On the Disappearance of a Cold Molecular Torus around the Low-luminosity Active Galactic Nucleus of NGC 1097

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The unified scheme of active galactic nuclei (AGNs) postulates that the existence (type-1) or absence (type-2) of a broad line region depends on the viewing angle of an optically and geometrically thick dusty/molecular torus [1]. However, the physical origin of the high-velocity dispersion or the vertical height of a torus is still being debated. At the circumnuclear ~ 10–100 pc scales, energy feedback from supernova explosions and radiation-driven outflows from the AGN itself can be candidate mechanisms [2,3].

In order to study the torus properties in more detail, we used the Atacama Large Millimeter/Submillimeter Array to map the CO(3–2) and the underlying continuum emissions around the type-1 low-luminosity active galactic nucleus (LLAGN; bolometric luminosity < 10^{42} erg s^{-1}) of NGC 1097 at ~10 pc resolution [4]. These observations revealed a detailed cold gas distribution within a ~100 pc of this LLAGN (Figure 1a). In contrast to the luminous Seyfert galaxy NGC 1068, where a ~7 pc cold molecular torus was recently revealed [5], a distinctively dense and compact torus is missing in our CO(3–2) integrated intensity map of NGC 1097, at its AGN location. Based on the CO(3–2) flux, the gas mass of the torus of NGC 1097 would be a factor of ~ 2–3 less than that found for NGC 1068 by using the same CO-to-H_2 conversion factor, which implies less active nuclear star formation and/or inflows in NGC 1097, i.e., an energy source to support the torus thickness would be missing in this LLAGN. To better confirm this view, we performed a dynamical modeling of the CO(3–2) velocity field to decompose the rotation component (V_{rot}) and dispersion component (σ) with tilted-rings (Figure 1b). We then found that NGC 1097 hosts a geometrically thinner torus than NGC 1068, indeed, as reflected by the σ/V_{rot} ratio (a surrogate of the disk aspect ratio; Figure 1c). Although the physical origin of the torus thickness remains unclear, our observations support a theoretical prediction that geometrically thick tori with high opacity will become deficient as AGNs evolve from luminous Seyferts to LLAGNs.

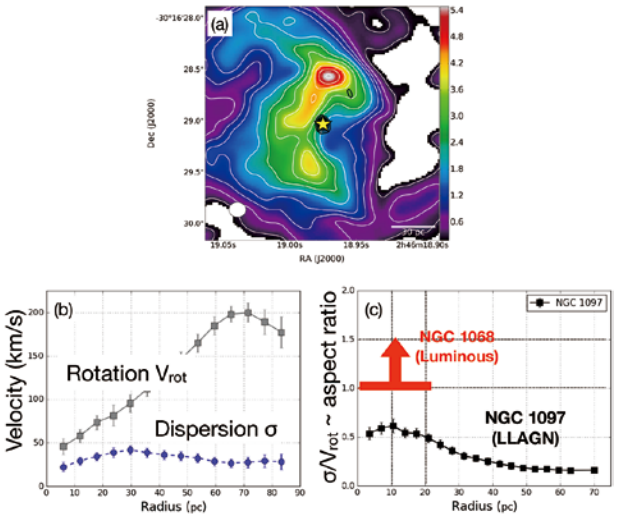

Figure 1: (a) Global spatial distribution of the CO(3–2) integrated intensity in the central ~130 pc of NGC 1097. The central star marks the AGN location. No clear gas concentration was found at the AGN position, indicating the deficit of the molecular torus. (b) Radial profiles of the rotation velocity (V_{rot}; squares) and the velocity dispersion (σ; circles) derived from the CO(3–2) line data with tilted-ring models. (c) Radial profiles of the σ/V_{rot} ratio derived from the CO(3–2) line of NGC 1097. The ratio of NGC 1097 is well smaller than that of the luminous AGN of NGC 1068.

References

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