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JWST Reveals Phyllosilicates on the Small Inner Moons of Neptune

Ryleigh Davis[1], Matthew Belyakov[1], Michael Brown[1], and Ian Wong[2]
[1]Division of Geological and Planetary Sciences, California Institute of Technology, Pasadena, USA
[2]Space Telescope Science Institute, Baltimore, USA

In the 1980’s, Voyager 2 discovered the abundant satellites and complex ring systems around the ice giants, with 13 small moons around Uranus and 7 around Neptune. Limitations posed by their size and scattered light from their host planets have left the compositions of these bodies and their associated rings largely unconstrained and their origins remain a subject of debate. Proposed formation scenarios include in situ formation within a circumplanetary disk, re-accretion from impact-generated debris following giant collisions, tidal disruption of a passing KBO, and fragmentation from disrupted regular satellites. We present the first NIR spectra of Proteus, Larissa, Galatea, and the Neptunian rings acquired with JWST/NIRSpec (Program 4645).

Neptune's inner moons are compositionally distinct from those at Uranus and all other outer solar system small bodies and moons, with very little CO_2 and no clear signs of water-ice, despite a deep 3-μm OH-band. Surprisingly, Larissa, Galatea and the rings show a distinct 2.72-μm absorption band commonly seen on CM chondrites and main belt asteroids typically associated with phyllosilicates produced via post-accretional aqueous alteration, which requires temperatures drastically higher than expected at 30 AU. This is the first detection of such inner solar system like chondritic material past the orbit of Jupiter. One possible explanation is that these moons are the collisional remnants of an original regular satellite system that was destroyed during Triton’s capture. In this case, the presence of phyllosilicates may indicate that we are seeing material from the mantles of these originally differentiated moons, providing a unique window into the interior compositions of large differentiated outer solar system satellites. Further complicating this picture, the NIR spectra of the inner moons of Uranus- also obtained as part of our JWST observations – lack the hydrated minerals found at Neptune and instead appear similar to water-ice rich Kuiper belt objects. These spectra reveal fundamentally different surface compositions between the two systems, providing critical clues to their divergent formation and histories. We will combine this emerging compositional picture with our best understanding of the dynamical evolution of these satellite systems to explore possible origins of these moons and discuss implications for the early history of the ice giants.