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Punctuating Instability of a 2D Dusty Plasma Colloidal Crystal

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When placed in a weakly-ionized RF plasma, colloidal microparticles can be trapped in the narrow Debye sheath region above a capacitively-coupled electrode. Known as a "dusty plasma", the particles become negatively charged, leading to the formation of large, 2D crystalline monolayers. At low pressures the particles can experience vertical oscillations due to plasma density fluctuations in the sheath. As a result of these fluctuations, we have found that at low pressures and low bias voltage, the colloidal crystal experiences temporally reoccurring instabilities. Such "punctuating" instabilities are caused by the redistribution of kinetic energy from vertical vibrations to horizontal motion, essentially melting the crystal into a gas-like state. After the incipient instability, without changing any external parameters, the system loses kinetic energy to damping with the surrounding gas, then eventually recrystallizes and remains stable until next punctuating instability. The period of the instability ranges from seconds to minutes depending on the system parameters, and can vary significantly within a given system. Using simple simulations of 2D crystals driven by a vertical Langevin forcing, we are able to capture the salient features of the punctuating instability.

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