Dust Processing in the M82 Superwind with JWST MIRI and NIRCam

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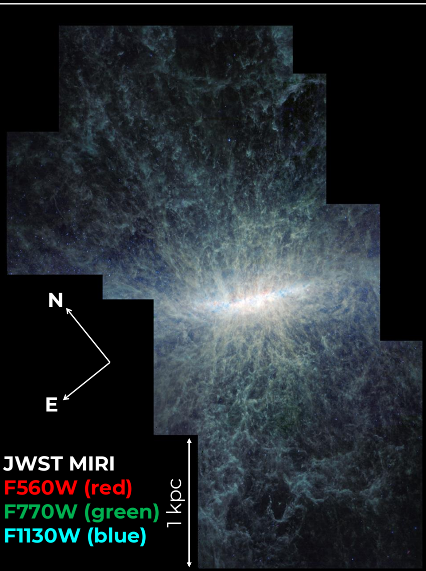
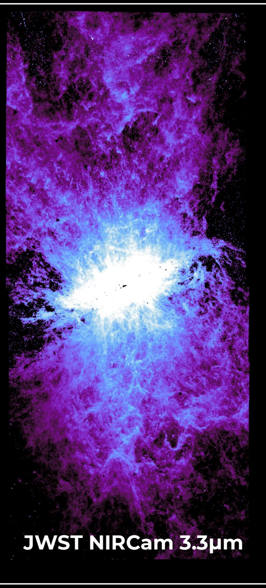


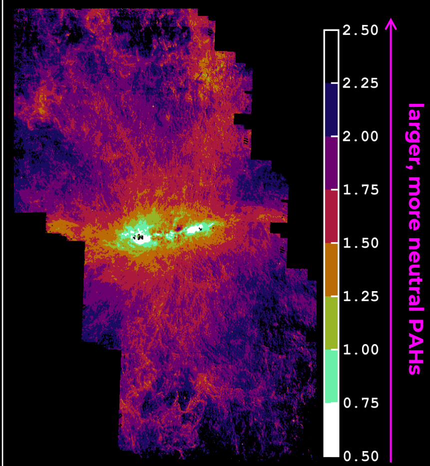
Credit: Alyssa Pagan, STScI

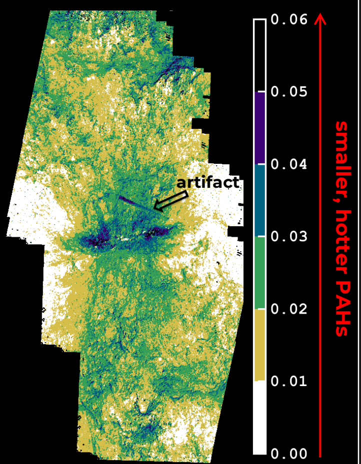


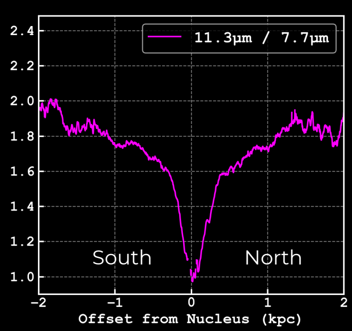
Background & Data

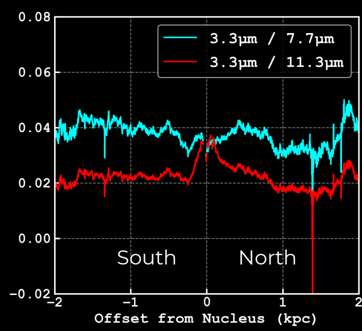
- Galactic winds are critical to galaxy evolution. Winds may enrich the CGM, prevent accretion from the halo, and trigger star formation via re-accreting "cold fountains" [1].
- The formation of massive ($\gtrsim 10^4$ $M_\odot$), compact (R ~ 1 pc) star clusters and supernovae in starbursts can drive multiphase galactic winds [2].
- M82 is an archetypal starburst galaxy. At d ~ 3.6 Mpc away [3], we can study this wind in incredible detail!
- JWST (GO #1701; PI: A. Bolatto) has revealed a complex filamentary structure of Polycyclic Aromatic Hydrocarbons (PAHs) in the M82 wind [4, 5].
- PAHs are easily destroyed by hot phases, so they trace the cooler phase of the wind. *How does this cool material survive the gauntlet of a hot wind?*

PAH Ratios



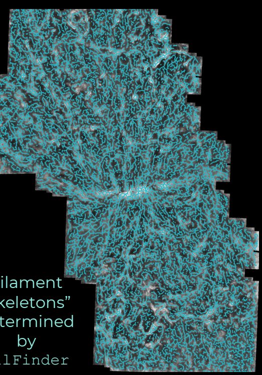






- PAH emission is sensitive to grain size, temperature, and ionization [6]. Thus, PAH ratios can diagnose the physical state of the cool phase of the wind.
- The 11.3 / 7.7μm ratio increases with distance from the ionizing starburst, indicating PAHs tend to be larger and/or more neutral in the wind.
- 3.3μm emission is sensitive to the smallest grains. The distributions of 3.3 / 11.3μm and 3.3 / 7.7μm indicate that the smallest PAHs can survive out to at least ~2 kpc.

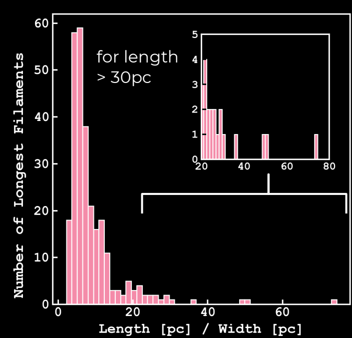
Wind Structure

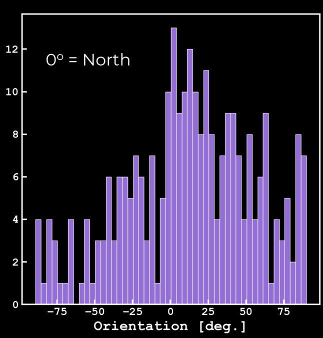


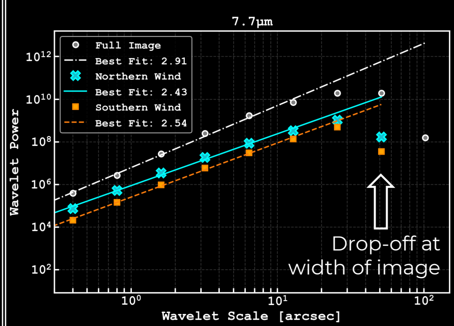
Filament "skeletons" determined by `FilFinder`

Unsharp-masked F770W

- `FilFinder` locates filaments and extracts their properties, such as length, width, and orientation [7].
- ***(Left) Skeletons and branches of filaments.*** The M82 wind contains a complex network of filaments. Of the ~1000 features found, ~275 are considered significant (> 30 pc long).
- ***(Below, left) Sizes of significant filaments.*** Significant filaments tend to be ~7x long as they are wide.
- ***(Below, right) Orientations of significant filaments.*** Significant filaments tend to be oriented ~ ±30° from the minor axis (0° = North). This is consistent with the opening angle of the molecular outflow cone (55° [8]).







- *(Left)* Wavelet power spectrum: $P_j \propto 2^{-j\gamma}$, where γ is the fractal dimension [9].
- Kelvin-Helmholtz instabilities create a thin, hot-cool mixing layer with γ ~ 2.5 [10].
- We apply a wavelet transform to regions of the 7.7μm image.
- Both sides of the wind have γ ~ 2.5, indicating the structure in both wind lobes arises from turbulence.

References

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Can't get enough of starburst-driven winds? Check out my recent paper on the warm, ionized phase of the NGC 253 galactic wind! arxiv.org/abs/2505.04707