EPSC Abstracts
Vol. 13, EPSC-DPS2019-1510-1, 2019
EPSC-DPS Joint Meeting 2019

EPSC
EPSC-DPS Joint Meeting 2019
15–20 September 2019 | Geneva, Switzerland

Temperature Dependent Laboratory Measurements of the Far-Infrared to MM Opacities of Amorphous Carbonaceous Dust Analogues

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Abstract

We are measuring and analysing the FIR- and THz-spectra of pyrolysed cellulose as an analogue of carbonaceous dust. We are using cellulose-powder with a crystal size of $20\,\mu$m and pyrolyse it with temperatures up to $T_{\mathrm{Pyr}} = 1000°$C. As the opacities vary with the temperature, the samples are cooled down to $T_{\mathrm{c}} = 10\,$K.

Our aim is to assess carbonaceous dust analogues in terms of structure, nature and morphology. For theoretical and observational investigation we are going to determine their optical constants. Furthermore, we are going to calculate the emission cross section of particles with different geometries to compare them with the measured results.

1. Scientific Objective

Data of various dust species obtained in the laboratory are needed to interpret observational and theoretical investigations in order to study debris disks, small body systems, but also protoplanetary disks and interstellar matter. As observations of these objects in the far infrared (FIR) and THz regime of the electromagnetic spectrum has become a major part in astronomy, we want to characterise the opacities of carbonaceous dust analogues in this wavelength regimes. Our aim is to assess carbonaceous dust analogues in terms of structure, nature and morphology to study their optical properties.

Moreover, the optical properties of carbonaceous materials vary with the temperature as it is shown in Fig. 1. Thus, we cool the samples to temperatures of $T_{\mathrm{c}} \in \{300\,\mathrm{K}, 200\,\mathrm{K}, 150\,\mathrm{K}, 100\,\mathrm{K}, 50\,\mathrm{K}, 20\,\mathrm{K}, 10\,\mathrm{K}\}$ for the spectroscopic measurements.

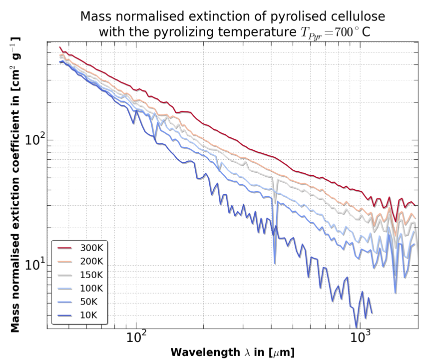

Figure 1: This figure shows the mass normalised extinction of pyrolysed cellulose at $T_{\mathrm{Pyr}} = 700°$C cooled to different temperatures.

2. Carbonaceous Dust Analogues

We used pyrolysed micro-crystalline cellulose as an analogue of amorphous carbonaceous dust. In order to obtain material of various degrees of carbonisation, we pyrolysed $20\,\mu$m sized, micro-crystalline cellulose at $T_{\mathrm{Pyr}} \in \{400°\mathrm{C}, 500°\mathrm{C}, 600°\mathrm{C}, 700°\mathrm{C}, 800°\mathrm{C}, 900°\mathrm{C}, 1000°\mathrm{C}\}$. As we want to obtain dust particles, the pyrolysed cellulose was milled to produce (sub-) micrometer sized particles, which were embedded into a polyethylene pallet as a matrix for FIR- and THz- spectroscopy.

3. Experimental Set-Up

For reflectance and transmittance spectroscopy we used a Fouier-transform infrared interferometer (FTIR; Bruker 113v), a time-domain terahertz spectrometer (TD-THz; TerraFlash, TOPTICA) and a mm-wavelength spectrometer (MMS) [3] for the wavelength ranges $\lambda_{\text{FTIR}} \in \{45\,\mu\text{m}, 500\,\mu\text{m}\}$, $\lambda_{\text{TD-THz}} \in \{85\,\mu\text{m}, 2000\,\mu\text{m}\}$ and $\lambda_{\text{MMS}} \in \{2000\,\mu\text{m}, 4000\,\mu\text{m}\}$ respectively. The samples were placed in a cryostat positioned in the beam of the spectrometers to obtain the temperature dependent measurements.

4. Summary

We are measuring and analysing the FIR- and THz- Spectra of pyrolysed micro-crystalline cellulose as an analogue of carbonaceous dust. We are using cellulose-powder with a crystal size of $20\,\mu$m and pyrolyse it with temperatures up to $T_{\text{Pyr}} = 1000°$C. First results of the mass normalised extinction are presented and compared to Jäger et al. (1998)[1]. The temperature dependent measurements took place in a dry environment and the samples were cooled to temperatures of $T_{\text{C}} \in \{300\,\text{K}, 200\,\text{K}, 150\,\text{K}, 100\,\text{K}, 50\,\text{K}, 20\,\text{K}, 10\,\text{K}\}$.

Our aim is to assess carbonaceous dust analogues in terms of structure, nature and morphology. For theoretical and observational investigation we are going to determine their optical constants. Furthermore, we are going to calculate the emission cross section of particles with different geometries to compare them with the measured results.

Acknowledgements

We wish to thank G. Born and S. Bock for the help with the sample preparation and measurements. This work is supported by the DFG under the grant numbers MU1164/8-2 and MU1164/8-2 within the priority programme SPP 1573 “Physics of the Interstellar Medium“ and the research unit FOR 2285 “Debris Disks in Planetary Systems”.

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