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Exploding drops on lubricated surfaces

Traditionally, investigations of Coulomb explosions have focused on charged microdrops levitated using quadrupole electric fields, i.e., a Paul trap. In a surprising twist, our work introduces a simple method to observe Coulomb explosions, with no drop levitation and no external electric field. Instead, we generate a charged water drop using a conventional micropipette, which we then deposit on a plastic petri dish lubricated with a thin oil film. As the droplet evaporates, its radius shrinks until it reaches the Rayleigh limit at which point we observe multiple, highly periodic Coulomb explosions ($>$ 60 events over 30 mins)—the first time Coulomb explosions have been reported for a sessile drop on a surface. The exploding drop produces a finely ejected liquid jet which disintegrate into microdroplets explosively within microseconds, i.e., an electrospray-in-a-drop. Intriguingly, the application of a small electric field $\sim 10^3$ V m^{-1}, just larger than the atmospheric electric field, aligns the electrospray direction. Our Coulomb explosions span diverse length scales (from micron to millimetres) and time scales (from microseconds to minutes), with potentially wide-ranging applications from nanoscopic material fabrication to electrospray ionization.

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