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Complex Kepler Orbits and Particle Aggregation in Charged Microscopic Grains VICTOR LEE, Univ of Chicago, SCOTT WAITUKAITIS, Leiden University, MARC MISKIN, Cornell University, HEINRICH JAEGER, Univ of Chicago — Kepler orbits are usually associated with the motion of astronomical objects such as planets or comets. Here we observe such orbits at the microscale in a system of charged, insulating grains. By letting the grains fall freely under vacuum, we eliminate the effects of air drag and gravity, and by imaging them with a co-falling high-speed camera we track the relative positions of individual particles with high spatial and temporal precision. This makes it possible to investigate the behaviors caused by the combination of long-range electrostatic interactions and short-range, dissipative, contact interactions in unprecedented detail. We make the first direct observations of microscopic elliptical and hyperbolic Kepler orbits, collide-and-capture events between pairs of charged grains, and particle-by-particle aggregation into larger clusters. Our findings provide experimental evidence for electrostatic mechanisms that have been suspected, but not previously observed at the single-event level, as driving the early stages of particle aggregation in systems ranging from fluidized particle bed reactors to interstellar protoplanetary disks. Furthermore, since particles of different net charge and size are seen to aggregate into characteristic spatial configurations, our results suggest new possibilities for the formation of charge-stabilized "granular molecules". We can reproduce the observed molecule configurations by taking many-body, dielectric polarization effects into account.

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