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Study of the evolution of interstellar dust by IR microspectroscopy of interstellar dust analogs: comparisonwith astronomical data

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Beamline(s): U4IR

Introduction: During their lifetime, interstellar silicate dust grains can be found in various astronomical objects such as circumstellar shells around old and young stars, in the Solar Sytem, in the interstellar medium (ISM). Recent results from the Infrared Space Observatory (ISO) show that the infrared (IR) spectroscopic properties of the silicate dust are different in these different environnements, suggesting that their chemical and structural properties evolve [1-2]. Interplanetary Dust Particles (IDPs) represent unique samples for the study of cosmic dust as they are, with meteorites the only extraterrestrial materials in astrophysicists hands. Some of them may have an interstellar origin [3]. The others represent very pristine grains dating from the formation of the Solar System.

Methods and Materials: Various interstellar dust analogs and 5 IDPs were analysed by infrared microspectroscopy in the 2-50 µm range. The IDPs were collected by aircraft-borne experiments by the NASA, their size was approximately 10x10 µm. The interstellar dust analogs were 50-200 A thick microtome slices of submicronic silicate grains embedded in epoxy.

Results: We have analysed various samples of crystalline silicates (forsterite, enstatite, diopside) which have been submitted to He^+ irradiation at 4 keV. The irradiation were performed in order to simulate the physical processing caused by supernovae explosion that interstellar dust grains undergo in the ISM [4]. The spectra show that the all the samples are amorphized by the irradiation. This confirms preliminary analysis by electron diffraction, however it appears that IR microspectroscopy is more sensitive to probe to structural alteration of minerals. Figure 1 shows a typical spectrum of amorphized enstatite compared with the ISO spectrum of the interstellar dust in the direction of the Galactic Center (GC IRS7). The abscence of structure of the two bands at ~ 1000 and ~ 450 cm^{-1}, due respectively to the stretching and bending of the O-SI-O bond in the silicates, reflects the amorphous structure of the dust in GC IRS7 and of the irradiated enstatite. The position and width of the amorphized enstatite bands are in good agreement with the astronomical bands. To understand the discrepancy in the band it is necessary to take into account radiative transfer effect in the interstellar spectrum. However these results show that grains in the ISM are a composition and structure similar to that of irradiated enstatite.

We successfully measured the spectra of 2 IDP in the 2-50 µm range. Figure 2 shows the IR spectrum of one of them. From comparison with the spectrum of crystalline forsterite we conclude that this IDP is mainly composed of forsterite. The other IDP was mainly composed of pyroxene. Spectra of the 3 other IDPs do not exhibit any strong spectral features. It is not yet clear whether this is due to composition or to the very small size of the IDPs or to experimental effect.

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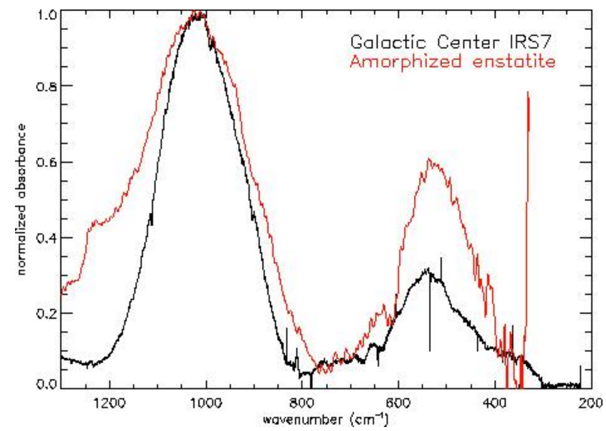

Figure 1: comparison of the IR spectrum of amorphized entatite, measured at the U4IR beam line, with the spectrum of interstellar dust observed in the ISM in the direction of the Galactic Center, taken by the ISO satellite.

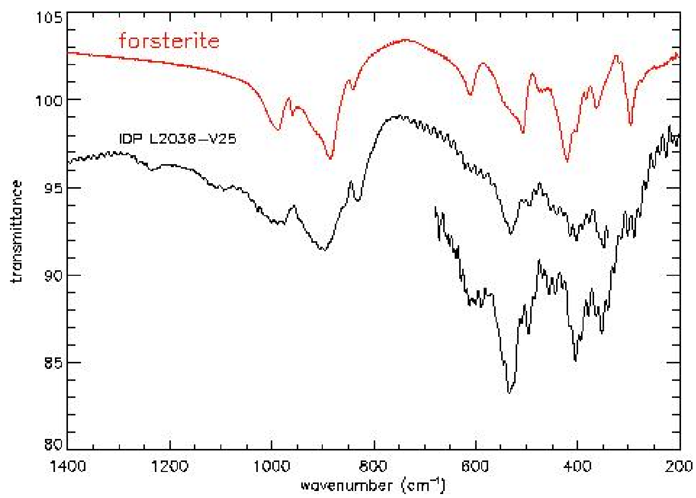

Figure 2: IR spectrum of an IDP (10 μm size), measured at the U4IR beam line, compared with the spectrum of crystalline forsterite. The two traces in the IDP spectrum correspond to different detectors.