Broadband spectroscopy of astrophysical ice analogues: reconstruction of CO and CO_2 ice optical properties

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Observational data in the millimetre and sub-millimetre range are increasingly available and can advance our understanding of the properties of dust and ice mantles in star- and planet-forming regions. To properly interpret these observations, one needs to combine models, theory, and laboratory experiments to put all the pieces of the bigger context together. For example, observations of dust continuum emission toward pre-stellar cores and protoplanetary disk mid-plane, where thick icy mantles are known to be present around dust grains, can be misinterpreted if information on dust opacities is missing. Although essential for this purpose, direct measurements of optical properties of astrophysical ice analogues in the infrared and terahertz (THz) ranges are not available in the literature and interpretation of the ice continuum relies on calculated opacity values, such as those tabulated by Ossenkopf & Henning (1994) [1].

In this work, we use two experimental techniques to obtain direct measurements of the optical properties of CO and CO_2 ices over a wide range of wavelengths. We developed an algorithm to reconstruct the real and imaginary parts of the refractive index of ices from THz Time-Domain spectroscopy data [2] and now we extend the frequency range using Fourier Transform Infrared Spectroscopy (FTIR) data. The complex refractive index of the two samples was determined in the wavelength range between 1 mm - 25 μm (0.3 - 12 THz). These data were used to calculate the opacity of dust grains covered with CO or CO_2 ice and were compared with opacity values available in the literature. The new opacity values will be useful for modelling sources that show drastic CO depletion, as is expected within pre-stellar cores (where CO freezes catastrophically onto dust grains) and in the CO and CO_2 snow-lines of protoplanetary disks.

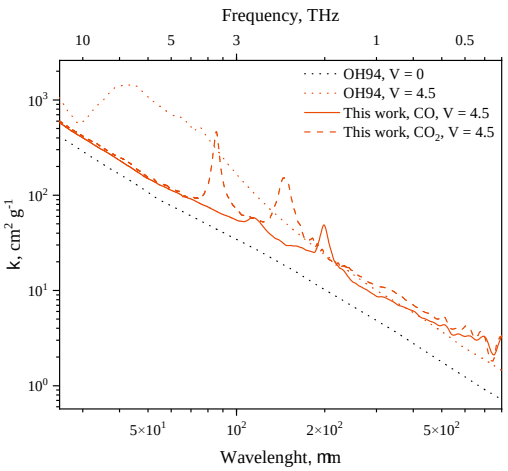

Figure 1: Calculated and reference opacities of astrophysical dust covered with icy mantles as a function of the wavelength.

References

[1] V. Ossenkopf & T. Henning, A&A 291, 943 (1994).

[2] B. M. Giuliano et al., A&A 629, A112 (2019).