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Exomoon detection via photometric signal variability due to surface hotspots

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Given the large number of discovered exoplanets, it is expected that exoplanets host exomoons as well, however their detection still remains to be confirmed. Searches for extra-solar satellites are unveiling either upper limits on exomoon properties from a non-detection, moon related effects or candidate systems, that are met with skepticism. These searches are mostly focused around close-in gas giants, which according to orbital evolution models are less likely to host satellites. Proposed exomoon detection methods around directly imaged exoplanets are limited to binary-like satellites or tidally heated exomoons (THEMs) with extreme tidal heating rates. We present an exomoon detection method, to identify extra-solar moons with similar volcanic features as the ones seen in the Jovian moon Io, whose volcanic temperatures reach up to $\approx 2000\text{K}$. Such a surface hotspot/hotspots on a THEM produce photometric signal variability in infrared wavelengths, as they go in- and out- of our line-of-sight alongside the moon's orbit. We explore the conditions under which this periodicity is detectable in thermal IR lightcurves of BD and directly imaged exoplanets with 2 MIRI/JWST filters; one (shorter) to capture the moon's volcanic variability and one (longer) to observe the planet's behavior. We find that Earth-sized exomoons with hotspot temperatures $> 500\text{K}$ and Io-sized satellites with hotspot temperatures $> 1500\text{K}$ produce detectable signals around a $T_{\text{eff}} = 600\text{K}$ brown dwarf, at 3pc. In the exo-Io case the moon requires as well to be moderately tidally heated ($\approx 300\text{K}$). We explore the parameter space for different planets and system distances. Compared to the exomoon transiting method, this method requires similar observation times, but does not require transiting inclinations, thus expanding the parameter space for exomoon searches.