Mineralogical properties of dust in heavily obscured AGNs and their implications for the evolution of circumnuclear material

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In general, many of active galactic nuclei (AGNs) in their early evolutionary phases are deeply embedded in and heavily obscured 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 material surrounding AGNs through mechanical shocks by energetic jets and irradiation by high-energy photons. The properties of the material thus influenced, in turn, can be an important probe to investigate obscured AGN activity and even trace back the history of the activity.

In this study, we aim to obtain mineralogical properties of silicate dust in nearby heavily obscured AGNs systematically, using the Spitzer/IRS 5 - 30 μm low-resolution spectral data. We selected the sample from the archival data by the following three criteria: (1) the apparent optical depth of the 10 μm silicate feature larger than 1.5, (2) the equivalent width of the 6.2 μm PAH feature smaller than 270 nm and (3) the redshift lower than 0.35. The sample thus selected comprises the mid-IR spectra of 98 heavily obscured AGNs, which are fitted by semi-physical models using a one-dimensional radiative transfer calculation with four dust species of different sizes and porosities. The opacity of the dust is calculated in detail, based on the laboratory optical data of amorphous olivine, amorphous pyroxene, crystalline olivine and amorphous carbon.

As a result, our models reproduce all the spectra notably well over the broad wavelength range of 5 - 30 μm. We find that 95 out of the 98 AGNs prefer a porous silicate dust model with absence of micron-sized large grains. The mineralogical parameters of the silicate dust derived by the fitting vary significantly from AGN to AGN; the mass ratio of amorphous pyroxene to total amorphous silicate is distributed between 0 - 40%, while that of crystalline to total silicate is between 0 - 14%. For the pyroxene mass fraction, the median and the 84 percentile of the distribution are 5.1% and 11.6%, respectively, which are significantly lower than 17%, a value typical of the diffuse ISM in our Galaxy. For the crystalline mass fraction, those are 5.8% and 8.2%, which are significantly higher than 1.4%, a value along the line of sight toward Sgr A* in our Galaxy. Overall, high porosity, small sizes, pyroxene-poor composition and high crystallinity are obtained for mineralogical properties of the silicate dust in heavily obscured AGNs. Those trends suggest that much of the dust is newly formed one originating from recent circumnuclear starburst activity, some of which has undergone crystallization processing through AGN activity.

In this presentation, we discuss the implications of the mineralogical properties of the silicate dust derived from the low-redshift bright sample of the 98 heavily obscured AGNs for the evolution of the circumnuclear material and also for that of the heavily obscured AGNs themselves. For further studies, we expect JWST for fainter AGNs and future far-IR missions like PRIMA (PRobe far-Infrared Mission for Astrophysics) for higher-redshift AGNs.