Ultraluminous infrared galaxies (ULIRGs; \(L_{\text{IR}} > 10^{12} L_{\odot}\)) are formed by gas-rich galaxy mergers and are shining brightly in the infrared due to thermal emission from dust heated by deeply buried starbursts and AGNs (= mass-accreting supermassive black holes; SMBHs). Distinguishing the hidden energy sources of ULIRGs is important to understand the star formation and SMBH mass growth during galaxy mergers. Since starbursts and AGNs have different energy generation mechanisms, physical and chemical effects to the surrounding molecular gas should be different. It is expected that starbursts and AGNs can be distinguished based on molecular rotational J-transition line flux ratios at the (almost) dust-extinction-free (sub)millimeter wavelength range.

It has been argued that HCN rotational J-transition line fluxes, relative to HCO\(^+\), are stronger in AGNs than in starbursts. Possible reasons include (a) high HCN abundance in AGNs, and (b) vibrational excitation of HCN by infrared radiative pumping (by absorbing 14 \(\mu\)m photons) and the increase of the rotational J-transition line fluxes at the vibrational ground level due to decay back. IRAS 20551−4250 (\(z=0.043\)) is a ULIRG which contains a luminous buried AGN and shows a higher HCN-to-HCO\(^+\) flux ratio than starbursts (Figure 1). Thanks to small molecular line widths, vibrationally excited HCN and HNC emission lines were clearly detected ([1]), so that this ULIRG is a good target to quantitatively estimate the contribution from (b). We have observed this ULIRG at multiple J-transition lines of HCN, HCO\(^+\), and HNC (Figure 2), and obtained the following results. (1) Main to isotopologue molecular line flux ratios at \(J=3–2\) is smaller for HCN than HCO\(^+\) and HNC, due to larger line opacity of HCN. An enhanced HCN abundance is suggested. The intrinsic HCN-to-HCO\(^+\) flux ratios corrected for line opacity in IRAS 20551−4250 will increase, further deviating from starbursts. (2) High-J to \(J=1–0\) flux ratios are higher for HNC than HCN (Figure 3, left), which cannot be explained by collisional excitation. Inclusion of infrared radiative pumping, by putting an AGN at 30–100 pc from molecular gas, can largely explain this result (Figure 3, right). However, the infrared radiative pumping rate is comparable for HCN and HCO\(^+\), so that this is not a main mechanism to enhance the HCN-to-HCO\(^+\) flux ratios [1].

Reference