10 micron dust emission spectra of beta Pic and their spatial distribution by Subaru/COMICS

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Through planetary system formation, dust grains play an important role. Silicate dust grains are as abundant in space as carbonaceous dust grains. They show many band features in the mid- to the far-infrared region according to their chemical composition and crystalline conditions. For example, some comets and interplanetary dust particles in the solar system contain crystalline silicate grains. For extrasolar objects, beta Pic, a Vega-like star suspected to have an extrasolar planetary system, shows a spectrum containing a crystalline silicate feature Knacke et al. 1993, ApJ, 418, 440). Vega-like stars already reached the main sequence and it is suggested that their circumstellar dust grains are not remainings of the primary dust grains in the proto-planetary disk but the secondary products from larger bodies. (So the disks of Vega-like stars are called as ""debris"" disks.) In contrast, most YSOs, that is T Tauri stars and Herbig Ae/Be stars which have proto-planetary disks still under star formation, show 9.7 and 18 micron broad band features corresponding to amorphous silicate grains. However for some YSOs crystalline silicate features were found recently. For instance, Short Wavelength Spectrometer on board Infrared Space Observatory discovered the prominent features due to crystalline forsterite toward HD100546, a Herbig Be star. In addition, Cooled Mid-Infrared Camera and Spectrometer (COMICS) on Subaru Telescope also found crystalline forsterite features toward an old T Tauri star, Hen3-600A.

Some mechanisms to crystallize the silicate grains have been proposed: heating by central star radiation and succeeding circulation to outer disks, heating by shock wave within the disks, and the heating due to chemical reaction within dust mantles. Observations of the radial distribution of the crystalline/amorphous grains would provide key information on which crystallization process occur within the proto-planetary and/or debris disks. We made observations of beta Pic with COMICS on 8m Subaru Telescope to take its 10 micron spectra. Beta Pic is an A5V star located at 19.28pc from the sun. Its 10 micron spectrum with spectral resolution (R) of 70 shows the 11.2 micron crystalline silicate feature in addition to the 9.7 micron amorphous silicate feature. To investigate the radial distribution of these and the other silicate features, we put the COMICS slit along the disk of beta Pic and make R=250 spectroscopy and took not only the spectra of the central star position but also the spectra at different positions along the disk. From the data, disk emission extends to at least 5 arcsec outside the star. By subtracting the model stellar spectra synthesized from the PSF determined from the standard star spectroscopy on the same nights, we obtain the dust emission spectrum at each disk position. Then from the spectrum integrated over central 5AU radius, 10.06, 10.42, 11.89 micron emission peaks due to crystalline forsterite grains are clearly detected. The spectrum also has a peak at 11.05 micron shifted from the 11.24 micron peak of the crystalline forsterite. It is the first clear detection of the crystalline forsterite features including sub-features. Although emission between 10.06 and 11.05 micron is caved in for the central spectrum, spectra for outer regions show flatter-shaped emission in this wavelength range. The central and outer regions of the disk may have different composition and/or size distribution of the dust grains.

In this presentation, we report the obtained spectra of beta Pic and their spatial distribution and discuss the suggested mechanism of crystallization through the planetary system formation.