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Modelling the circular polarisation of Earth-like exoplanets: constraints on detecting homochirality

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The circular polarisation of light is a property of electromagnetic radiation from which extensive information can be extracted. It is oft-neglected due to its small signal relative to linear polarisation and the need for advanced instrumentation in measuring it. Additionally, numerical modelling is complex as the full Stokes vector must always be computed. Circular polarisation is commonly induced through the multiple scattering of light by aerosols [**?**] and multiple reflections of light by rough surfaces [**?**]. Most interestingly, distinctive spectral circular polarimetric behaviour is exhibited by light reflected by organisms due to the homochiral molecular structure of all known organisms [**?**]. Especially fascinating is the unique circular polarimetric behaviour of light reflected by photosynthesising organisms at the absorption wavelength of the chlorophyll pigment [**?**]. This presents the previously unexplored possibility of circular polarimetry as a method for identifying and characterising the presence of organisms, a method which could be applied in the hunt for extraterrestrial life.

To date, few telescopes exist that measure circular polarisation and none that have been deployed in space. Observations of the circular polarisation reflected by other planets in the solar system have been made with ground-based telescopes, with significant results [**?**]. However, none of these observations have been made at the phase angles at which exoplanets will be observed. Also, none have been made of the Earth, which is the logical starting point for the study of biologically induced circular polarisation signals. This introduces the need for numerical modelling to determine the extent to which circular polarisation is present in light reflected by exoplanets or the Earth.

In this study, we model the multiple scattering and reflection of light using the doubling-adding method [**?**]. We will present circular polarisation signals for both spatially resolved and spatially unresolved planets, using various atmospheric and surface properties and across a range of phase angles. As a test, the calculated degree of circular polarisation resulting from the multiple scattering of light in an atmosphere with varying properties was compared with results presented by Kawata [**?**] and was found to be in agreement.

Initial modelling of the atmospheric scattering of light by a planetary disk has shown a presence of degree of circular polarisation in the order of 10^{-4}. This represents a static case with one cloudy hemisphere, one cloudless hemisphere and a Lambertian surface. Results containing varied patchy cloud patterns shall also be presented in a bid to reflect the random nature of planetary cloud cover. We will also present the calculated degree of circular polarisation of planets with various cloud coverage and a circularly polarising surface in order to discover the influence of organisms on the numerical results.

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