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Finding and characterizing ringed planets with polarimetry

D.M. Stam (1,2)

(1) SRON Netherlands Institute for Space Research, Utrecht, the Netherlands (2) Technical University Delft, the Netherlands (d.m.stam@sron.nl)

Polarimetry has been recognized as a strong tool for studying exoplanets: 1) because it can be used to distinguish direct starlight, which is unpolarized, from starlight that has been reflected by a planet, and which will generally be polarized, and 2) because the degree of polarization of the planet is sensitive to the physical characteristics of a planet. Polarimetry can thus be used both for finding and for characterizing exoplanets. An example of a polarimeter that is being build for exoplanet research is ZIMPOL, the Zurich Imaging Polarimeter, on SPHERE, the "Planetfinder" for ESO's VLT. Polarization signatures of exoplanets have been presented before. These show that exoplanets can be highly polarized, depending on the composition and structure of their atmosphere, and that the degree of polarization of a given exoplanet varies strongly with the planetary phase angle. Here we present calculated fluxes and in particular the degree of polarization of starlight reflected by gaseous exoplanets that are surrounded by unresolved rings. Our numerical calculations take into account scattering properties of non-spherical ring particles, multiple scattering by the ring particles, and the shadowing of the planet on the rings and of the rings on the planet. The ring systems we study vary from wide, Saturn-like rings to narrow, Uranus-like rings. Our results indicate that rings can significantly alter the phase angle dependence of a planet's polarization signal, depending on the physical properties of the ring system (particle properties, optical density, and horizontal extension) and on the viewing and illumination geometries (e.g. the ring obliquity angle, the ring opening angle, the longitude of the ascending node, the orbital inclination angle). Although the starlight rings reflect is generally polarized, it is only slightly so, compared to the degree of polarization of the planet. However, because rings can contribute significanty to the total reflected flux of the planetary system, they can change the degree of polarization of the system

(which is the ratio of polarized flux to the total flux). In particular, rings betray their presence by sharply changing the degree of polarization around the two locations in the planetary orbit where the rings are seen edge-on.