# NASA's James Webb Space Telescope:
## Observations of Cometary Dust, Gas, and Nuclei

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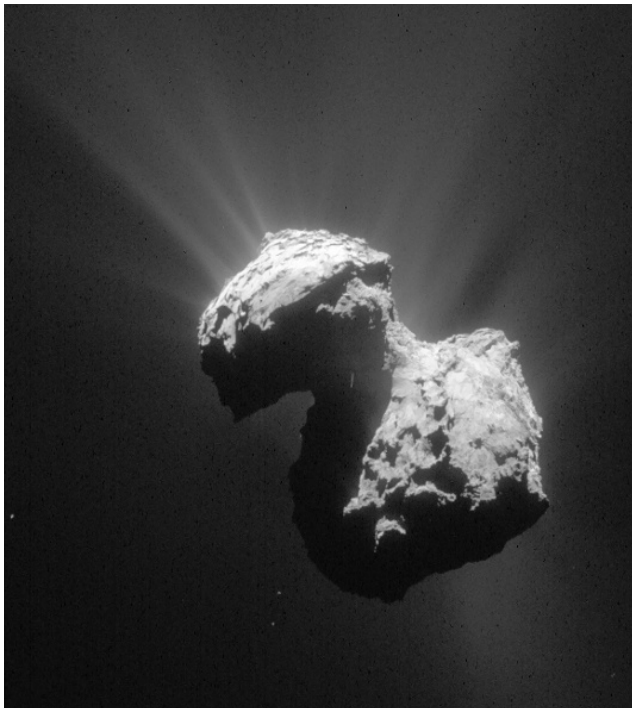
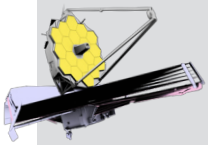
Comets provide valuable information about the formation and subsequent evolution of the solar system. Long-period comets may represent the most pristine material in the solar system, while short-period comets provide clues to the dynamical history of minor bodies and planets. JWST will open new avenues in comet research through investigations focused on the following broad topics:

- Drivers of cometary activity
- Comet nucleus heterogeneity
- Water ice in comae and on nuclei
- Activity of faint comets and main-belt comets

JWST is primed to make the most distant detections yet of gas around comet nuclei; will study dust and gas properties of relatively nearby comets simultaneously with a single instrument; and will more deeply explore the question of activity among main-belt comets.

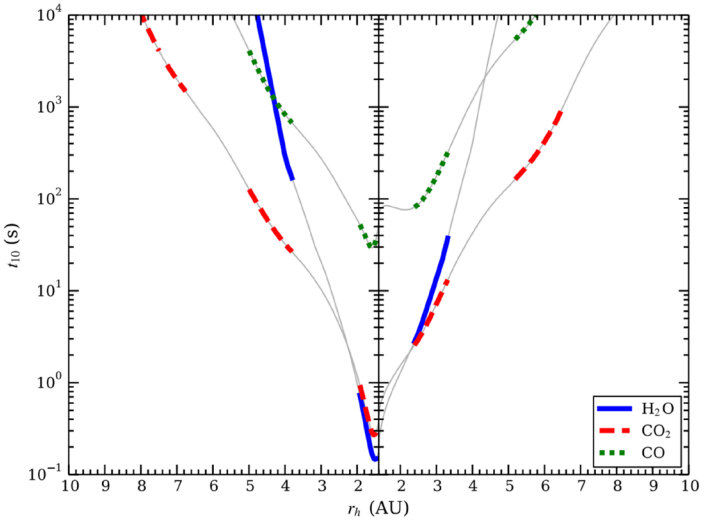


Comet 67P/Churyumov-Gerasimenko from Rosetta. (ESA/Rosetta/NAVCAM)



The timing of comet observations is constrained by two factors: the JWST field of regard and the non-sidereal tracking limit. The field of regard constraints are in place to keep the instruments and mirror in shadow and prevent observations of objects outside the solar elongation range from 85° to 135°. The other constraint is the maximum non-sidereal tracking rate of 30 mas/s (108"/hr), the maximum apparent rate of Mars. These two constraints combine to prevent observations of comets in the inner solar system. This places a particularly strong constraint on observations long-period and Oort cloud comets, which are best observed in the inner solar system when they are moving at their fastest apparent rate.

The primary gas species responsible for cometary activity, $H_2O$, $CO_2$, and CO, are best observed in the near-infrared. Since $CO_2$ cannot be observed from ground-based facilities, JWST observations will significantly contribute to our understanding of the role this species plays in cometary activity. The study of water ice absorptions at 1.5, 2.0, 3.0 μm can provide insight into coma-nucleus interactions and the surface evolution of the nucleus. Time-domain spectroscopic studies can trace the evolution of gas production at different heliocentric distances. Spectroscopy with the MIRI Medium Resolution Spectrometer (MRS) can be used to investigate the characteristics of dust in the coma, including composition, grain size, and porosity. Spectral mapping of dust in the coma can be performed with the MIRI Low Resolution Spectrometer (LRS) by slit scanning or the MRS (FOVs ranging from 3.3" x 3.7" to 7.2" x 7.9").



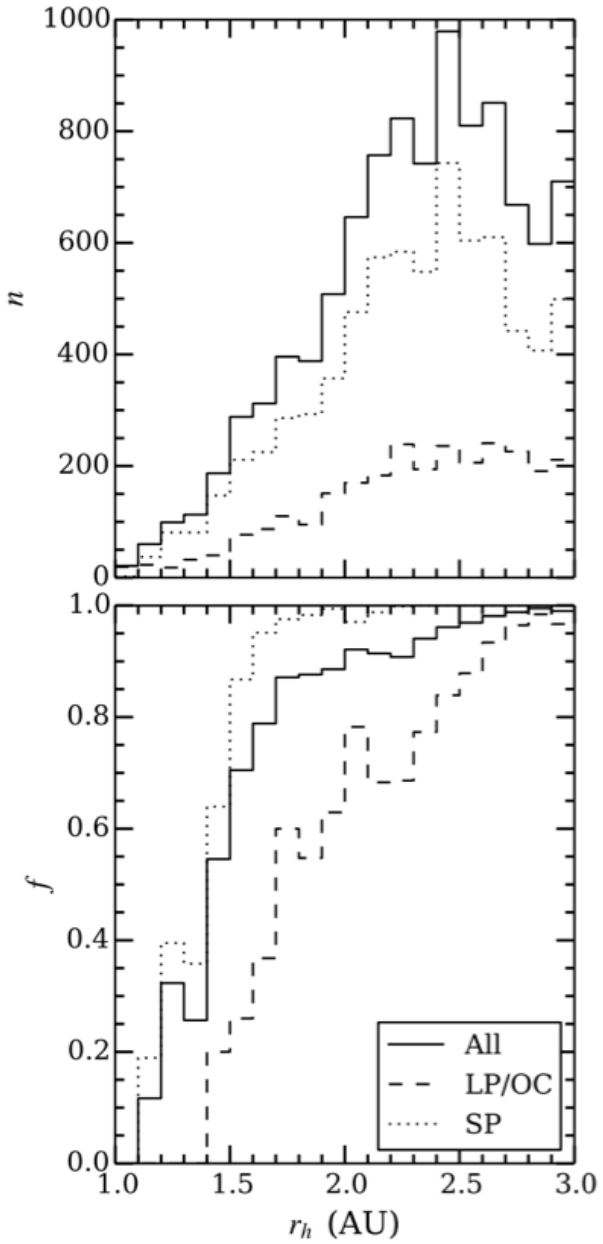

Estimated NIRSpec observation times needed to achieve a signal-to-noise of 10 for $H_2O$, $CO_2$, and CO band peaks. The thick lines indicate when the hypothetical comet is within JWST's field of regard. (From Kelley et al., 2016)

| Comet | Perihelion date |
|---|---|
| 2P/Encke | 2023-10-23 |
| 6P/d'Arrest | 2021-09-18 |
| 67P/Churyumov-Gerasimenko | 2021-11-02 |
| 99P/Kowal1 | 2022-04-12 |
| 103P/Hartly 2 | 2023-10-12 |
| 104P/Kowal 2 | 2022-01-08 |
| 107P/Wilson-Harrington | 2022-08-25 |
| 117P/Helin-Roman-Alu1 | 2022-07-08 |
| 126P/IRAS | 2023-07-05 |
| 176P/LINEAR 52 | 2022-11-21 |
| P/2010 R2 (La Sagra) | 2021-05-09 |
| C/2014 F3 (Sheppard-Trujillo) | 2021-05-23 |
| (596) Scheila | 2022-05-26 |

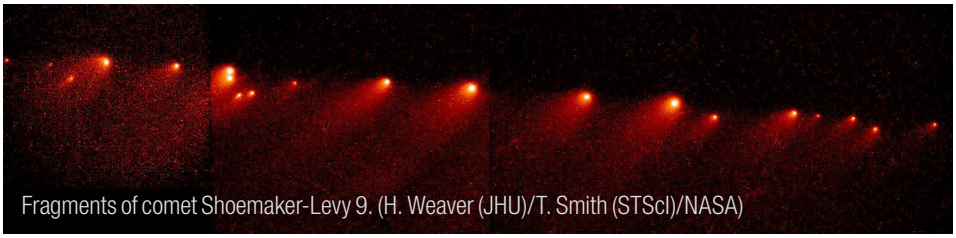
List of comets with approximate perihelion dates during the expected period of JWST's primary mission. (Adapted from Kelley et al., 2016)

**Search for activity.** JWST will be able to routinely make observations of main belt comets (MBCs), dormant comets, very small comets, and very distant comets. NIRCam imaging can be used for identifying signs of weak activity and characterizing the physical properties of nuclei. NIRSpec may be able to detect spectroscopic signatures of the volatiles driving weak activity.

**GTO programs.** Two Guaranteed Time Observation (GTO) programs are already planned to observe comets. GTO 1252 aims to spectrally map the inner 1000 km of the coma of a moderately bright comet. GTO 1253 is a target of opportunity (ToO) program that will be triggered at the appropriate time to observe a dynamically new comet or an outburst from a periodic comet. Neither of these programs have a proprietary period, and can therefore be the subject of Archival Research (AR) proposals in GO Cycle 1.




Top panel: Number of epochs within JWST's field of regard vs. heliocentric distance. The solid, dashed, and dotted lines in both panels represent all comets, long-period and Oort cloud comets, and short-period comets, respectively. Bottom panel: Fraction of epochs observable within JWST's tracking limit vs. heliocentric distance. The 30 mas/s tracking limit significantly impacts observations of comets within a heliocentric distance of 2 AU. (From Kelley et al., 2016)



Fragments of comet Shoemaker-Levy 9. (H. Weaver (JHU)/T. Smith (STScI)/NASA)

See more at **jwst.stsci.edu** and **jwst-docs.stsci.edu**

https://arxiv.org/abs/1510.05878