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Magnetic and electrostatic charging properties of electrical discharges

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Abstract

Lightning is a discharge of electricity, which typically occurs during atmospheric thunderstorms, and sometimes during dust storms and volcanic eruptions.

The way lightning forms is not yet fully understood: the root causes range from various atmospheric perturbations to the impact of solar wind and accumulation of charged solar particles. Charge separation and accumulation continue until the electrical potential becomes sufficient to initiate a lightning discharge, occurring when the distribution of positive and negative charges forms a sufficiently strong electric field.

Lightnings periodically occur also in protoplanetary nebulae during solar discharge events such as flares [1]. Recently [2], we have proposed a hypothesis that the lightnings could be responsible for the growth of macroscopic bodies in planetary system formation by non-uniform magnetization of ferromagnetic components in the grains of the protoplanetary nebula. Later, this idea has been developed further in [3, 4]; see also [5, 6].

Here we describe laboratory experiments of the magnetizing and electrostatic charging effects of electrical discharges on the micrometer-sized ferromagnetic and diamagnetic dust grains. Very fast dust aggregation was observed and explained by the acquired magnetic attraction between the magnetized ferromagnetic grains and enhanced electrostatic attraction between diamagnetic grains. The results may find application in the physical description of early stages of planetesimal formation in protoplanetary disks.

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