Laboratory measurements of the far-infrared to millimeter dust opacity of amorphous Mg/Fe silicates

Pierre Mohr (AIU, Friedrich Schiller University Jena), Harald Mutschke (AIU, Friedrich Schiller University Jena), Frank Lewen (I. Phys. Inst., Univ. of Cologne) and Alexey Potapov (I. Phys. Inst., Univ. of Cologne)

We present laboratory measurements of the wavelength-dependent dust opacity for amorphous Mg/Fe-silicate particles in the far-infrared and microwave ranges. Amorphous silicates represent very likely the most abundant dust species in interstellar space. We produce analogs to these dust grains by melting and quenching of appropriate precursors. The chemical composition of our samples is checked using SEM-EDX and electron microprobe analysis.

We have measured the absorption spectra of a variety of samples with a variable Mg/Fe ratio in the wavelength range between 50 micrometers and 4 millimeters and at temperatures between 300K and 7K. For that purpose we used an FTIR-spectrometer and a custom-built total-power microwave spectrometer, which recently delivered first (still preliminary) results.

In all our measurements we can observe a clear temperature dependence of the opacity. This behavior is already reported by other authors (e.g. Boudet et al. 2005, Coupeaud et al. 2011). The cause thereof is related to the microstructure of amorphous silicates, but is not yet fully explored. In addition, we found a dependence of the opacity on the Mg/Fe-ratio. Starting from pure magnesium silicate, the opacity is decreasing with increasing iron content, but at a certain amount of iron the trend is inverted and the integration of still more iron leads to an increment of the opacity. This effect is probably due to the presence of Fe-ions with different oxidation states. In contrast to divalent ions, trivalent ones can act as both network formers and network modifiers. This affects the microstructures and thereby the absorption properties of a compound.

Because in our experiment it is currently impossible to avoid the oxidation of some fraction of the iron, a detailed characterization of the structure is inescapable. For that purpose we are using Mössbauer spectroscopy to determine the Fe^{2+}/Fe^{3+}-ratios of our samples. We plan to expand the structural investigation by further analytical methods such as Raman spectroscopy and high resolution transmission electron microscopy.

References:

Boudet, N., H. Mutschke, C. Nayral, C. Jäger, J.-Ph. Bernard, Th. Henning, C. Meny 2005, ApJ, 633, 272

Coupeaud, A., K. Demyk, C. Meny, C. Nayral, F. Delpech, H. Leroux, C. Depecker, G. Creff, J. B. Brubach, P. Roy 2011, A&A, 535, 124