Trans-neptunian objects (TNOs), a small body population beyond Neptune's orbit, were formed at low temperature of a few 10 K in the distant region from the Sun. H₂O ice is the most abundant volatile material of these bodies and should originally have been in the amorphous phase. However, crystalline H₂O ice has been detected from almost all TNOs of which the near-infrared spectra were obtained in high quality, such as (50000) Quaoar [1]. The transition from amorphous to crystalline ice requires heating up to ~100 K. Although several hypotheses for H₂O ice crystallization on the surface of TNOs have been suggested, including radiogenic heating [2], cryovolcanism [3], and micrometeorite impact annealing [4], the mechanism remains unclear. It is important to investigate homogeneity/diversity of the surface abundance of crystalline H₂O ice among TNOs and its relationships with the orbital elements and body size for revealing the crystallization processes.

Crystallinity of H₂O ice can be determined by strength of the diagnostic absorption at 1.65 μm. However, most TNOs are too faint to acquire the near-infrared spectra with sufficiently high S/N ratio even by large-aperture telescopes. Therefore, we introduced a photometric method using Subaru/MOIRCS and the narrow band NB1657 with the center wavelength of 1.657 μm, allowing us to measure the fraction of crystalline H₂O ice on TNOs precisely and efficiently [5]. We obtained the imaging data with H and NB1657 filters for six TNOs which were known to contain H₂O ice on the surface. As a result of comparison between the measured H–NB1657 indexes and those estimated from the model spectra, all of the target TNOs except for (38682) Huya showed more than 50 % crystallinity (see Figure 1).

It is interesting that crystalline H₂O ice has been detected from not only the large-size TNOs including (136108) Haumea, (50000) Quaoar, and (90482) Orcus, but also from the relatively small objects, (315530) 2008 AP₁₂₉ and (42355) Typhon. It is difficult to explain the surface crystallization of such small-size objects by cryovolcanism or radiogenic heating with long-lived isotopes (e.g., ⁴⁰K), but, the decay of short-lived isotopes (e.g., ²⁶Al) could induce sufficient heating [2].

We also found that while H₂O ice on Haumea and Quaoar is highly dominated by the crystalline state, Orcus has only ~50 % crystallinity. The low bulk density of Orcus (~1.5 g cm⁻³) could cause suppression of the surface heating and stagnation in crystallization.

References