# Thesis subject

**Laboratory** : Institut Fresnel

**Thesis supervisor** : A. Litman (https://www.fresnel.fr/perso/litman)

**Title of the thesis subject** : *Inverse methods for light scattering problems*

Description of the thesis subject :

In light scattering applications, light waves are shined into a system of particles. The light sources can be man-made, as for example when detecting pollutants or pollen in air [1]. They can also be natural ones, as for example in astrophysics, when we observe with telescopes on earth, how the radiation by a young star is affected by the dust and accumulation of gas contained in protoplanetary disks surrounding it [2].

A major key issue is to be able to characterize the properties of the dust and thus the particles from their light scattering patterns. Identifying their properties (shape, refractive indices, …) will enable to understand how the dust-gas dynamics are governed and how dust may grow. Such analysis will help in the understanding on early planet assembly in protoplanetary disks.

The purpose of the PhD is to develop the numerical tools adapted to the resolution of this inverse light scattering. The problem is challenging because of the ill-posedness and nonlinearity associated with inverse scattering problems. From the scattering properties (phase function, polarization, other components of the Mueller matrix), the applicant will need to construct an algorithmic methodology to extract the quantities of interest (morphology, compositions, fractal dimension, roughness, ellipticity…).

After a thorough literature survey, the student will explore and implement the algorithms that will be well suited for this task (deterministic approaches such as gradient-based optimization techniques such as explained in [3], Bayesian approaches or machine learning algorithms). The schemes will be validated with simulated datasets as well as with measurements, thanks to the unique micro-wave analogy experiment available at Institut Fresnel.

This PhD work is fully in line with the ERC Dust2Planets project in which the host team is involved.

**Keywords**: Light scattering, Electromagnetism, Inverse Problems, Modelling, Optimization, Machine Learning

**References** :
[1] JB Renard et al, “Towards an Automatic Pollen Detection System in Ambient Air Using Scattering Functions in the Visible Domain”, Sensors (Basel). 2022 Jul; 22(13): 4984.

[2] G. Columba et al, “Disk Evolution Study Through Imaging of Nearby Young Stars (DESTINYS): HD 34700 A unveils an inner ring”, Astronomy & Astrophysics, A&A, 681, A19 (2024)

[3] M. Hajihashemi, H Jiang “An inverse light scattering technique for morphological characterization of irregular particles based on the Gaussian-random-sphere model”, J Opt Soc Am A Opt Image Sci Vis. 2012; 29(6): 1124–1131