On the light scattered by porous particles

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Natural dust particles are known to display very disordered shapes. Generic examples are fractal aggregates of grains, which are made in the shape of fluffy disordered structures. In these cases, it is uneasy to find direct reliable information about the complicated particle morphologies from the light scattering patterns. Consequently, analysis of the light scattered by such particles is often frustrating regarding the good quality of the observational data.

In this context, the fractal dimension is a central structural parameter. It is important characteristic indeed, because estimated value of that dimension can provide insight into the mechanisms forming the particles. Recently, we showed that the so-called “fractal regime” in the Rayleigh-Gans-Debye (RGD) theory was much more robust than commonly accepted, provided definite observational conditions are fulfilled. As a result, we now know when the possible fractal dimension of the scattering dust particles can be deduced in a reliable way. The explicit conditions were deduced from the analytical mean-field T-Matrix theory, and substantiated from the compared analysis of the light scattered by a number of numerically-generated finite particles of various fractal dimensions. Light scattering computations were performed using the RGD and the T-Matrix methods.

Another parameter of interest is the porosity. This physical quantity is amazingly very difficult to define unambiguously, though porosity is expected to play a central role in the scattering of light since related to another form of mass correlation inside the particle. For example, a sphere can be of high porosity even with effective fractal dimension equal to 3. Moreover, the porosity of fractal particles of fractal dimension < 3 is ill-defined as it goes to 1 when the particle size grows. Then, it is natural to wonder if any signature of porosity can be deduced from the scattering plots of porous particles, and which is the proper definition of the porosity relevant for light scattering. These questions have been addressed recently for model particles in the shape of spheres of various inner open porosities. Here, the porosity is controlled and the particles are connected, like for grain aggregates. We will discuss and compare results of (DDSCAT and T-Matrix) light scattering by porous particles built using different models, and with same porosities.

This kind of approach builds little by little a bundle of tools for direct analysis of the electromagnetic waves scattered by disordered dust particles, though we are still far from the extensive tools existing when the RGD theory applies. By the way, we will also review these unique tools within the RGD theory and how they could be applied for the data (from SWIFT or CHANDRA space observatories) of X-ray radiation scattered by dust particles surrounding X-ray source.