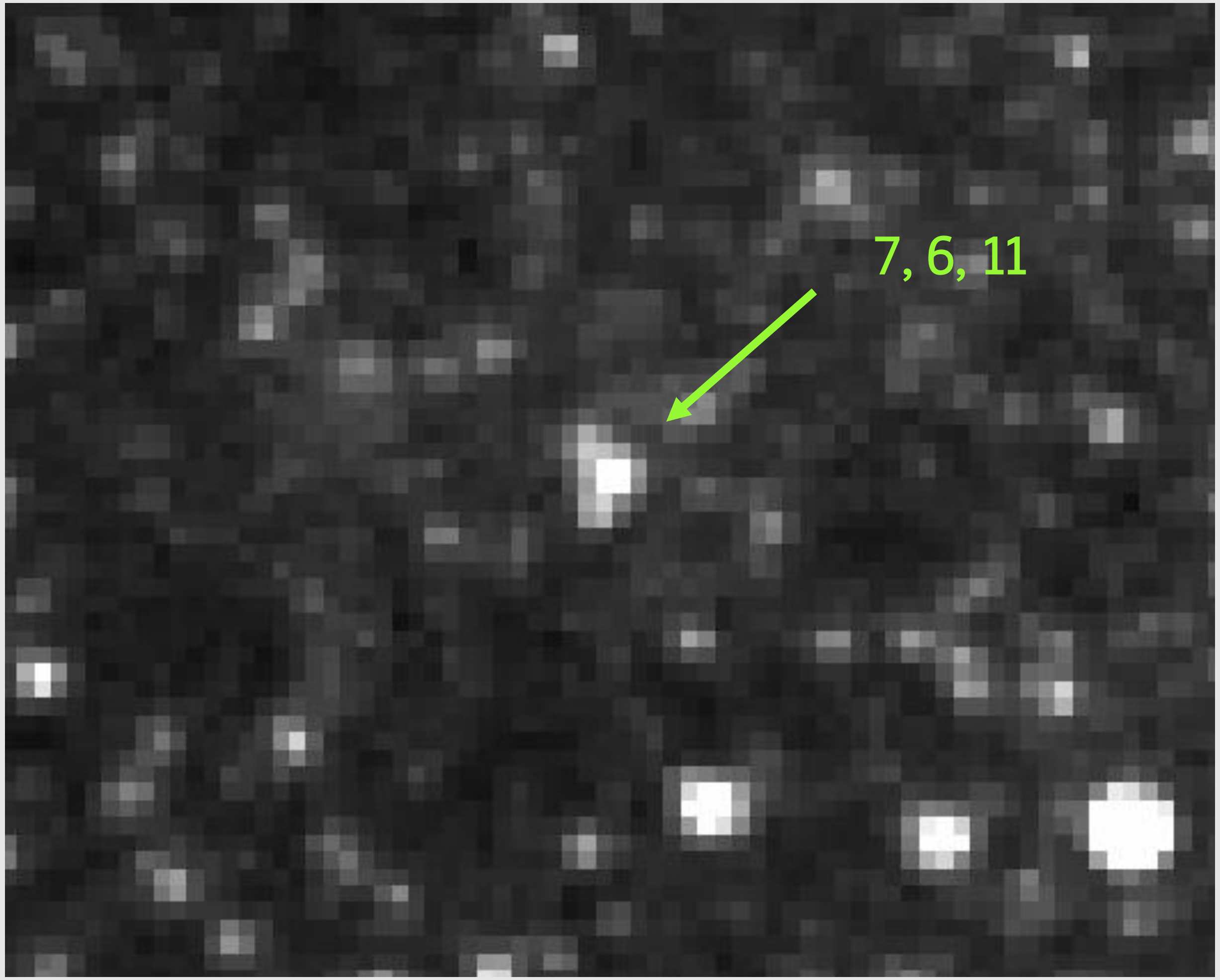

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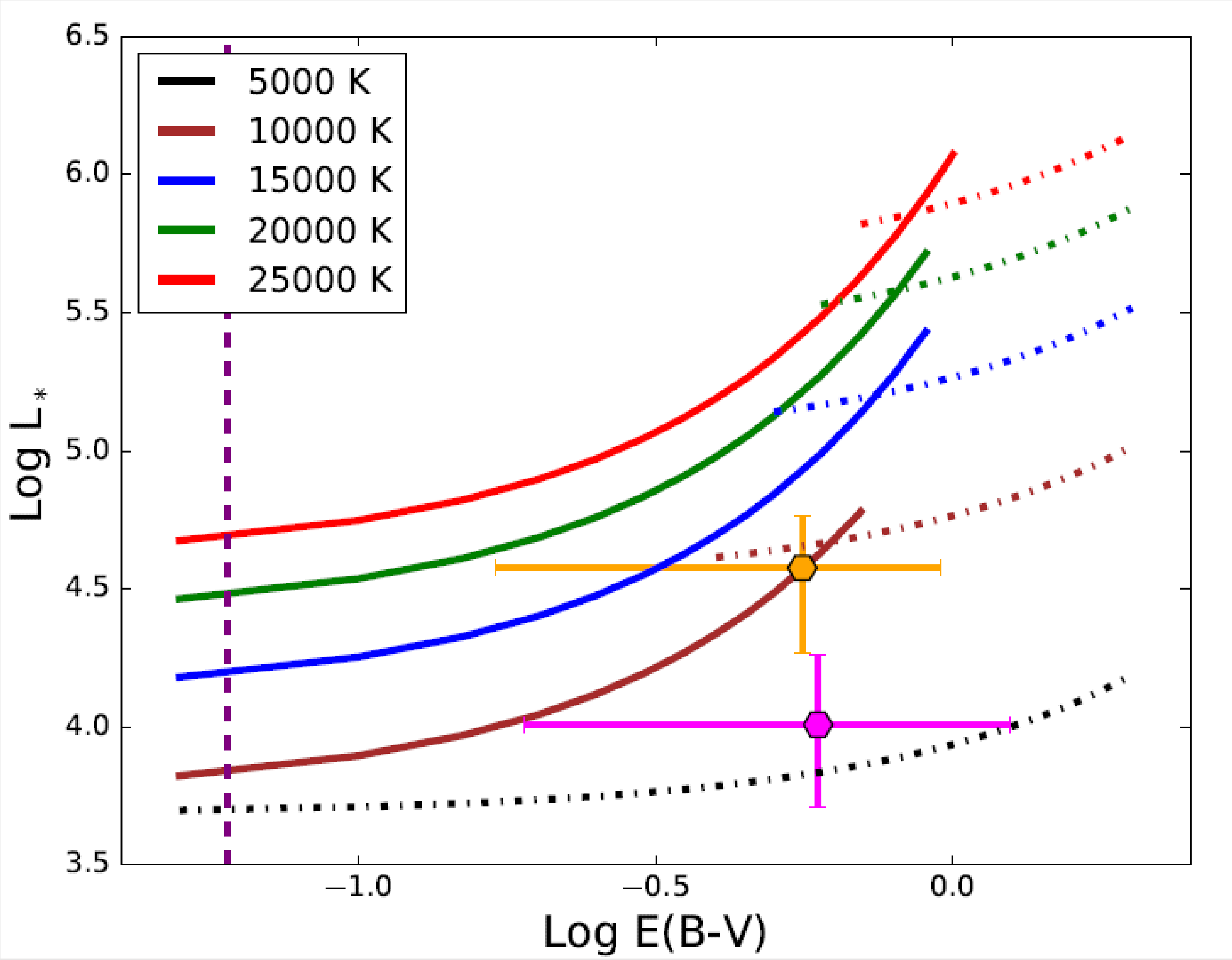

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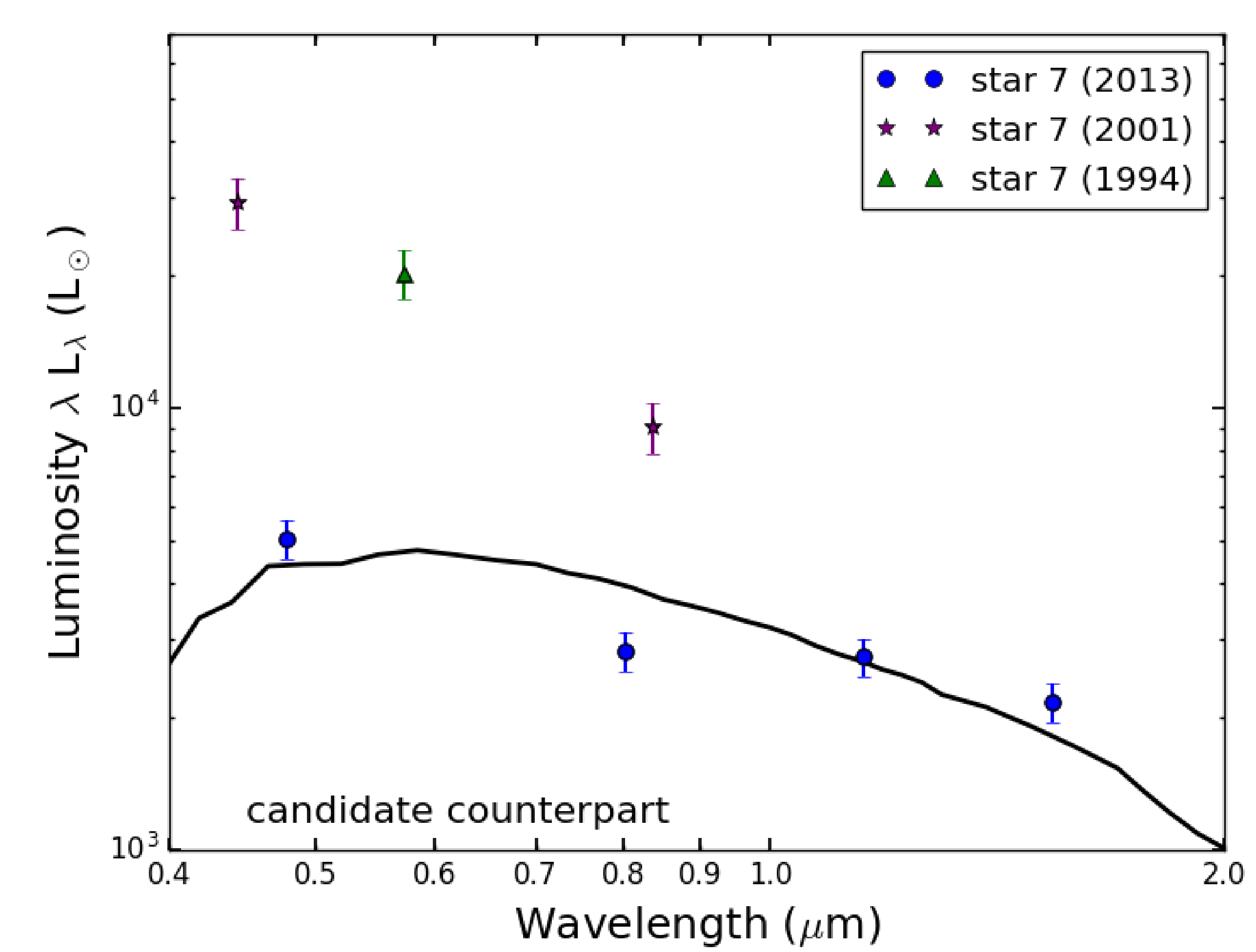

# Summary

Correctly separating the impostors from the true supernovae is critical for understanding massive stellar eruptions.

All probes of both SN 1954J and SN 1961V find little dust optical depth.

**For 1954J:** Hard to reconcile with spectra and light curve

Most likely scenarios: SN 1954J and SN 1961V were true supernovae or the survivors were misidentified

See arXiv:1811.06991 for full paper