Polarimetry of Venus upper atmosphere with a new single-shot type polarimeter

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Polarimetry is a powerful mean of sensing aerosol properties in the upper atmosphere of Venus as demonstrated by Hansen and Hovenier (1974). They analyzed the ground-based linear polarization data of Venus (disk integrated) and found that the data were consistent with a uniform cover of sulfuric acid droplets of which effective radius and variance are 1.05 um and 0.07, respectively. In 1980' s, OCPP onboard Pioneer Venus Orbiter performed spatially-resolved imaging polarimetry, and studied in detail characteristics of aerosols and their variability (Kawabata et al. 1980; Knibbe et al. 1998; Braak et al. 2002).

Our team carried out polarimetric observations of Venus in 2012, 2014, and 2015 at Kyoto University's Hida Observatory, by attaching HOPS (Hida Optical Polarimetry System) to the 65-cm refracting telescope. The 930-nm data revealed rapid decrease of the polar haze from 2012 to 2014, while 435-nm data indicated change in cloud-top altitude in polar regions (Enomoto et al., in revision). HOPS is a traditional two-beam type polarimeter and thus requires a set of 4 images with the half-wave retarder plate rotated every 22.5 degrees to obtain the linear polarization vectors. From the ground, variable seeing condition during these 4 exposures is unavoidable and is major source of error when obtaining linear polarization.

A single-shot type polarimeter should therefore be advantageous for observations of planets as required exposure time is usually short and small spatial scale (~arcsecond order) matters. We are developing such a polarimeter by utilizing a "Wedged Double Wollastone (WeDoWo)" (Oliva, 1997) device as an analyzer. The device is composed of 6 precision-shaped calcite blocks: the first two (wedges) separate the incident light into two beams, and beams are subsequently separated to four beams of different polarization state ($I \pm Q$, and $I \pm U$). This allows us to obtain linear polarization vectors just in one shot. We plan to use this instrument during BepiColombo' s flyby to Venus (closest approach on 15 October 2020). There will be 4 instruments (UVI and LIR onboard Akatsuki, plus PHEBUS and MERTIS onboard BepiColombo/MPO) to observe the upper atmosphere of Venus but none has the polarimetric capability. Therefore, our observations with a new single-shot type polarimeter will complement observations from the space.

Keywords: shingle-shot polarimetry, Venus cloud, BepiColombo flyby