REVEALING THE COMPOSITION AND HISTORY OF THE SOLAR SYSTEM WITH JWST'S INFRARED EYES

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The first glimpse of the amazing capability for solar system science with the James Webb Space Telescope (JWST) came from images of Jupiter in the near–infrared[1]. Exquisite details on not only the planet and its dynamic atmosphere, but also the rings, small satellites, aurorae, and the Great Red Spot — all achieved in mere moments of telescope time. The dynamic range (a factor of 10,000 between the brightness of the rings and the planet), moving target tracking and precision, as well as the sensitivity and resolution for details of tiny upper stratospheric features are all revealed. As one of the largest and brightest objects in the solar system (a true challenge for a distant galaxy hunting machine), this observation really demonstrated early on that new discoveries await with this telescope. All planets (and many of their satellites[2]) from Mars and beyond have now been observed with JWST (imaging and spectroscopy) revealing new molecular species, dynamics, and other properties that eluded detection until now[3].

Not only is JWST studying the big and bright, but also has impeccable capability to study the small bodies of the solar system — often considered the fossils of planet formation. Programs to study and characterize near–Earth asteroids (NEAs)[4], main belt asteroids (MBAs), Centaurs, Comets[5,6], trans–Neptunian objects (TNOs), and of course minor planets are all underway and revealing new insights about the size distribution, volatile composition, activity, and dynamic families. The high resolution spectral capability and wavelength coverage of JWST enables detailed studies on composition not accessible from the ground. Key volatile species, ices, dust and grains, etc can be searched for to gain insight into the distribution and evolution of molecular and macromolecular materials during planet formation. JWST has already

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[2] doi: 10.1038/s41550-023-02009-6 Villanueva, G.L., Hammel, H.B., Milam, S.N., et al., (2023) JWST molecular mapping and characterization of Enceladus water plume feeding its torus., Nature Astronomy

[3] Fletcher, L.N, King, O.R.T., Harkett, J., et al. (2023), Saturn's Atmosphere in Northern Summer Revealed by JWST/MIRI, JGR, submitted.

[4] Rivkin, A., Thomas, C.A., Milam, S.N., et al. (2023) Near to Mid–Infrared Spectroscopy of Didymos with JWST, PSJ, in press.

[5] doi: 10.1038/s41586-023-06152-y Kelley, M.S.P., Hsieh, H.H., Bodewits, D., Saki, M., Villanueva, G.L., Milam, S.N., Hammel, H.B., (2023) Spectroscopic identification of water emission from a main-belt comet, Nature

[6] Milam, S.N., Roth, N.X., Villanueva, G.L. et al., (2023) Morphology of Molecular Emission in Comet C/2022 E3 (ZTF) with JWST, Science, in preparation.

made new discoveries in its first year of science studying these small bodies and will continue to do so as new questions emerge from this preliminary data.

Within the first year of science JWST has already provided fundamental insight into the composition of solar system bodies, the distribution of volatiles and processed materials across the different reservoirs, and new insights into the formation of the solar system. This presentation will highlight some of the early science emerging for the solar system and implications for planet formation and evolution.