Particle Aggregation Induced by an Impulse Magnetic Field. I. Tunyi, P. Guba and A. Bocik, Geophysical Institute, Slovak Academy of Sciences, Dubravska cesta 9, 845 28, Bratislava, Slovakia (geoftuny@savba.sk)

Introduction: 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.

Method: Lightnings periodically occur also in protoplanetary nebulae during solar discharge events such as flares [1–6]. Recently [7], 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 [8, 9]; see also [10, 11]. Here we describe laboratory experiments of the magnetizing and electrostatic charging effects of electrical discharges on the sub-cm-sized ferromagnetic and diamagnetic dust grains.

Results: We have designed and constructed a Marx generator (Figure 1), capable of generating high-voltage discharges of storage voltage 45 kV, arc current 10–40 kA, discharge time constant 350 ns and total stored energy 630 J. High-voltage impulses were applied to the demagnetized ferromagnetic particles of sub-cm size (Figure 2*a*). Very fast particle aggregation (Figure 2*b*) and an increase in the electrostatic potential of the system (Figure 3) were observed. An explanation is proposed in terms of an acquired magnetic attraction between the magnetized ferromagnetic grains and an enhanced electrostatic attraction between the charged particles. The results may find application in the physical description of early stages of planetesimal formation in protoplanetary disks.

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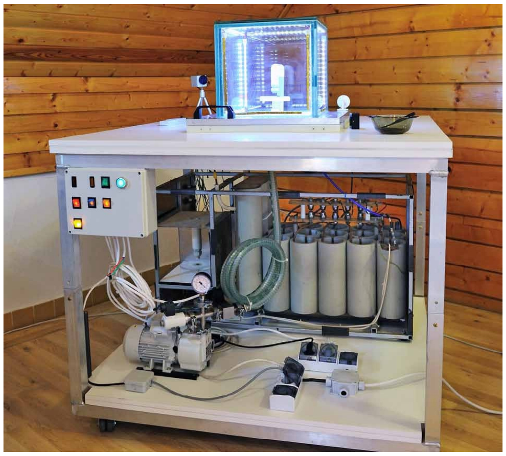
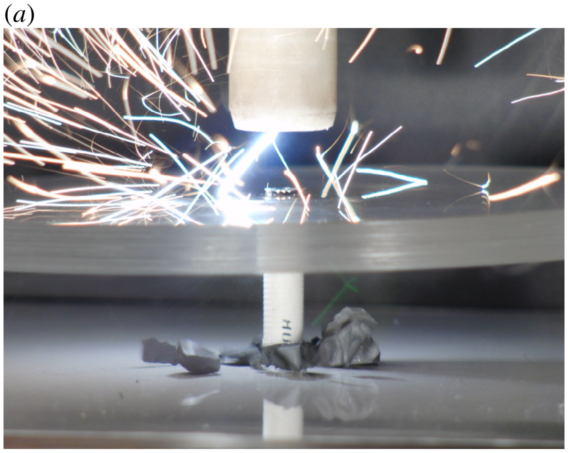


Figure 1: A Marx generator with a vacuum chamber.

(*a*)



(*b*)

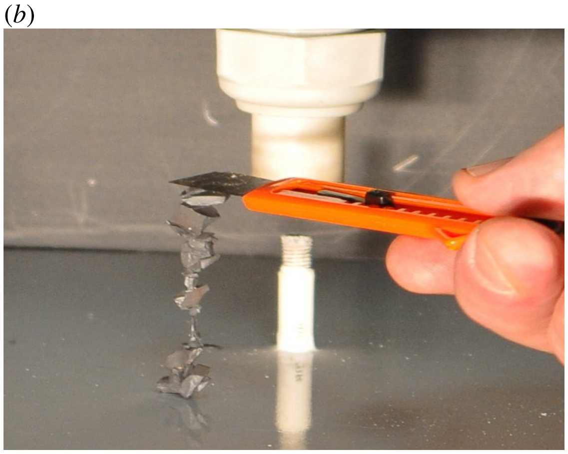


Figure 2: (*a*) Application of space-localized, short-time discharge stroke to a demagnetized sample. (*b*) An impulse magnetic field associated with the discharge stroke is capable of magnetizing ferromagnetic materials to saturation levels, enabling the formation of particle assemblages.

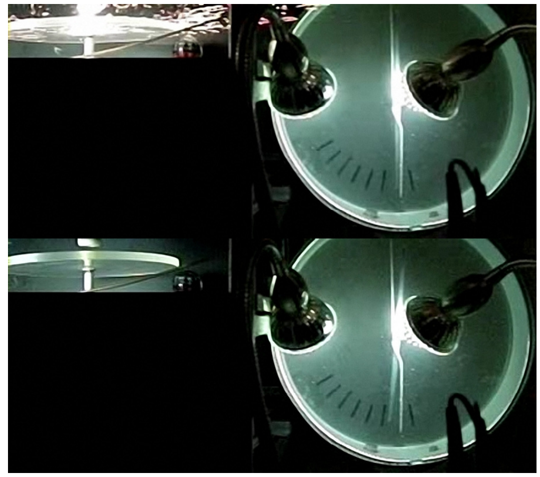


Figure 3: Electroscopic detection of the presence and magnitude of electrostatic charge induced by the discharge stroke. The accumulated charge typically reaches 100 V.