WR DustERS: a JWST-ERS program to resolve the nature of dust in Wolf-Rayet winds

Collaborators: M. Hankins (Caltech), I. Sakon (U Tokyo), Astrid Lamberts (OCA), JJ Eldridge (Auckland), P. Williams (ROE), and the WR DustERS Team
Talk Outline

- **Background:**
  Wolf-Rayet (WR) stars and dust formation

- **Science Focus:**
  Revisiting WR dust input and their impact on galactic dust budgets

- **Early Science with JWST:**
  The WR DustERS Program

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Wolf-Rayet stars and how they form dust
Wolf Rayet (WR) Star:
descendent of a massive O-star

- Luminous ($>10^5 \ L_{\odot}$)
- Hot ($>40,000 \ K$)
- Strong winds ($>1000 \ km/s$)
- High mass-loss ($\sim 10^{-5} \ M_{\odot}/yr$)
Dust Formation in WR Binaries

(Williams+ 1990; Usov+1991)
Dusty outflow and orbital motion form a “Pinwheel”
A Dusty WR “Pinwheel” Nebula!

WR 104 (K band)
Period = 220 days
d ~ 2.4 kpc

200 mas
(~500 AU)

Potential source of dust in early and local Universe

Tuthill et al. (1999; 2008)
# Dust Sources in the LMC

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A dusty WR binary \(\Rightarrow ~10^{-10} - 10^{-5} M_{\text{Sun}}\ yr^{-1}\)

Lau et al. (Submitted)
Implications and big questions...

**Implications:** WR Binaries should be an important source of dust

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**Further questions...**

**WR dust chemistry:** What are the molecular precursors of the carbon dust?
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Implications and big questions...

**Implications:** WR Binaries should be an important source of dust

**Further questions...**

**WR dust chemistry:** What are the molecular precursors of the carbon dust?

**Dust formation:** How does dust form in such a hostile environment?

**Dust Survival:** Does dust survive as it incorporates into the ISM?
Early Science with JWST!
Dust Formation from Wolf-Rayet binaries
WR DustERS Team

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Anand Sivaramakrishnan (STScI)
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Macarena Garcia Marin (ESA)
Pat Morris (Caltech/IPAC)
Ian Stevens (University of Birmingham)
WR DustERS Science Goals

Composition
- PAHs?
- HACs?
- QCCs?

Dust Growth and Destruction

Ryan Lau - ryan.lau@jaxa.jp
ERS Target: Wolf-Rayet (WR) 140

Episodic Dust Formation in WR140

WC7 + O5 (d = 1.6 kpc)
P = 7.94 yr
e = 0.9
i = 120°

Williams et al. (2009), Monnier et al. (2011)

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ERS Target: Wolf-Rayet (WR) 140

Gemini/MICHELLE

12.5 um

-2.0” 0 2.0”

Williams+ (2009)
WR DustERS – JWST Observing Modes: \textbf{MIRI Im, MIRI IFU, NIRISS AMI}

MIRI Imaging (FoV: \(\sim 1 \times 2\)’)
15, 21, and 25 \(\mu\)m imaging to detect at least 8 past dust formation episodes
WR DustERS – JWST Observing Modes: MIRI Im, MIRI IFU, NIRISS AMI

MIRI Integral Field Spectroscopy (FoV ~ 4 – 8’’)
5 - 28 μm R ~ 2000 IFU spectroscopy to detect molecular precursors to WR dust

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WR DustERS – JWST Observing Modes: MIRI Im, MIRI IFU, **NIRISS AMI**

A **natural synergy**: NIRISS probes hot dust at finer spatial scales, while MIRI probes warm extended dust.

**NIRISS Aperture Masking Interferometry** (Resolution ~ 65 mas)

3.8 & 4.8 μm high contrast observations of hot inner dust to resolve morphology

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WR DustERS - Technical Goals

• Many people want to point JWST at IR bright sources…
  – E.g. AGN tori, protoplanetary disks, massive star ejecta

• How well can we detect faint extended emission around bright sources with JWST?
  – Dealing with bright source artifacts for MIRI/MRS and NIRISS/AMI (e.g. persistence, row/column scattering and pull-up/down)
  – How close to a bright source can we detect faint extended emission? (with bright source correction and PSF subtraction)
**Summary**

**Dusty WR Binaries**

WR+OB binaries form dust via colliding winds

*WR binaries should be important source of dust*

Composition, formation, and survival of WR dust still unclear

**JWST Early Science: WR DustERS**

**JWST** – Enables high spatial resolution and sensitivity in mid-IR

**WR DustERS** – Investigating dust composition, growth and destruction from **WR140**

**On-going work** – ground-based mid-IR survey w/ Subaru of WR binaries

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