Levitating dust clouds on orbital platforms: pathways to support the experimental calibration of interstellar dust models

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The study of dust particles in the universe is relevant to numerous fields of research and it is an exciting and challenging area of current astrophysics. Dust grains are omnipresent from the disks and halos of the most distant galaxies to the zodiacal cloud in the vicinity of Earth in our Solar System, and dust is involved in some of the most important processes in the universe, such as star and planet formation. In addition, dust clouds in the universe interfere with the way we see stellar objects, so that the understanding of how these dust grains behave, evolve, and in particular, interact with light is therefore essential to the advancement of our understanding of our universe.

In addition to their composition, the size and shape of interstellar medium (ISM) dust grains have a significant impact on absorption spectra collected from a variety of stellar objects. In particular, interstellar extinction presents a **flat feature in the mid-IR from 3 to 8 µm** that can be seen in the Spitzer Infrared Array Camera (IRAC). It has been speculated that the absence of common ISM spectral features from stellar objects in that wavelength range is due to **the agglomeration of the dust grains into larger clusters** (up to 10 µm). So far, only theoretical and numerical models are used to support this hypothesis. We are working on an experimental investigation on light absorption by clouds of 10 nm to µm-sized particles at wavelengths in the mid-IR in order to study (1) the effect of grain sizes and shapes on absorption lines, and (2) if grain size and/or shape is at the origin of the observed mid-IR flat extinction feature. The goal is a better understanding of spectra flattening by ISM dust and therefore for a better calibration of stellar and galactic observations.

The main challenge in the laboratory study of interstellar dust clouds is induced by the presence of gravity. While the levitation of clouds of particles can (and has) been achieved using transparent bounding media (liquids, gels, gas), ultrasounds, electromagnetic and mechanical effects, the results of such experiments are only conclusive when same-sized spherical particles are used. Indeed, gravity will sort any population of levitated grains by size and gas/liquid drag will orient irregular grains in preferred directions, so that realistic populations of irregular grains with a distribution of sizes cannot be studied. These limitations are significant, as it has been shown that the shape and size of dust grains in a cloud have an important effect on the way they interact with stellar light. For these reasons, microgravity experiments have been performed for several decades on-board platforms such as drop towers and parabolic flights. We will present an experimental setup currently developed for the study of protoplanetary dust on suborbital rockets that we plan to leverage for spectral absorption measurements in the mid-IR on orbital platforms. This hardware setup uses thermophoresis and allows for the observation of an undisturbed (no physical contact between grains and test cell walls) dust cloud for several minutes (no cloud shifting). It builds on past experiments and offers a flexible, long-term microgravity platform for the experimental study of homogeneous dust cloud absorption in the mid-IR.

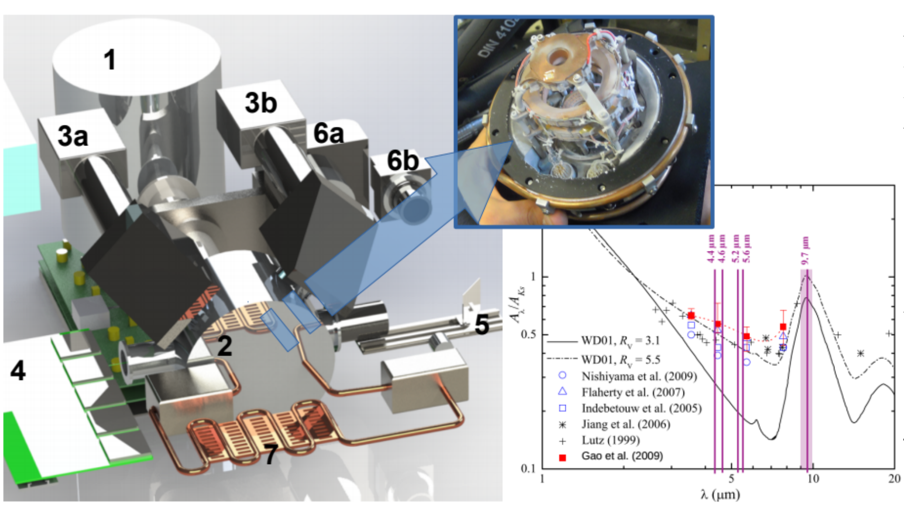

Figure 1: Payload concept for the study of mid-IR absorption by simulated ISM dust clouds. (left) Hardware design for suborbital flight. (1) Dust production chamber; (2) Cloud manipulation chamber; (3a,b) Cloud positioning cameras; (4) Laser light sources; (5) mirror; (6a,b) IR cameras; (7) Cooling loop for the Peltier elements. (top) Picture of the cloud manipulation Peltier rings. (right) Wavelengths of absorption measurements over the observed 3-8 µm flat feature and the 9.7 µm silicate absorption peak (Gao, et al. 2009).