EPSC Abstracts
Vol. 18, EPSC-DPS2025-1419, 2025, updated on 20 Oct 2025
https://doi.org/10.5194/epsc-dps2025-1419
EPSC-DPS Joint Meeting 2025

JWST observations of distant long period comet C/2024 E1 (Wierzchos)

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We observed the recently discovered long period comet C/2024 E1 (Wierzchos) with JWST at three epochs in 2024 and 2025 as it approaches its perihelion in 2026. These observations, at heliocentric distances of approximately 7, 5 and 3 au, bracket the point where water ice sublimation is expected to begin, and provide a unique insight into the drivers of cometary activity. We use the integral field unit of NIRSpec on JWST to obtain spatially resolved spectroscopy of the comet at each epoch. These observations cover a wavelength range of 0.6 - 5.3 microns, and are sensitive to emissions from the three major drivers of cometary activity: H_2O, CO, and CO_2.

The first epoch was obtained in June 2024 with the comet at 7 au from the Sun. The spectrum (shown in the figure) shows clear CO_2 emission but no evidence of water or CO sublimation. At this distance water ice was not expected to sublimate, but the lack of CO emission was surprising, as it is more volatile than CO_2. The CO_2 production rate was measured to be 2.546 +/- 0.019 x 10^{25} molecules/s. The spectrum also shows clear absorption features due to water ice. The Fresnel peak at 3.1 microns suggests that this water ice is crystalline, and the spatial distribution of the absorption feature indicates that the ice is on coma particles. The spatial distribution of water ice absorption matches that of the dust (reflected light component), and is distinct from the distribution of the CO_2 emission. The dust and ice are asymmetric, extending in the anti-solar direction with a weak clockwise spiral, while the CO_2 emission is symmetric around the nucleus.

The absorption spectrum of the comet's coma is remarkably similar to the water dominated Centaurs and Trans-Neptunian Objects (TNOs) observed by the large 'DiSCo' programme on JWST (e.g. Pinilla-Alonso et al 2025). With the caveat that we observed coma particles rather than the nucleus surface, and that the comet is likely a much smaller body (we find an upper limit nucleus radius of 13.7 km) than those observed in the DiSCo sample, this similarity is intriguing. The DiSCo observed objects and this Oort cloud comet likely formed in a similar region of the disc, but have undergone different evolution since then: the TNOs remained largely at the same distance from the

Sun, Centaurs had repeated closer passages (potentially within the water ice sublimation zone if they temporarily transitioned to become Jupiter-family comets), and the comet has been kept in deep freeze in the Oort cloud since it was scattered there, likely during the era of giant planet formation and migration. The lack of CO emission from C/2024 E1 suggests that it possibly underwent significant thermal evolution (and lost any near-surface CO) during the process of being scattered into the Oort cloud (Gkotsinas et al 2024 predict this to be a common outcome for dynamically new Oort cloud comets); alternatively, it might have formed in a region depleted in CO ice.

At the time of writing this abstract the second epoch observations have just been taken, and the third epoch is scheduled for July 2025. At EPSC/DPS we will describe the results from the first epoch (details published by Snodgrass et al 2025) and updates from the second and third epochs, in particular whether or not CO emission is seen as the comet approaches the Sun (and presumably deeper layers could become active), when and how water sublimation starts, and how the water ice absorption features change (they are expected to disappear).

References:

- Gkotsinas A., Nesvorný D., Guilbert-Lepoutre A., Raymond S. N., Kaib N., 2024, PSJ, 5, 243
- Pinilla-Alonso N., et al., 2025, Nature Astronomy, 9, 230
- Snodgrass C. et al., 2025, MNRAS in press (arXiv 2503.14071)

Figure: Spectrum extracted within a 0.4'' radius aperture centered on the nucleus.