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Earth-as-an-Exoplanet: Comparing Earthshine Observations to Models of an Exo-Earth

K. Gordon[1], T. Karalidi[1], P. A. Miles-Páez[2], D. M. Stam[3], K. M. Bott[4], W. Mulder[5]

[1]Department of Physics, Planetary Sciences Group, University of Central Florida, Orlando, FL,
[2]European Southern Observatory, Garching, Germany,
[3]Delft University of Technology, Delft, Netherlands,
[4]University of California, Riverside, Riverside, CA, [5]Leiden University, Leiden, Netherlands

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Traditional methods of exoplanet characterization that only make use of emitted or reflected flux lack the ability to fully distinguish between different physical features of the target, such as cloud layers, hazes, or surface features. Polarimetry, however, is a powerful, more sensitive technique that has this ability, as it measures light as a vector (by the orientation of the electric field) rather than a scalar intensity. It is therefore extremely sensitive to the composition and structure of the planetary atmosphere and surface, being affected by properties such as the mixing ratios of atmospheric absorbing gases, cloud optical thickness, cloud top pressure, cloud particle size, and surface albedo. Various groups have theoretically studied the optical linear polarimetric signals of Earth-like exoplanets as functions of both orbital phase and wavelength. With this project we assess the accuracy of these theoretical models against observations of the Earthshine, the only known observations of an Earth-like planet thus far. Using data of the atmosphere and surface taken by the MODIS instrument aboard the Terra and Aqua satellites, as well as surface reflectance spectra from the JPL EcoStress Spectral Library, we created a gridded model of the Earth. Then, using this model data as input for three separate radiative transfer algorithms, we generate the flux and linear polarization spectra for the model exoplanet-Earth across the optical to near-infrared wavelengths. We compare the results from all three codes to each other and to the observational linear spectropolarimetric data of the Earthshine obtained by a member of our group. We identify similarities and potential pitfalls between the codes, and make necessary adjustments to them, in an effort to improve our future characterizations of terrestrial exoplanets.