Near-Infrared spectro-polarimetry of Venusian upper cloud structuer

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In estimating structures of planetary atmosphere by means of remote sensing, simultaneous determination of various parameters is required. The problem doesn't get easier even for simple structure such as thin haze layer above thick cloud layer. In case that the size of cloud and haze particles is distinctively different, however, parameters of both layers should be determined by considering the wavelength dependence of the characteristics. In this paper, we propose such a technique and report a result obtained by adapting to Venusian atmosphere.
Spectro-polarimetry in near-infrared region is specific technique. Venusian main cloud consists of the cloud and haze particles, of which the radii are on the order of 1μm and sub-micron, respectively (Mie theory can be adopted). The advantages in near-infrared region (0.9μm<λ<2.5μm) are
(1) characteristics of the cloud is dominant because of rapid decrease of scattering cross-section of hazes, and
(2) a neutral point (point where the sign of polarization changes) exists and is easy to detect.
Using such characteristics, we can determine the parameters of the main cloud independently from hazes.
We calculated radiative transfer including polarization in semi-infinite cloud (cloud particle size is standard: r=1.05μm) in near-infrared region. The sign of polarization turned negative to positive with an increase of wavelength (hereafter we use λ_n as the transition wavelength). Additionally, when particle sizes were changed as r=0.8μm (small), 1.05μm, 1.5μm (large), λ_n were found at 1.81μm for standard particle, at 1.46μm for small particles, at 2.28μm for large particles. Therefore, the particle size within the range of 0.8μm< r <1.5μm can be determined by obtaining λ_n from spectro-polarimetric observations in J, H and K band (central wavelength is 1.25μm, 165μm and 2,2μm, respectively) range.
In order to validate this technique and to study the cloud properties of Venusian cloud, which we have recently detected rapid decrease of hazes on, we performed observations at Higashi-Hiroshima observatory / Hiroshima University from May 19 through 25, 2015. We used "HONIR"(Hiroshima Optical and Near-Infrared) instrument attached to "Kanata" telescope. Observing wavelengths are J, H and K bands. We observed Procyon (unpolarized standard star) for calibrations of mechanical polarizations caused in its optical system, and we verified that we don't need to do such calibrations. There are variations of 0.2% in the polarization degrees (P[%]), which means that measurement error is of such degree.
The inclination of obtained polarization spectra P(λ) of low latitude of Venus is dP/dλ~4.5%/μm. With the combination of dP/dλ and measurement error (±0.2%), we obtained determination accuracy ±0.05μm for λ_n. Since $d\lambda_n/dr$ is ~1.16, which is deduced by r dependence of λ_n obtained from model calculations described above, we finally have ±0.04μm in average for the determination accuracy of particle size. Obtained λ_n of Venus are λ_n=2.1μm for May 21, and λ_n=2.2μm for May 22, 24, 25. Those λ_n obtained on May 21 and the other days are similar to the results of model calculations for r=1.2μm and r=1.35μm, respectively. This result indicates the existence of larger particles compared with the particle size (1.05μm) of standard model (Esposito et al., 1983).
Rossi et al. (2014) reported some cases that model calculations for cloud particle size r=1.2μm is consistent with the near-infrared (λ~1.1μm, 1.27μm) polarimetric data of low latitude of Venus obtained in Apr. and May 2010 by SPICAV onboard Venus Express, we possibly detected such variations

in Venusian cloud.

Keywords: Venusian Upper Cloud, Spectro-polarimetry

