, , , , ,

Composite dust particles - the shape and the composition -

R. Botet[a], R. Rai[b], E. Hadamcik[c], A.-C. Levasseur-Regourd[d], R. Gupta[b], and A. Sen[e]
[a] *Laboratoire de Physique des Solides Bât.510, CNRS UMR8502 / Université Paris-Sud, 91405 Orsay, France*
[b] *IUCAA, Post Bag 4, Ganeshkhind, Pune-411007, India*
[c] *UPMC Univ. Paris 06, LATMOS/IPSL, F-78280 Guyancourt, France*
[d] *UPMC Univ. Paris 06, UMR 8190, LATMOS/IPSL, BC 102, F-75252 Paris cedex 5, France and*
[e] *Department of Physics, Assam University Silchar-788011, India*

Natural dust particles are generally composite objects made of various parts coming from different origins. Therefore, study of their physical properties should take into account the proper distribution of each of the constituents, not only the overall shape of the particle. This would be the case when the properties are sensitive to length-scales smaller than the size of the particle, otherwise, 'mean-field' description (*e.g.* mixing rule) might be sufficient for the purpose. Optical properties is an example, for which Maxwell-Garnett formula can be used when the wavelength is larger than the dust particle size, but not correct if smaller. However, the definite limit where the Maxwell-Garnett approach breaks down, is difficult to obtain without precise numerical computation.

We shall here describe a realistic composite dust particles formation scenario, expected to be relevant where the formation process involves a sequence of various chemical and physical media: 1) a low-density cloud of small compact hard grains evolves through successive random aggregations ; 2) this ensemble of aggregates crosses a cloud rich in a chemical compound able to be adsorbed on the grains ; 3) we will then consider the reverse process, where the chemical material coating the aggregates can desorb and reveal progressively the aggregate of grains – possibly disturbed because of mechanical stress –. This kind of scenario should be relevant for silicate grains covered with ice and carbonaceous compound, which are expected to be part of the interplanetary or cometary dust population (see Fig.1). Urban atmospheric pollution is another example caused by dust particles issued from diesel engines in a humid environment.

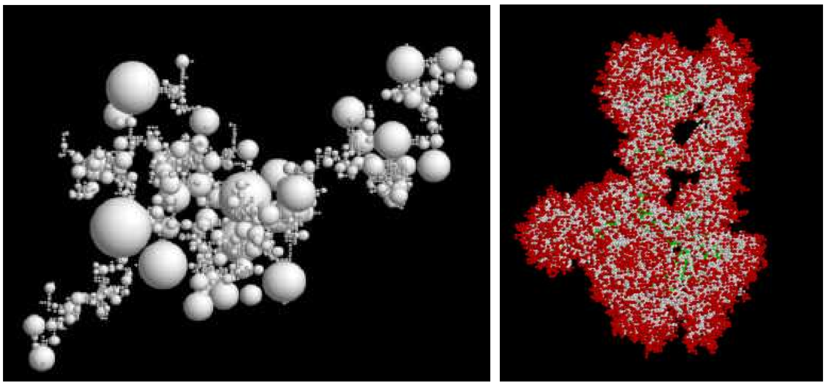

FIG. 1: The left-hand figure shows an aggregate of 2048 polydisperse grains (power-law radius-distribution, with exponent -3). The Reaction-limited Cluster-Cluster Aggregation model was used. The right-hand figure shows the aggregate of grains (green spheres) covered with ice molecules (white spheres), then with carbonaceous molecules (red spheres). The Ballistic Cluster-Cluster Aggregation model was used for the deposition process. In this example, evaporation of the ice will lead to a porous carbonaceous crust surrounding the initial grains.

We will see how the optical absorption by such particle evolves along the aggregation/disaggregation scenario, and how it compares with the mixing rule approach. For example, a cluster of optically absorbent material coated with almost transparent compound can be quite different from the same structure with exchanged constituents (transparent core coated with absorbing material), when the wavelength is smaller than the particle size. We shall discuss this example in details in function of the wavelength, in order to exhibit the various optical features one can expect on a simple composite dust particle, and conclude if there is a route to measure definitely average refractive index from optical properties of composite particles.

This work is part of a 3-years France-India CEFIPRA collaboration project about cometary dust particles.