Imaging observation of Jupiter using liquid crystal variable filters in the near-infrared and visible spectral ranges

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A large optical depth of clouds obstructs us to observe the movement of the atmosphere under clouds directly. However we can investigate dynamics of the atmosphere indirectly, if we get information on rugged cloud top. Although horizontal motions of clouds have been investigated over 40 years since the 1960s, studies on the vertical structure of clouds started in the 1990s. Spectral observations are useful in order to know differences in cloud top altitudes because the methane and ammonia absorb specific wavelengths, consequently, it enable us to derive the vertical cloud structure from depths of methane and ammonia absorptions. In the past observations of clouds, however, fixed wavelength filters were used to obtain spectra at only several wavelengths corresponding to individual absorption bands. Recently the Galileo spacecraft took images and spectrum of Jupiter 30 wavelength in the wavelength from 410 to 5200 nm: However, this number of selected wavelengths is not enough for deriving detail cloud structures.

It is necessary to take images of Jupiter at a number of wavelengths to reproduce three-dimensional structures of clouds and haze. We have developed a new imaging system which can take cloud images of Jupiter at with high wavelength resolution. The most important component of this system is a liquid crystal variable filter covering the wavelength range of 650 - 1100 nm with a bandwidth (FWHM) of 10 nm. Using this filter and a cooled high-speed CCD camera (PixelVision, 652x494 pixels), we can obtain the cloud images of Jupiter in the range of 650 - 1100 nm in a short time period. Since the center wavelength of this variable filter can be selected at 1 nm intervals, images at 451 wavelengths can be available. This imaging system was attached in the 60 cm visible and near-infrared reflecting telescope installed at Iitate observatory, Fukushima. Using this facility we conducted spectral observations of Jupiter on June 7 and July 15, 2004. The center wavelength of the filter was shifted by 5 nm, for the range of 650 - 1000 nm. We obtained Jovian cloud images at 71 wavelengths and 50 images were taken at each wavelength. To reduce the influence of atmospheric turbulence, the exposure time of 150 ms was selected. To correct absorption effect due to the atmosphere of the Earth and the characteristics of the instrument in wavelength, a star with the A0V spectral type Vega was observed in the same operation mode.

Good quality images were selected from the 50 images at each wavelength, and stacked after correction of position's gap due to the atmospheric turbulence. By correcting the image data of Jupiter, we obtained a spectrum at each region of Jupiter's disk. The results of these observations will be reported and discussed. In the near future we will calculate detail cloud and haze structures of all over Jupiter based on this technique. We will also discuss about an application of this developed system to balloon-borne and satellite-bone telescopes for observations of planetary atmospheres.