Microwave scattering measurements of analogs of dusts from planet-forming disks to improve knowledge of the planet formation process

Background: This thesis will be carried out as part of the interdisciplinary Dust2Planets project, which aims to study the early stages of planets formation, in particular the growth of dust in protoplanetary discs. We are studying the signatures of dust growth in proto-planetary discs through an innovative approach, which consists in characterizing the optical properties of analogs of such dust particles with microwave. Indeed, as the exact growth processes are poorly known, any new direct information, particularly on centimetric dust, will be fundamental.

Objectives: One of the major aims of the PhD work is to enrich our database of scattering properties (EMSCOP), initiated in a previous PhD work, with measurements of new dust analogs made by 3D printing. These analogs will have realistic and controlled shapes and sizes. Their interactions with electromagnetic waves will be measured in our renewed anechoic chamber. These scattering measurements will serve as input to radiative transfer codes to simulate protoplanetary disk images. The results will also be used to quantify the shape and size of the dust particles in the discs. The benefits of the project are numerous and extend beyond astrophysics.

Skills: The candidate will develop a wide range of skills. He will be fully involved in the optimization of the microwave experimental setup, to ensure fast and accurate measurements. He will be involved in the exploitation and publication of these measurements. The candidate must have a good knowledge of electromagnetism and basis in CAD. The experience of our last doctoral student shows that the employment prospects, following a similar thesis, are excellent. He has been directly hired in a large multinational company and he is working on the microwave control of semiconductors. In summary, the skills that will be exploited and developed combine: Electromagnetism, Microwave, Instrumentation, CAD, Signal Processing and Programming.

Role of the doctoral student:

1/ Become familiar with the new equipment (network analyzer and spherical positioning devices) of our anechoic chamber to optimize the measurements. Characterize experimentally the quantities of interest in astrophysics (Phase Function, Degree of Linear Polarization, …). Convert the experimental data as usable entry data for radiative transfer codes used to simulate protostellar disks.

2/ Once the required precision is reached and, in close collaboration with astrophysicists, the candidate will have to choose the different objects to measure to enrich our database, find the useful geometry files and prepare the realization of the analogs at the microwave scale by additive manufacturing, either locally or by collaborations or subcontracting.

3/ The scattering properties (Jones and Mueller parameters) of each analog will be characterized and interpreted. Several particles will have to be measured, with an increasing level of complexity.

4/ As the measurements are made, the results will be published in specialized journals (e.g., IEEE Microwave Theory and Techniques, JQSRT) and presented at major international conferences (e.g., IEE-APS, ELS, …).

5/ The ultimate objective is the comparison and check of adequacy of the diffraction measurements of the analogs with the astrophysical results. The results will be published in specialized astrophysics journals (Astronomy & Astrophysics, ICARUS, Nature Astronomy. …).

Supervisor: Amélie Litman (Institut Fresnel)
Co-superviors: Jean-Michel Geffrin (Institut Fresnel), François Ménard (IPAG)
Financing: ERC Advandced Grant project: Dust2Planets
Main place of activity: Institut Fresnel, Marseille
Contact: Jean-Michel Geffrin: jean-michel.geffrin@fresnel.fr
Application: https://emploi.cnrs.fr/Offres/Doctorant/UMR7249-JEAGEF-008/Default.aspx?Lang=EN