# Constraining Circumstellar Dust around Extragalactic Red Supergiants with JWST

Rebecca Wisenbaker[1, 2], Charlie Kilpatrick[2], Aswin Suresh[2]

[1]Department of Astronomy, The University of Texas at Austin, 2515 Speedway, Stop C1400, Austin, TX 78712, USA
[2]Center for Interdisciplinary Exploration and Research in Astrophysics (CIERA) and Department of Physics and Astronomy, Northwestern University, 1800 Sherman Ave., Evanston, IL 60201, USA

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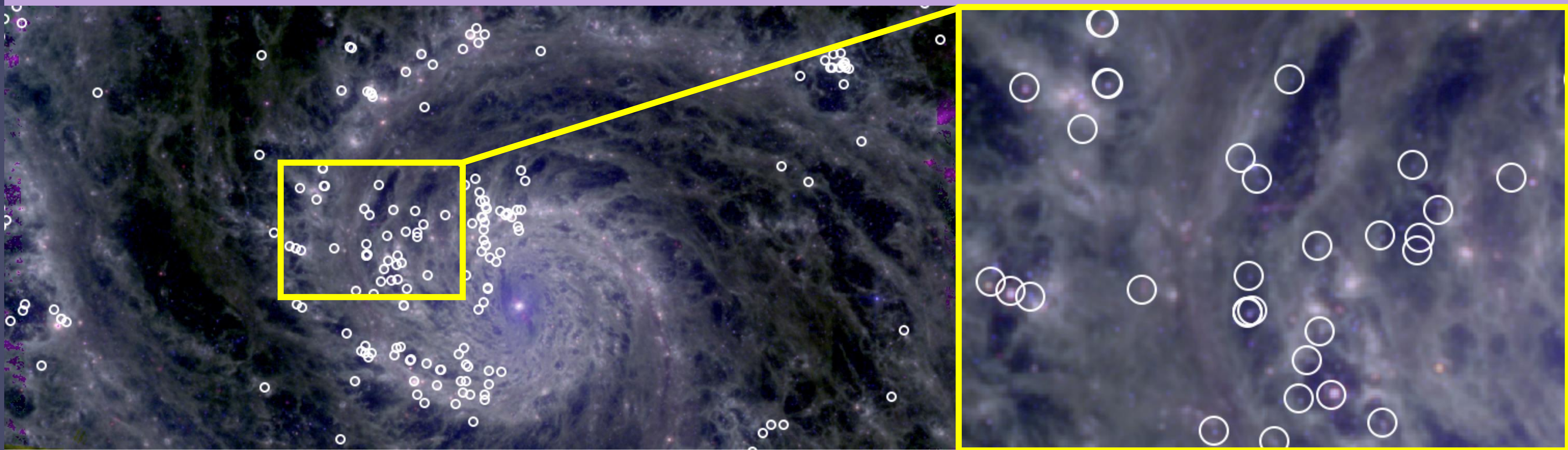

## Background

• **Red supergiants (RSGs)** are the expected progenitors of Type II core-collapse supernovae [1], but their pre-explosion properties, especially **mass-loss rates and circumstellar dust**, remain poorly constrained.

• **JWST/NIRCam** (Near- Infrared Camera) imaging identifies RSG candidates, and **JWST/MIRI** (Mid-Infrared Instrument) probes warm circumstellar dust. Aligned **NIRCam+MIRI** photometry enables SED constraints on dust composition.

• RSG winds are expected to be oxygen-rich, favoring **silicate dust**. However, the **SN 2025pht** progenitor preferred graphite-rich models [2]. Comparing **silicate vs. graphite** fractions informs **circumstellar material (CSM) chemistry and RSG evolution**.

## Methods

• Target host-galaxies are **M51 and M82** due to extensive JWST imaging, NIRCam-MIRI overlap, and contrasting star-forming environments. Level 2 NIRCam and MIRI data are obtained from MAST [3] and Level 3 mosaics are built for source detection and image alignment.

• **NIRCam-MIRI overlap** is confirmed with **Shapely** [4] and **DS9**. **Relative alignment** is performed with jhat [5]. Image pairs with successful matching and low residual dispersion are retained.

• RSG catalogs from prior NIRCam **DOLPHOT** [6] **PSF photometry** are used to perform **matched photometry** across aligned NIRCam+MIRI bands. This enables characterization of RSG infrared properties and cooler circumstellar dust probed by MIRI.

•SEDs are fit with **MCMC** stellar+dust models to determine the preferred dust composition for each RSG and the fraction of RSGs better explained **by graphite- vs. silicate-dominated CSM dust models**.

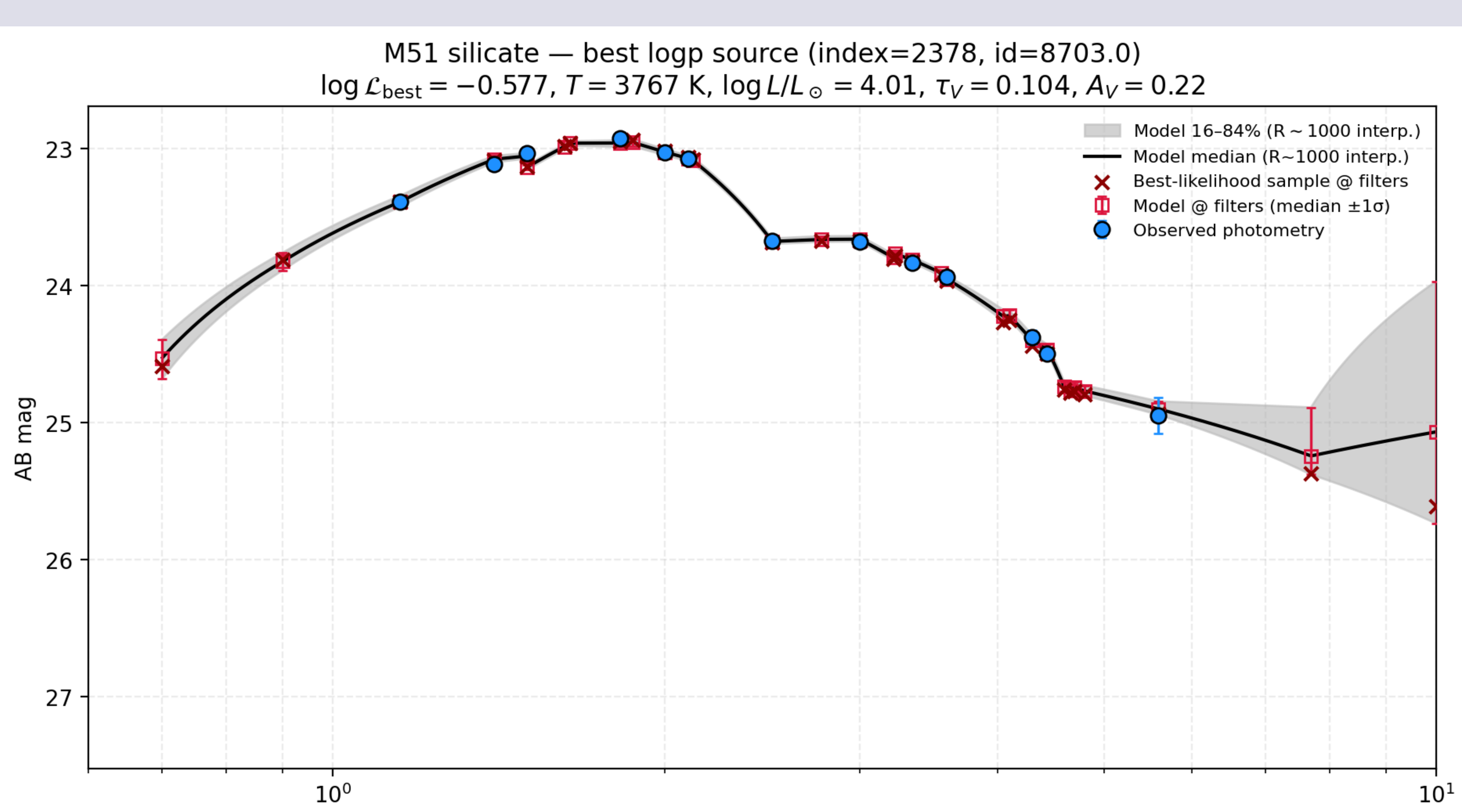


**Figure 1:** The best-fit silicate-dust model for an RSG in M51. The model closely reproduces the observed near- and mid-infrared SED, with most photometry near the model median and within the 16–84% uncertainty range. Model uncertainty increases toward longer wavelengths. The best-fit parameters are $T$ = 3,767 K, $\log(L/L_\odot)$ = 4.01, $\tau_V$ = 0.104, and $A_V$ = 0.22.

## Results

• **M51 (3,360 RSGs): 63.9%** are found to be **silicate-dominated**, and **36.1%** are **graphite-dominated**.

• **M82 (303 RSGs): 68.0%** are found to be **silicate-dominated**, and **32.0%** are **graphite-dominated**.

• **Silicate dust is preferred in both galaxies**, with **~2/3** of RSGs favoring **silicate** and **1/3** favoring **graphite**. Similar ratios suggest that dust chemistry is not strongly dependent on host-galaxy properties.

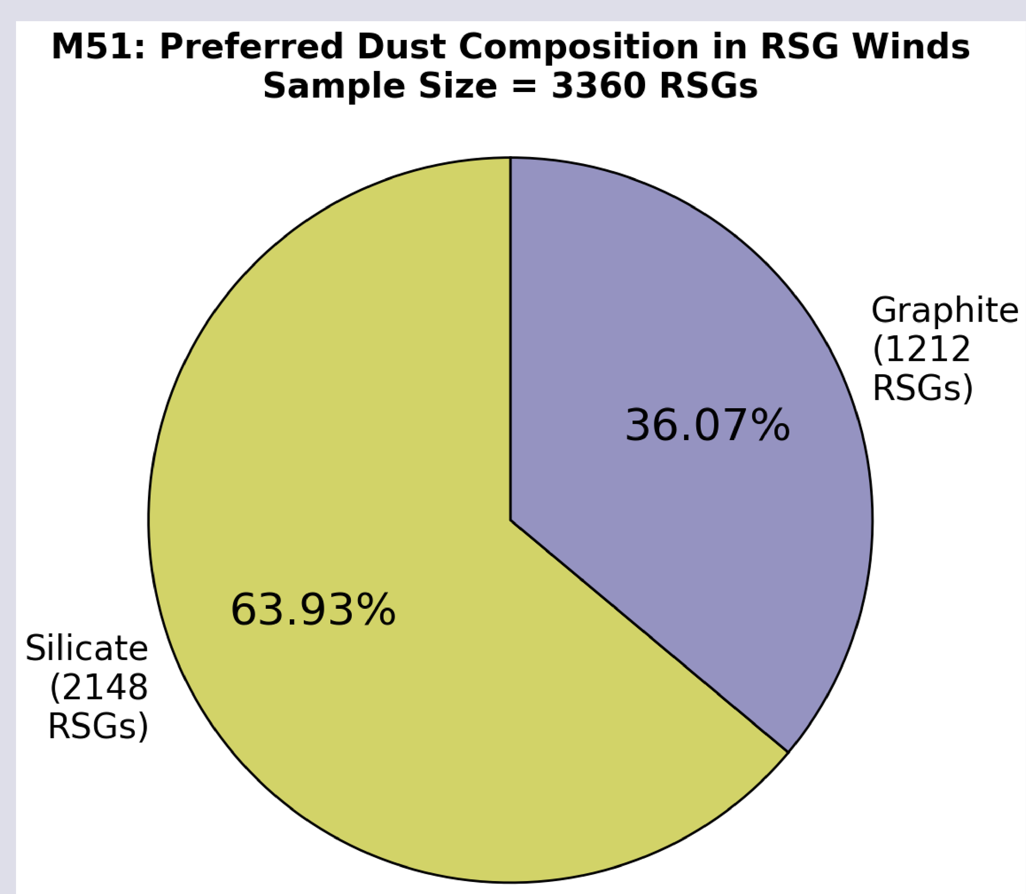


**Figure 3:** The preferred dust composition of a sample of 3,360 RSGs in M51. Silicate dust is favored for 63.93% (2,148 RSGs), while graphite dust is favored for 36.07% (1,212 RSGs).

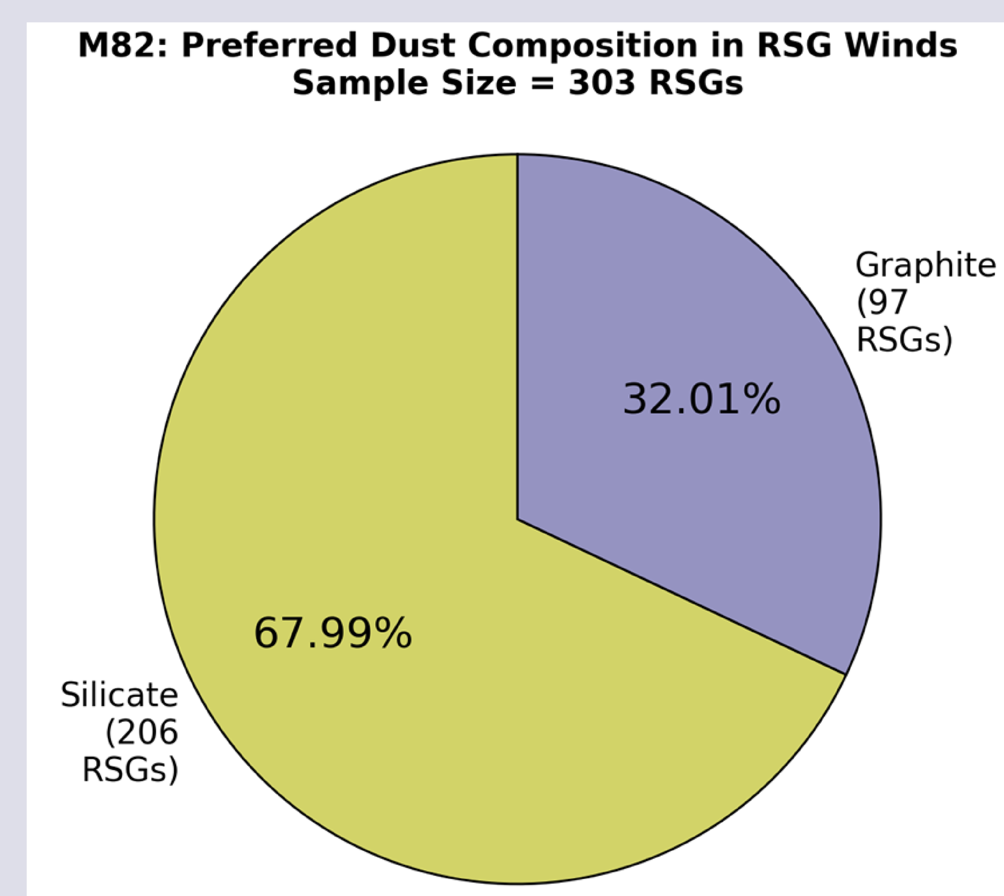


**Figure 4:** The preferred dust composition of a sample of 303 RSGs in M82. Silicate dust is favored for 68.0% (206 RSGs), while graphite dust is favored for 32.0% (97 RSGs).

## Discussion

• RSGs in both galaxies are found to be **predominantly silicate-rich**, as expected for oxygen-rich winds.

• Silicate-rich CSMs imply that early winds have a **greater ratio of oxygen to carbon (C/O < 1)** before dust nucleation.

• Combining NIRCam+MIRI photometry enables a more complete analysis of CSM and **tightens constraints on dust composition and temperature**.

• Mid-Infrared coverage better constrains **luminosity and dust optical depth.**

• These dust constraints will enable more reliable **RSG mass-loss rates**.

• Previous work with M31+M33 demonstrates that **multiband photometry** constrains RSG properties **without spectroscopy** [7]. This study extends that approach to circumstellar dust composition and wind properties.

## Future Work

• Expand the analysis to **additional nearby galaxies** containing previously identified RSGs.

• **Identify RSG outliers** with **unusually red NIRCam–MIRI colors** or **unexplained photometry** to further investigate circumstellar dust properties or processes not captured by current models.

## Acknowledgements

This material is based upon work supported by the U.S. National Science Foundation (NSF) under Award Number AST-2446392. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the NSF.

This research was conducted through the CIERA Research Experience for Undergraduates (REU) Program at Northwestern University.

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