On the good way to generate a numerical analogue of fractal dust particles for optical purposes

Robert Botet[1], and Pascal Rannou[2]

[1]*Laboratoire de Physique des Solides UMR CNRS 8502, Paris-Saclay University, Orsay 91405, France,* [2] *Groupe de Spectrométrie Moléculaire et Atmosphérique UMR CNRS 7331, Université Reims Champagne Ardenne, Reims 51687, France*

Standard analysis of light scattered by a cloud of dust particles comes from quantitative comparison with computer data calculated from modeled finite particles. When dust particles are expected to be fractal, the use of standard light scattering software (e.g. T-Matrix codes, DDA codes, etc.) requires the digital generation of dust particles in the form of grain aggregates for which the location of each grain is known. The corresponding Particle-Cluster or Cluster-Cluster aggregation codes are today effective up to a few millions grains per dust particle. That way, the number, N, of grains of radius a in an aggregate scales as a power law with the reduced radius of gyration of the particle, R_g/a, following: $N = k_f(R_g/a)^{d_f}$, where k_f (the prefactor) and d_f (the fractal dimension) are the parameters of the fractal morphology of the particle. Long ago, it was proven that this scaling relation was representative of a critical system, and that the fractal dimension was universal (*i.e.* d_f depends on a few parameters, such as the space dimension and the diffusion of dust particles as they form) while the prefactor was not (that is k_f depends on a multitude of details). An important consequence of the concept of universality is that it is illusory to try to reproduce the observed (real) value of the prefactor using a computer program, while the value of the fractal dimension is absolutely correct as soon as the relevant parameters are included in the model. If therefore the optical cross-sections depend on both universal and non-universal parameters (that is generally the case), light scattering programs - even if they are exact - are not able to give reliable values to compare with values observed in nature. A way around this issue is to use numerical codes generating particles of imposed fractal dimension *and* prefactor. Such numerical codes exist but the corresponding calculation load is heavy.

Instead of trying to reproduce the scaling law between N and R_g for a large collection of finite fractal aggregates, it is more natural to precisely model the pair-correlation function of a large fractal particle, and to use a light scattering code directly employing that correlation function as input. In this presentation we will discuss the novel method called MFT+ (for: Mean-Field T-matrix, and + for the improved version). When we proposed the first version of that method MFT, twenty-five years ago, too schematic consideration of the pair correlation function in the domain of small distances, limited the accuracy of the method. We have recently significantly improved this part of the MFT method. Now,the values of the optical cross sections of fractal particles of any size can be calculated with good accuracy in short times. One can then obtain an estimate of the values of the optical cross sections with realistic error bars using a range of possible values of the prefactor (coming from the shape of the pair-correlation function). We will see an analysis of Titan's dusty atmosphere using the MFT+ method.