Five Extragalactic Candidate $\eta$ Carinae Analogs

Rubab Khan

JWST Fellow
NASA Goddard Space Flight Center

“From Stars to Massive Stars”, Gainesville, FL
April 9, 2016
Unknown

Cause?
One-off?
Evolution?

Binary merger?
Binary interaction?
Single star evolution?
HST image (Morse et. al. 1998)

Low optical, near-IR luminosity
HST image (Morse et al. 1998)

Low optical, near-IR luminosity

Rising in mid-IR

$\lambda_A(L_\odot)$

$\lambda(\mu m)$

Low optical, near-IR luminosity

$\eta$ Car
HST image (Morse et. al. 1998)

Low optical, near-IR luminosity

Rising in mid-IR

Turn over: warm dust

Low optical, near-IR luminosity
First Search: 7 Galaxies, 1-4 Mpc

- NGC6822, M33, NGC300, M81, NGC2403, NGC247, NGC7793
- SFR = ~2 M$_{\odot}$/year
- No η Car analogs found
- Identified a class of dusty stars analogous to IRC+10420
- $L_{\text{bol}} = 10^{5.5-6.0} L_{\odot}$
- $M_{\text{ZAMS}} = \sim 25 - 60 M_{\odot}$

Khan et. al. (2011, 2013, 2015a)
4 Galaxies at 4-8 Mpc

- M51, M83, M101, NGC6946
- SFR = ~7 M☉ / year
- 20 ccSN in past century
- Identified 5 likely η Car analogs
- $L_{\text{bol}} = \sim 3 - 8 \times 10^6$ L☉
- 5-10 M☉ warm (400-600K) ejecta
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Mathematical Equations:

$$M_e = 4\pi R_{\text{in}}^2 \tau_v \left(\kappa_{v100}^{-1}M_\odot\right)$$
Candidate >>> Real (?) Analogs

- Mimics photometric properties:
  - At least one very high mass star in each system
  - Obscured in many solar masses of close warm ejecta
  - Unlikely to be contaminants (QSO, cluster etc.)
Candidate >>> Real (?) Analogs

- But we don't know:
  - What is the stellar temperature? Hot or cool?
  - Post giant eruptions or continuous thick winds?
  - Single or binary?
What's next?

- HST UV and IR imaging
  - \( T_* \approx 50,000 \text{K} \) or \( \sim 7,500 \text{K} \)
  - Dust optical properties
- 'Ideal' targets for JWST
  - MIRI: Dust chemistry
  - NIRSpec: 'cool' star
- Fill the 'gap' (?)?
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SLSN-II Connection?

• Would $\eta$ Car die as a Type II Superluminous Supernova?

• SLSN-II rate is expected to be $\sim0.1\%$ of the ccSN rate

• If $\eta$ Car analogs are detectable for $\sim200$ years, then …

• … the “$\eta$ Car” rate may be $\sim10\%$ of the observed ccSN rate

• Two possible explanations:
  
  – One, $10^3$-$10^4$ years long eruption mechanism, or
  
  – Two eruption mechanisms, most “$\eta$ Car” not $\Rightarrow$ SLSN
Summary

•Identified five extragalactic candidate analogs for the present day η Carinae

•Mimics observed properties, but physical properties and evolutionary states TBD

•Next: Follow up in the UV and IR, and expand search to more diverse host galaxies


(UGC 2773-OT, an extragalactic Great Eruption analog)