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MAGRATHEA: A PROPOSAL FOR A SATELLITE MISSION ON PROTOPLANETARY DUST GROWTH EXPERIMENTS

Abstract

The process of planet formation, from dust to protoplanetary disks, is not very well understood. The physics of both particle growth in protoplanetary disks and small particle dust gravity dynamics are well studied. However, the link between the two, *i.e.* the growth gap between dust grains and mm-sized particles, is still not understood. Additionally, current methods cannot model the full complexity of interactions in this phase of planet formation. Therefore, experiments in microgravity are crucial to revealing the underlying physics. Previous experiments have several limitations in particular their short duration and constrained dimensions. Accurately representing the conditions in the protoplanetary disk, such as the dust particle mean free path and large spatial extent of the dust, is very demanding, especially with larger, longer duration experiments.

In order to create the best conditions for these experiments to be scientifically sound, with a reasonable solution, here we present a concept satellite with a $6\,m^3$ chamber. The payload bay provides different measurements of ongoing collision processes, and samples of collision products. Its modularity and capacity is designed to carry several instruments in a carrousel, with 28 experiment canisters. Those experiments have a range of compositions (including silicates and Fayalite, both with or without ice layers), size distribution (between $1\,\mu m$ and $100\,mm$), and shape properties, probing the conditions that could benefit grain growth. Each experiment will last up to one month allowing the record of approximately 10^6 collisions, with relative velocities of up to $5\,mm/s$, obtaining statistically meaningful results.

With the science objectives and requirements formulated, payload solutions were prepared, and a conceptual mission and spacecraft design was developed. Considering the experiment phase will last up to 5 years, and during that time external influences should be minimised, the three most complex systems are the structure, thermal control, and attitude control. After several trade-offs and a cost analysis, a $1000\,kg$ spacecraft solution was reached, set on a $800\,km$ Sun-synchronous orbit. The mission would cost around $438\,MEuros$.

The full work was developed during the 10 days of the 2017 Alpbach Summer School, by a group of fifteen young scientists and engineers, with various backgrounds, from all across Europe, with the support of two dedicated tutors. A concurrent engineering approach, with participants divided among several teams has been used to evaluate more than one scenario, and thus reach a concise solution.

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