Comparison of scattering properties of meteorite inclusion analogs

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To better understand protoplanetary disk images obtained with telescopes like ALMA or JWST, it is essential to have a good understanding of the scattering properties of the different objects that compose them. In our Solar System, we can find chondritic meteorites that contain a matrix (fine, sub-micron dust) with millimeter-sized inclusions. These inclusions were formed during the first stages of the protosolar system, and we can imagine finding similar ones in protoplanetary disks where asteroids and planets are yet to form.

Here, we wish to investigate whether the scattering properties of these inclusions are specific enough to leave a signature in young disk images. A non-invasive method known as X-ray computed tomography was performed to retrieve the morphology of actual inclusions. We obtained the shape of three chondrules and one Calcium-Aluminum-rich Inclusion (CAI) found in a carbonaceous chondrite. We then 3D-printed them at centimeter scale using materials whose refractive index is close to that of astronomical silicates. Finally, to measure their scattering properties, we rely on the microwave analogy, using the CCRM facility in Marseille (see [1,2] for details).

For each analog, we obtained the scattering phase function (SPF) and the degree of linear polarization (DLP) from 3 GHz to 18 GHz (size parameters from $\sim$1 to $\sim$15). For the SPF, a comparison with Mie theory shows that the chondrules and the CAI behave roughly like spheres of equivalent mass. However, when looking at the DLP, the CAI differs from Mie theory with a much lower polarization fraction, likely due to its more irregular morphology [3].

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References

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