According to the widely accepted unified model of active galactic nucleus (AGN), a mass accreting supermassive blackhole is surrounded by a toroidally-distributed dust and gas, the so-called torus. Various observational properties of AGNs can naturally be explained by different viewing angle toward the torus. However, since the torus is very compact in size (< 10 pc or < 0.15” at distance ~15 Mpc), its observational understanding is still highly incomplete. ALMA is expected to play an important role for its observational understanding, thanks to its very high angular resolution.

We have observed the nearby well-studied AGN, NGC 1068 (z=0.0037, distance is ~14 Mpc) using ALMA at the HCN J=3–2 (265.89 GHz) and HCO+ J=3–2 (267.56 GHz) lines. The achieved angular resolution is 0.1” × 0.2”. Molecular gas observations of NGC 1068 have previously been conducted with > 0.5” angular resolution, but molecular gas emission at the location of the putative AGN torus has not been clearly revealed, because it is overwhelmed by the nearby, very bright molecular gas emission at the eastern side of the host galaxy. Thanks to our new very high angular resolution ALMA data, we successfully detected molecular gas emission at the putative AGN torus location (C-peak in Figure 1), by clearly separating from the nearby bright molecular gas emission in the host galaxy [1]. The estimated dense molecular gas mass and size are several × 10⁵ M☉ and ~10 pc, respectively, both of which are roughly comparable to theoretically predicted values.

We have also detected the possible sign of molecular gas emission which bridges between the eastern bright molecular gas emission knot and the AGN position (Figure 1). We may be witnessing the theoretically argued molecular gas supply from the host galaxy to the torus. Additionally, we found that the HCN-to-HCO+ flux ratios at J=3–2 in the central several arcsec regions of NGC 1068 are high, as seen in AGN-important regions (Figure 2). This supports the previously argued scenario that physical conditions at the NGC 1068 nuclear regions are dominated by AGN activity. However, thanks to the very high sensitivity of ALMA, we have also detected continuum emission at several off-nuclear regions, suggesting the presence of weak (~10 % of AGN luminosity), but a detectable amount of star-formation activity in the central several arcsec of NGC 1068.

Reference

Figure 1: Integrated intensity maps and velocity profiles, at selected positions, of HCN J=3–2 (Upper) and HCO+ J=3–2 (Lower) in the NGC 1068 nucleus.

Figure 2: Spectra at the representative positions (shown in Figure 1) in NGC 1068.