EPSC Abstracts
Vol. 17, EPSC2024-1020, 2024, updated on 18 May 2025
https://doi.org/10.5194/epsc2024-1020
Europlanet Science Congress 2024

On using polarization filters to build a high performance polarimeter/spectrometer

Justin Erwin, Filip Vanhellemont, Yannick Willame, and Séverine Robert
Belgian Institute for Space Aeronomie, Bruxelles, Belgium (justin.erwin@aeronomie.be)

Polarization is a topic largely neglected in spectroscopic investigation of planetary science. While true the degree of polarization is small in many observational situations, one can show that it has incur some bias in recent retrieval studies. Looking towards the future, with more high-performance spectrometers being sent to other planets, we would argue that future spectrometers should consider addressing polarization early in their design.

Polarization of light commonly occurs dues to scattering by surfaces, aerosols (e.g. clouds), and molecules. The different polarization states of light entering the spectrometer instrument can have different transmission efficiencies to arrive at the detector, leading to a polarization sensitivity of the instrument. The combination of these two mechanisms leads to an incorrect calibration of radiances used for science retrievals. Especially when the target absorption features and the polarization features are correlated/anticorrelated, this leads to an unknown error in the retrieval. One can adapt their end-to-end tool to characterize this error and include it in the total error budget.

One can include other elements in their design to correct for, or measure, the polarization. The simplest method might be to include a polarization scrambler early in the optical path. This would nullify the polarization sensitivity of the instrument. Then the retrieval tool can ignore polarization in the forward model completely. Still, in some cases, the forward model including or not including polarization can lead to large difference in the total radiance entering the instrument due to missing terms in scattering. Therefore, including a scrambler can still lead to some retrieval error. We present some estimations of this bias from recent Mars missions.

Alternatively, one can use a combination of polarized filters and perform simultaneous (or near simultaneous) observations of the reflected radiance. By combining these spectra and using the knowledge of (and some assumptions based on) the observation geometry, one can determine the total radiance and some elements of the polarization state. We will present different options for filter combinations and discuss their calibration accuracy and performance. We present some design options for a spectrometer going to Venus, with the trade offs that need to be considered. As a bonus, the polarization state is a result of properties of the scattering medium. So, for instance, it can be used to constrain the aerosol size and composition.