A systematic study of dust in the harsh environments of AGNs with AKARI, Spitzer, and JWST infrared spectroscopy

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In general, active galactic nuclei (AGNs) in their early evolutionary phases are surrounded by dense clouds in the circumnuclear regions. In such early phases, the activity of AGNs is usually quite high, and thus expected to significantly influence the physical and chemical properties of the dust in the clouds surrounding AGNs through mechanical shocks by energetic jets and irradiation by high-energy photons. Indeed, it is observationally known from past studies that, for instance, the crystallinity of silicate grains in AGNs tends to be high, while the abundance of polycyclic aromatic hydrocarbons (PAHs) is considerably low, as compared to the properties of interstellar dust typical of the diffuse ISM in our Galaxy or usually observed in star-forming galaxies.

In this presentation, we show the results of our systematic study on the properties of silicate and hydrocarbon dust under the influence of the AGN activity, which are revealed by Spitzer mid-infrared and AKARI near-infrared spectroscopy for about 100 infrared-bright AGNs. We find that the crystalline mass fractions of the total silicate are significantly high, 5.8% on average, for the AGNs, compared to 1.4%, a value along the line of sight toward Sgr A* in our Galaxy, while the amorphous pyroxene mass fractions of the total silicate are significantly low, 5.1% on average, for the AGNs, compared to 17%, a value typical of the diffuse ISM in our Galaxy. We also find that the aliphatic-to-aromatic ratios of hydrocarbons are systematically higher for the AGNs than for star-forming galaxies, which tend to increase with the AGN activity traced by the hot dust emission, with the aliphatic emission features at 3.4 - 3.6 μm showing unusual profiles stronger at longer wavelengths as compared to those of star-forming galaxies. Hence the silicate and hydrocarbon dust in the AGNs both seem to be processed significantly in the circumnuclear regions, their properties changed through the AGN activity.

Based upon those results, we suggest that the crystalline-rich and pyroxene-poor tendencies of the silicate in the AGNs may be attributed to crystallization and differentiation through heating processes related to the AGN activity, while the relatively abundant aliphatic hydrocarbon dust with the unusual spectral emission features may come from a new population created through mechanical processes such as shattering of large carbonaceous grains by AGN outflows. In order to verify the hypothesis, a spatially-resolved study using the JWST data is crucial; several AGNs in our sample have already been observed with JWST. In this presentation, therefore, we also show a tentative result of our analysis on the spatial variations of the silicate and hydrocarbon features utilizing the JWST archival data.