Observation proposal for solar system bodies by using the ALMA

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Planetesimals have played an important role in the evolution process of the solar system as bodies that have related to the late heavy bombardment and the late veneer hypothesis as well as planetary formation. The remnants of planetesimals to the present are asteroids and comets. Revealing the shape of asteroids become clues to elucidate the history of planetesimals that have experienced collision, destruction and coalescence from the era of planet formation to the present. Besides, outer planets' satellites provide the key information about the origin of ice and organic materials. Plumes have detected on Jupiter's satellite Europa and Saturn's satellite Enceladus (Roth et al. 2014; Porco et al. 2006). If we monitor of the plumes for a long term and reveals the composition, temperature, distribution and abundance, we would obtain the clues to make clear the inner activity of the satellites and how the ice and organic materials distributes in the solar system.
The high spatial resolution of the ALMA (Atacama Large Millimeter/submillimeter Array) helps us to address these topics. The shape of asteroids has been shown directly by the probe explorations and the large telescopes equipped with AO (Adaptive Optics). However, the probe explorations needs with a large amount of budgets. Nevertheless the Keck telescope equipped with AO reveals the shape of several dozen asteroids (Marchis et al. 2006), the observed asteroids limit to the diameter of larger than 100 km. Although the TMT (Thirty Meter Telescope) equipped with AO will increase the target asteroids, the first light day of the TMT will be after 2020. Therefore, the ALMA is the most suitable observation instrument to reveal the shape of asteroids. The figure shows the spatial resolution for the ALMA, the Keck+AO and the TMT+AO. The spatial resolution of the ALMA exceeds that of the Keck+AO. The ALMA is able to deduce the shape of larger than 50 km asteroids that locate in the main belt region. The number of target asteroid reaches 163. On the other hands, the shape of asteroids has been shown indirectly by the lightcurve inversion method (Kaasalainen and Torppa 2001). The lightcurve inversion method derives the most adequate shape model and the corresponding direction of total rotational angular moment using the time-series photometry data, so-called lightcurve. The lightcuve inversion method makes it possible to estimate the shape of small asteroids on the condition that the data archives enough photometric accuracy. Recently, the ADAM (All-Data Asteroid Modeling Concise) algorithm has been released (Viikinkoski et al. 2015a). The ADAM deduced more accurate shape model by combining with disk-resolved data (adaptive optics or other images, interferometry, and range-Doppler radar data), disk-integrated data (photometric lightcurve), and occultation timings (sparse silhouettes). For example, the image of (3) Juno was improved by the combined with ALMA data and VLT+AO data (Viikinkoski et al. 2015b). When the shape of various asteroids is estimated by the ADAM algorithm, we are able to discuss the shape of asteroids, statistically.
The high spatial resolution of ALMA would also deduce the local temperature distribution on the surface of outer planet's satellites. The long term monitoring by the ALMA for the Europa and the Enceladus might show the change of inner activity for such satellites. In addition to it, the ALMA has a possibility to detect plumes on the other outer planet's satellites.
This presentation gives the observation proposals for asteroids and outer planet's satellite. On the basis of our observation proposals, we would like to discuss with many scientists for the science of solar system bodies by using the ALMA.

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