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Aerosol Clustering Patterns in Oscillating Flows

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It is well known that the interaction of particles and droplets with the ambient gas is important for various problems of aerosol mechanics, such as, engineering, environmental and medical applications including those related to modeling of dynamics of atmospheric particles, marine particles (Winter et al., 2007), modeling of inhaled particles, modeling of sprays in internal combustion engines (Katshevski et al.,2008), and other applications. Numerous experimental and numerical studies of free shear flows showed that in many cases a flow has a large-scale vortex structure which has a periodic form and moves in the direction of the flow. Owing to this fact, the flow velocity field is fairly periodic both in time and in the direction of the flow. This problem is challenging from the point of view of mathematical analysis. We present a qualitative mathematical analysis of particle dynamics in periodically changing flows. It reveals various modes of particle dynamics, which shed light on particle behavior in more general and complex configurations. We term here the tendency to form groups and clusters as "**grouping**". The grouping/clustering phenomenon is illustrated schematically in Fig. 1.

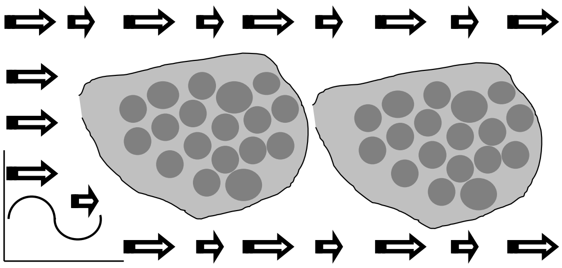

Figure 1. Schematic description of travel-grouping of aerosol particles in an oscillating flow field.

Particle grouping/clustering patterns

Our calculations reveal that there are three modes of grouping behavior. These modes include: I) Stable grouping, II) Weak Grouping, and III) Non-Grouping.

Particle trajectories in stable and weak grouping are presented in Fig. 2. The first mode of behaviour, "*Mode I*" is characterized by the formation of particle groups and a subsequently stable conjoint motion. In "*Mode II*" which stands for *weak grouping*, temporarily joined particles shift from one group to the other or groups break up. In contrast "*Mode III*" defines a clear *non-grouping* situation where there is very little tendency, if any, to aggregate. As grouping is associated with conditions, such as the host-flow velocity, the frequency of the oscillations as well as particle/droplet size, we may say that in certain range of conditions we expect to observe one of these modes. This will be elucidated in the presentation.

In the case where we use a frame of reference moving at the phase velocity we find a different outocme for grouping and non-grouping representation of the trajectories. Grouping trajectoires converge into a dot when the grouping is clearly stable and non-stable grouping results in an osscilating trajectory behavior. The stable grouping implies that the stable groups in Fig. 2 (left) may later in time break. This will not be the case according to the second represntation.

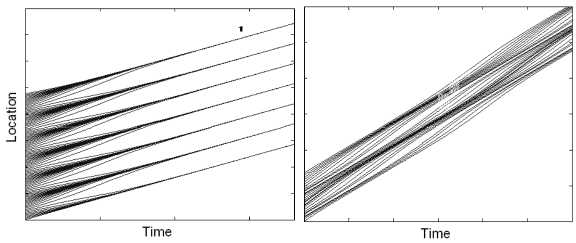

Figure 2. Left-stable grouping, Right-weak grouping

Grouping may lead to aerosol coagulation and this should have an effect on the coagulation modelling included in the aerosl general Dynamic Equation (Katoshevski and Seinfeld, 1997).

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