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Calculation of collision rate between small non-spherical particles in a turbulent flow

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Collisions between non-spherical particles (ice crystals) give rise the formation of aggregates, collisions of non-spherical crystals with cloud droplets is the main mechanism of graupel production. The rate of riming and that of ice-ice collisions is not well known even in pure gravity case. Often these collisions take place in the regions of enhanced turbulence in cumulus clouds. In spite of its high importance, the problem of collisions of such particles in a turbulent flow is not yet solved. In this work we present novel method of collision kernels calculation between small (less than 50 μm) spheroidal particles of different aspect ratios (both prolate and oblate).

An equation system determining motion of small non-spherical particles in a sheared flow is derived in the application to the particle collisions. Scale analysis indicates that spatial and time characteristic scales of the Lagrangian acceleration and turbulent shears are much larger than the adaptation time of the particles, as well as the characteristic time of particle interaction. The results of this analysis allows one to consider turbulent flow as a combination of small regions in which accelerations and shears can be considered to be unchanged during the particles' approach and collisions. A statistical model is used to generate long series of turbulent strains and accelerations reproducing probability distribution functions (PDF) at high Reynolds numbers, as they were obtained in recent laboratory and theoretical studies.

The collision kernel between two non-spherical particles is defined in terms of velocity fluxes of the particle of one type relative to the particle of another type. In this study hydrodynamic interaction between particles is not taken into account, so that the collision kernel represents the swept volume of colliding particles. The probability distributions of swept volumes are calculated for different particles sizes, shapes

(aspect ratios) and turbulence intensities. The swept volume for given turbulent field is obtained by averaging over many realizations of Lagrangian acceleration and tensor of velocity strains.

The collision kernels of non-spherical particles are compared to those of spherical particles of the same mass. It is shown that swept volumes of non-spherical particles in some cases can be significantly higher than those of spherical particles.