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Nonlinear dynamics of ice growth and charge production in thunderstorms

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We show with laboratory experiments in which we grow ice films in situ from the vapour phase within an environmental scanning electron microscope that there are two positive feedback effects that favour the charging of a thundercloud by the collisions between ice particles: (1) the rate of ice growth is increased by the charging, and (2) the ice morphology is altered and becomes such that easily breakable structures are produced, which when broken off form further secondary nuclei. Both of these effects produce positive feedback in the electrification mechanism of thunderstorms.

Thunderstorms arise by the collisional charging of ice; small ice particles and larger pellets of hail collide within a cloud, and charges separate and the cloud electrifies as the particles break up [1]. We present the results of studying the growth of ice in a thunderstorm by growing ice films in situ from the vapour phase within an environmental scanning electron microscope (ESEM). The effect of the electric field is twofold: on one hand it speeds up ice growth, and on the other it induces a change in ice morphology including the formation of long ice 'palms' intermediate in morphology between whiskers and dendrites; we had noted these palmlike forms in earlier experiments [2], but had not then realized that the electric field was involved in their production. There is hence a species of 'observer effect': the electric field of the microscope alters the ice growth. Such electrically charged ice growth is of interest as a nonlinear dendrite-growth instability [3], but moreover these morphologies involving charging effects in the vapour phase deposition of ice have practical importance in thunderstorm electrification.

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