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Searching for Transiting Exomoons around Free-Floating Planetary Mass Objects

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While we expect moons outside of our Solar System to be common based on our own Solar System's moon population and the predictions of satellite formation models, there have been no confirmed exomoon detections to date. JWST is collecting time-series observations of many free floating planets (FFPs) to study their weather, but these light curves are also the ideal datasets to search for exomoons that transit the FFP during observations. As a case study, we search for companions around WISE 0855 (T=250–285K, M=6.5±3.5M$_{Jup}$, d=2.3 pc), and demonstrate the overall sensitivity required to detect exomoons with JWST. We analyze 11 hours of time-series spectra from NIRSpec, and while we do not find statistical evidence of an exomoon transit in this dataset, injection and recovery tests of artificial transits for depths ranging between 0.1-1% allow us to explore the exomoon parameter space where we could successfully detect transits. For transit depths ≥0.5%, our detection rate is 96%, which, for WISE 0855, corresponds to a moon with a companion-to-host mass ratio similar to that of Titan and Saturn. Given our sensitivity, transit probabilities, and our observational duration, we determine a ~91% probability of detecting a Titan mass analog exomoon after 18 similar observations if every observed system hosts a Titan mass analog exomoon in a Galilean-like system. This suggests that JWST observations of dozens of FFPs could yield meaningful constraints on the occurrence rate of exomoons.

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