

# JWST Smokes Out Organic Molecules in Early Universe

Presenter: Jane Rigby

- Affiliation: NASA Goddard Space Flight Center
- Cell: 240-475-3917
- Email: [Jane.Rigby@nasa.gov](mailto:Jane.Rigby@nasa.gov)
- Role: Principal Investigator of the TEMPLATES program
- *Note: Jane is also Operations Project Scientist for JWST*

People you should actually quote:

- Justin Spilker, Texas A&M U., [jspilker@tamu.edu](mailto:jspilker@tamu.edu)
- Kedar Phadke, U. of Illinois Urbana-Champaign, [kphadke2@illinois.edu](mailto:kphadke2@illinois.edu)

Other contacts:

- Joaquin Vieira, U. of Illinois Urbana-Champaign, [jvieira@illinois.edu](mailto:jvieira@illinois.edu)
- Shana Hutchins, Texas A&M University, [shutchins@tamu.edu](mailto:shutchins@tamu.edu)

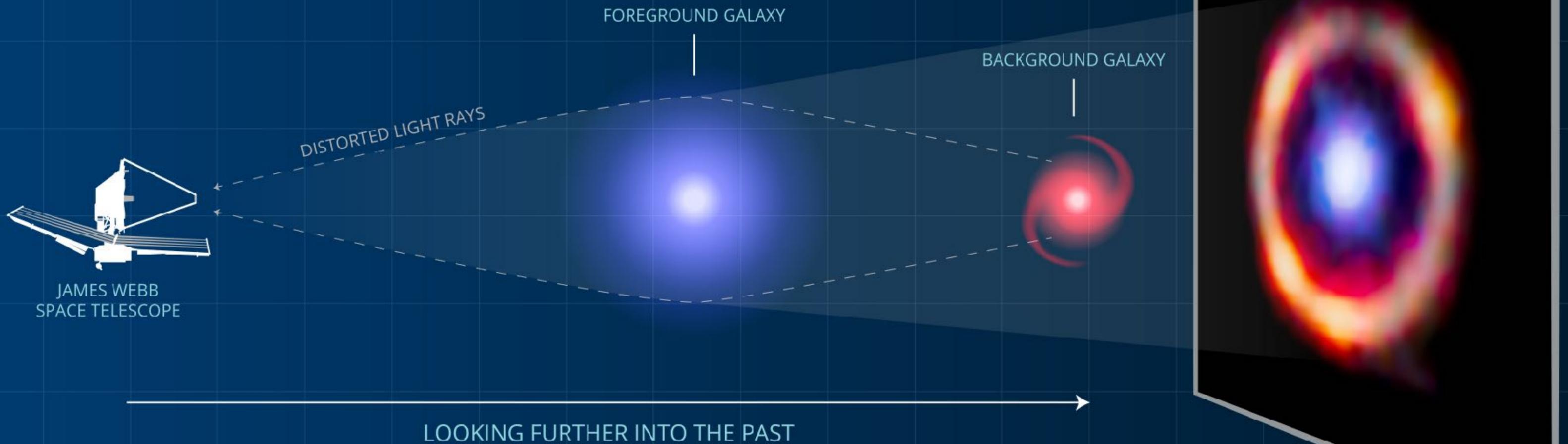
# Context

- New results from TEMPLATES, 1 of JWST's 13 "Early Release Science" programs.
- TEMPLATES studies 4 galaxies. The light from each galaxy went through not just JWST, but also a "cosmic telescope" (gravitational lens).
- JWST sees these TEMPLATES galaxies in new ways. 2 of the 4 galaxies are so dusty that they're utterly invisible to Hubble. JWST sees through the dust to the stars and gas inside these galaxies, and maps the dust.

NIRCam/JWST images of the TEMPLATES targets, from Rigby et al. (in prep.), presented at AAS242



## WHAT CREATES AN **EINSTEIN RING?**



The galaxy observed by Webb shows an Einstein ring caused by a phenomenon known as lensing. Lensing occurs when two galaxies are almost perfectly aligned from our perspective on Earth. The gravity from the galaxy in the foreground causes the light from the background galaxy to be distorted and magnified, like looking through the stem of a wine glass. Because they are magnified, lensing allows astronomers to study very distant galaxies in more detail than otherwise possible. (Credit: S. Doyle / J. Spilker)

# Result: Webb finds smoke in the early universe

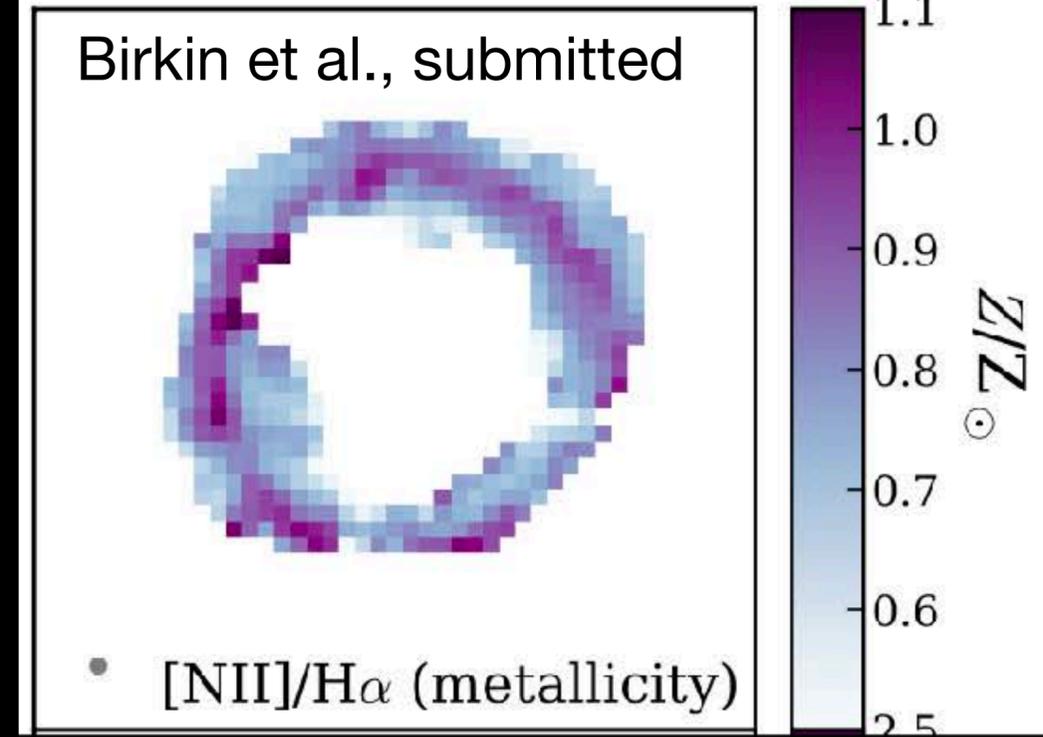
Astronomers using the Webb telescope discovered evidence of complex organic molecules similar to smoke or smog in the distant galaxy shown here. The galaxy, more than 12 billion light years away, happens to line up almost perfectly with a second galaxy only 3 billion light years away from our perspective on Earth. In this false-color Webb image, the foreground galaxy is shown in blue, while the background galaxy is red. The organic molecules are highlighted in orange. (Credit: J. Spilker / S. Doyle, NASA, ESA, CSA)

*Paper: Spilker et al. 2023, Nature, this week*

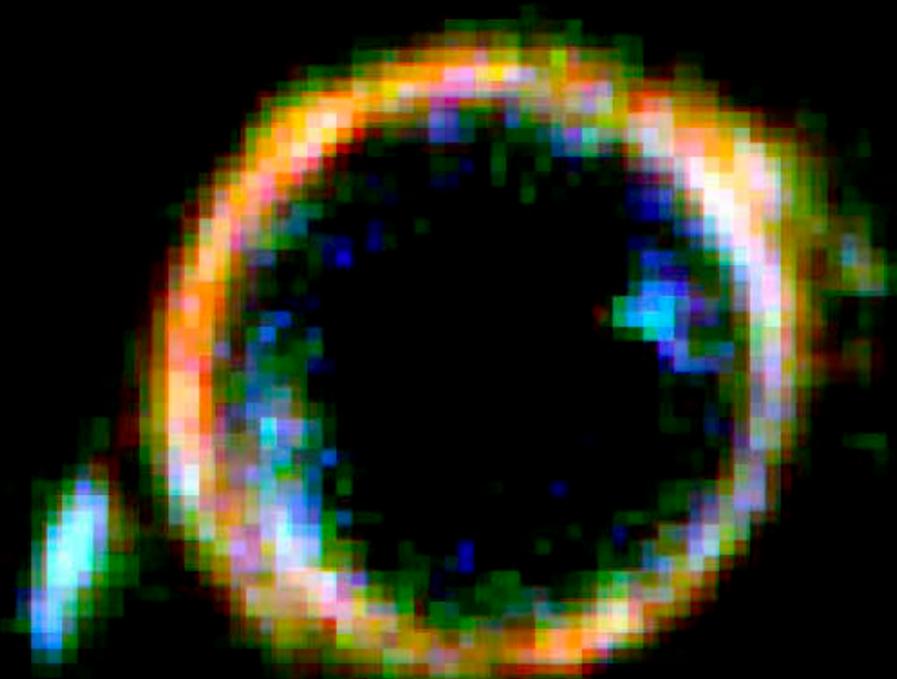


# Result: JWST is showing us how stars form in distant galaxies, in ways previously impossible

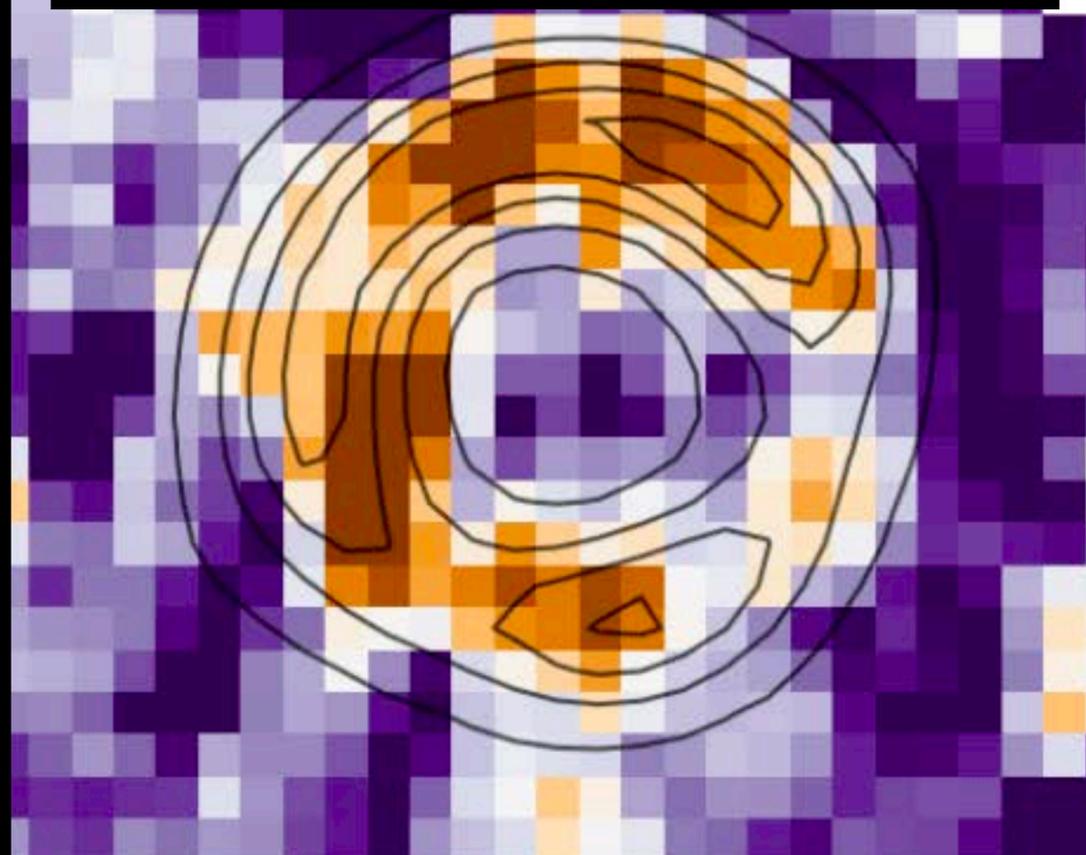
Results reported in Spilker et al. (2023, Nature, this week) or presented by Rigby at AAS242



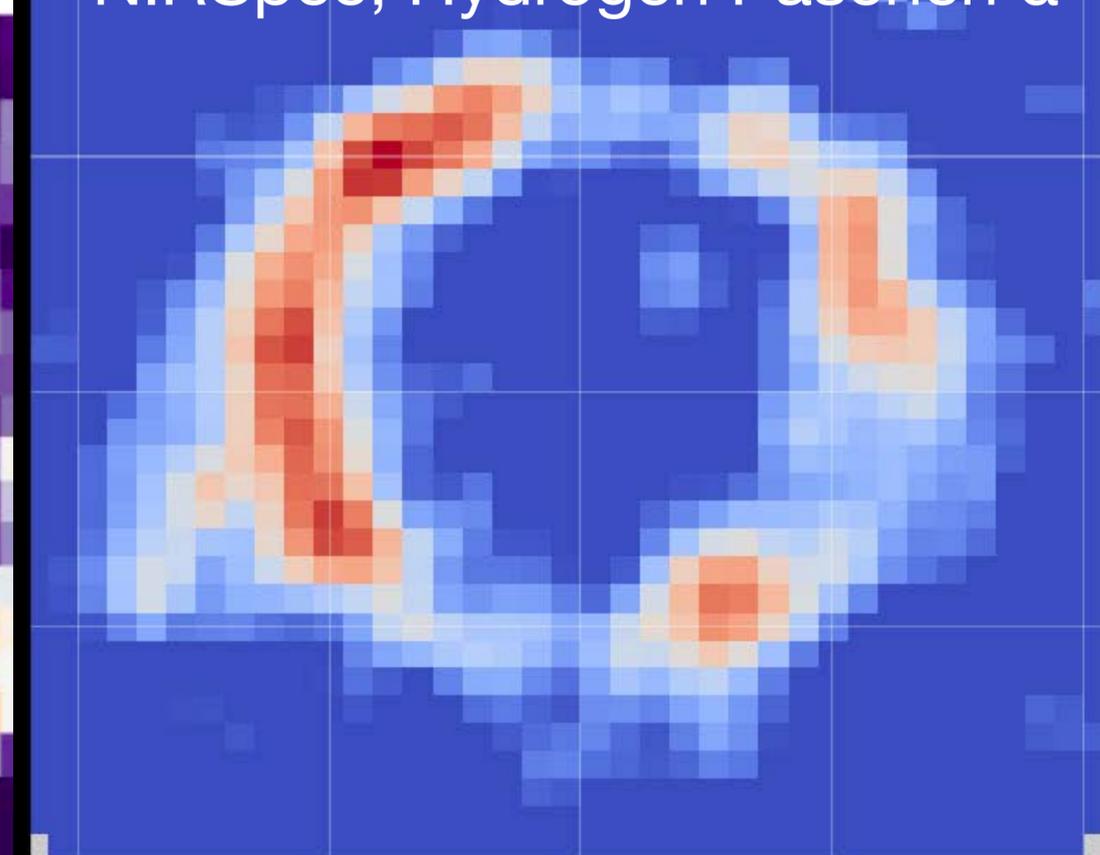
NIRCam 2.8, 3.5, 4.4 $\mu$ m



MIRI MRS, 3.3 micron PAH dust



NIRSpec, Hydrogen Paschen  $\alpha$



Cathey et al., in prep. See also Peng et al. (2022)

Spilker et al. 2023, in press

Phadke et al., in prep.

SPT0418-47 at redshift  $z=4.22$ , seen by 3 JWST instruments

# Implications

- This is Webb's first detection of complex molecules in the early universe.
- “Detecting smoke in a galaxy early in the history of the universe? Webb makes this look easy.” -J. Spilker
- “Discoveries like this are precisely what Webb was built to do: understand the earliest stages of the universe in new and exciting ways” -K. Phadke.
- “Astronomers used to think these big molecules were a good sign that new stars were forming. Anywhere you saw these molecules, baby stars were also right there blazing away.” But, “Thanks to the high-definition images from Webb, we found a lot of regions with smoke but no star formation, and others with new stars forming but no smoke.” -J. Spilker
- Smoke signals from the early galaxies are one of several new ways that JWST is revealing how stars formed and galaxies evolved.” - J. Rigby

# Summary

- JWST has discovered smoke within a distant galaxy, seen as it looked 12.3 billion years ago. New paper, Spilker et al. (2023, Nature, this week).
- This is JWST's first discovery of complex organic molecules in the early universe.
- This discovery used a cosmic telescope (gravitational lens), plus the Webb telescope.
- These smoke signals are one of several new ways that JWST is revealing the invisible universe, in this case how early galaxies formed their stars.
- These results come from TEMPLATES, a JWST Early Release Science team.

TEMPLATES



Credit: ESA/Webb, NASA & CSA, J. Rigby