

Introduction: Solid particles in space may form clusters (aggregates) due to particle collisions and adhesion. Since many lightscattering effects cannot be explained within the framework of model of aggregates of compact particles [1], for more adequate simulation of scattering properties of cometary and interplanetary dust some hierarchical (fractal-like) properties of aggregates should be taken into account. Structures that are formed at association of solid grains, in the case of diffusive character of their movement, are called fractal clusters or fractal aggregates. The fractal clusters have characteristic branchy structure. For the last years intensive investigations of such objects by computational methods were carried out [e.g., 2]. Computer experiments allowed us to gain some insight about such aggregates and character of their formation.

We note that processes of fractal cluster formation at association of solid grains are related to a number of many other physical systems and processes. These are solidification of colloidal solutions, coagulation and percolation processes, formation of polymers, dielectric break-down, etc. This also includes formation of aggregated particles in space and on the planetary surfaces.

Used model of aggregates: To construct prefractal clusters, we use the Whitten-Sander model, generalizing it for the 3-D case. According to this model we divide a limited 3-D spherical volume on a set of cubic cells. Then we locate in the volume one particle (grain) adding another particles one by one. Each new particle moves in an adjacent cell in random mode – its path is selected by the Monte Carlo method. If the particle reached the border of the volume, it is reflected from the border proceeding its movement till it appears in the neighborhood of one of particles of the cluster. Then it is stopped in a given cell, and next particle begins its moving in the volume. This process forms a fractal cluster.

Let us consider one more model of generating fractal clusters – so-called “random rain” model. As before we divide restricted three-dimensional space on a set of cubic cells, one particle seats in the center of range, and further particles – candidates for addition – drop on growing cluster, as rain drops, along some random directions from the volume border. Each particle starts the motion from randomly selected cell and move along some random chord [2]. Fig. 1 and 2 show examples of Whitten-Sander (a) and “random rain” (b) fractal clusters for 2-D and 3-D cases, respectively. As can be seen the “random rain” model generates more ramified structures.

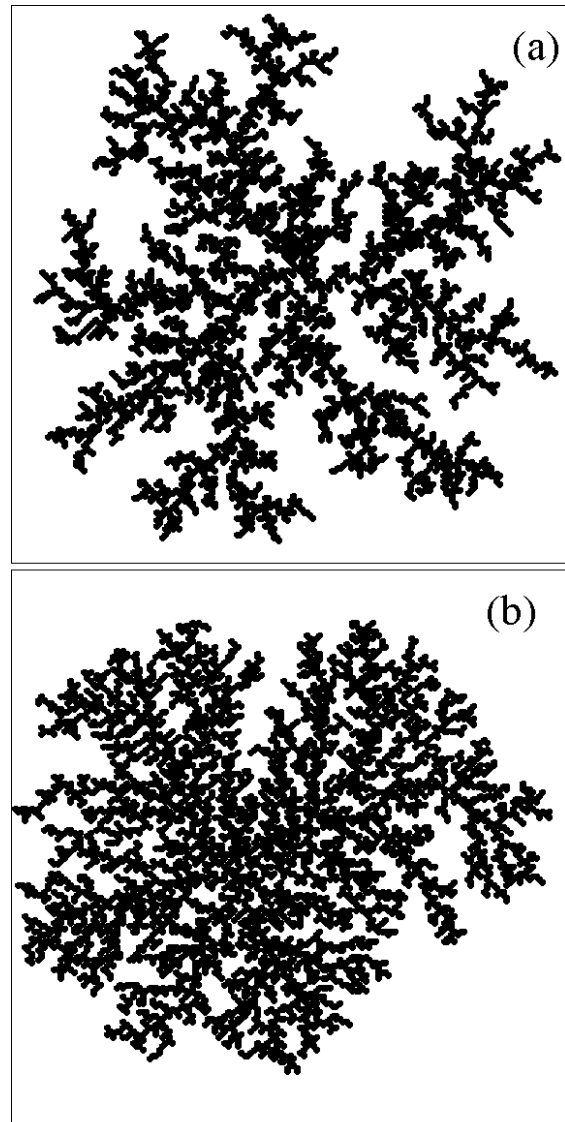


Fig. 1. Examples of two-dimensional fractal clusters from the Whitten-Sander (a) and «random rain» (b) models. The “random rain” model generates more ramified structure.

Results and discussion. To investigate polarization properties of random inhomogeneous chaotically oriented dielectric scatterers we used the DDA method. Figure 3 shows the phase curves of the intensity and degree of linear polarization of scattered light for Whitten-Sander’s (a) and for “random rain” fractal aggregate (b) with the size parameter $x = 8$ (solid lines), 10 (dashed lines) and 12 (dot lines), where $x = 2\pi r/\lambda$, r and λ being the radius of spherical volume and wavelength, respectively.

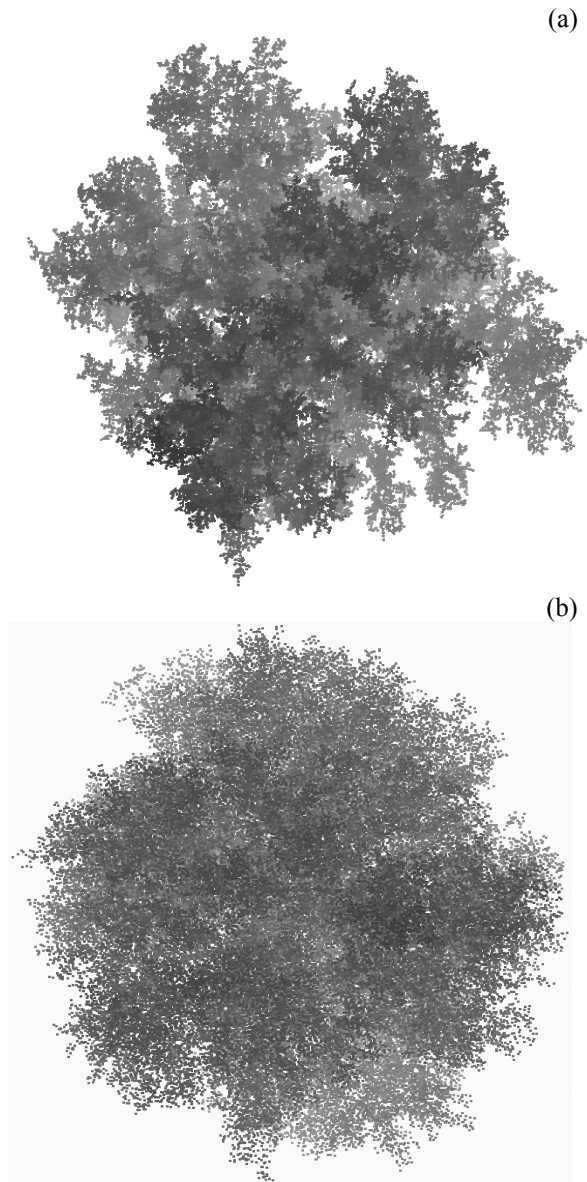


Fig. 2. Examples of three-dimensional fractal clusters from the Whitten-Sander (a) and “random rain” (b) models.

Calculations were done at the refractive index $m = 1.5 + 0.1i$ which corresponds to “organic” particle. As can be seen in Fig. 3, the degree of polarization originating at light scattering on fractal aggregate increasing the size parameter makes the negative polarization more prominent.

Conclusion. We have made calculations for various size parameters and different types of fractal particles. We find that the negative polarization of aggregated particles depends weakly on the fractal cluster type. Increasing the size parameter makes the negative polarization more prominent.

References: [1] Gustafson, B.A.S, Kolokolova L. (1999). *JGR*. **104**(D24), 31,711–31,720. [2] Belko, A.V., Nikitin A.V. (2002). *Vestnik of Grodno State University*. 2(11).

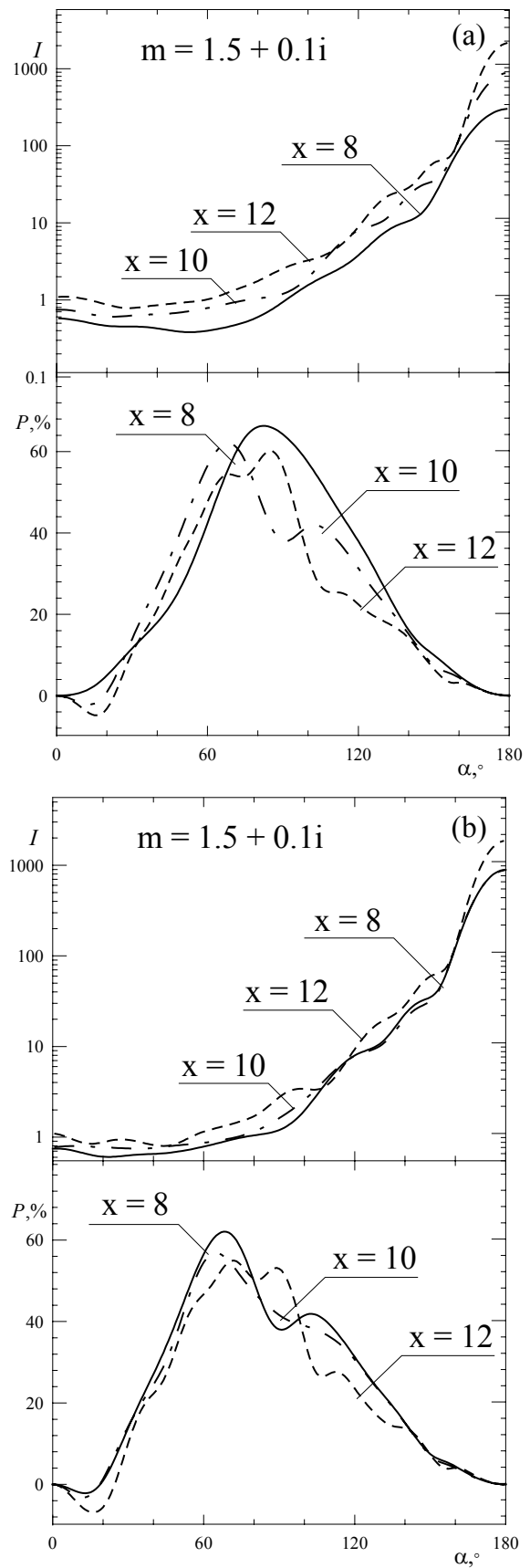


Fig. 3. Phase curves of intensity and degree of linear polarization for the Whitten-Sander (a) and “random rain” (b) fractal aggregate.