Paper Presentation

Vishal

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Paper details

Title	Electrical charging overcomes the bouncing barrier in planet formation
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Department	Physics, Biomedical Engineering
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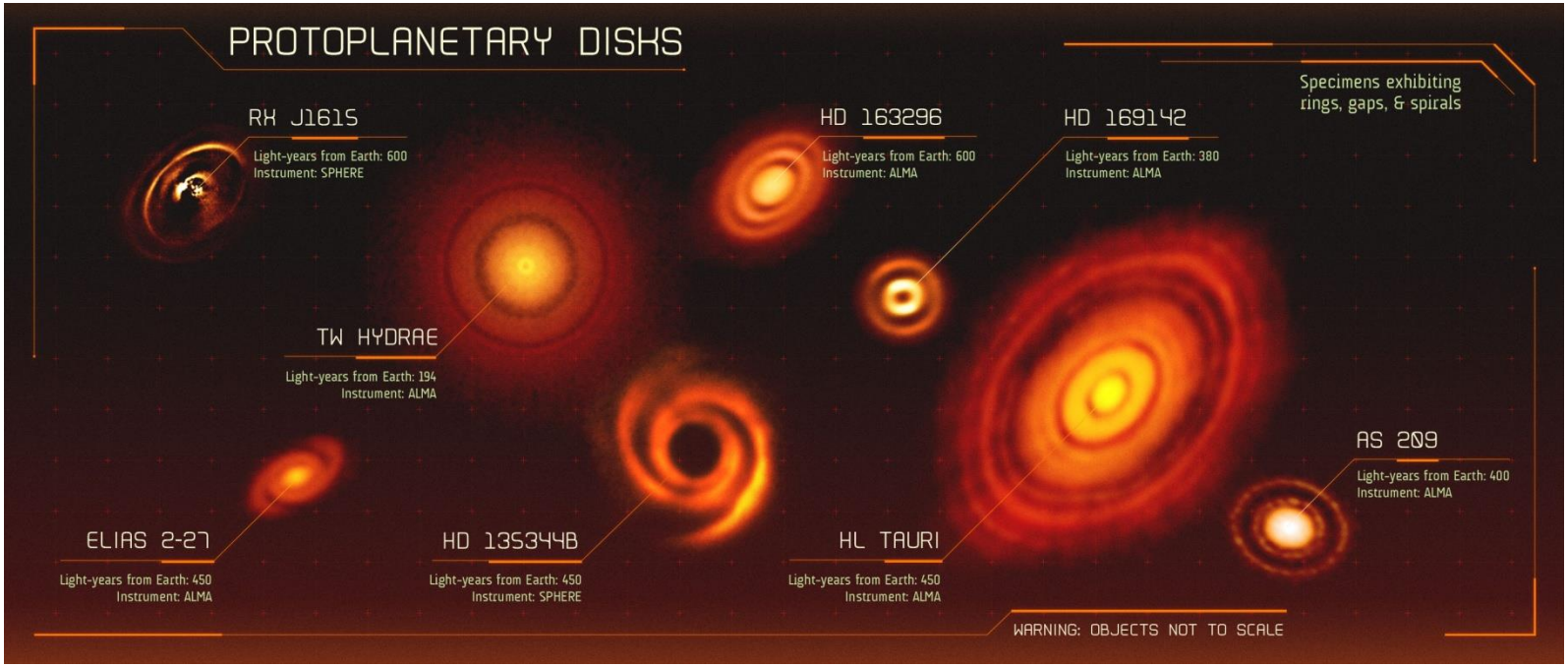


A spinning disk around a newborn star, sculpting planets out of gas and dust like clay on a potter's wheel.

A protoplanetary disk is a disk of gas (99% by mass) and dust (1%), orbiting a newly formed star, from which planets are (hypothesized to be) formed.

Stellar Disks Reveal How Planets Get Made
https://doi.org/10.1007/978-3-642-11274-4_1299

Introduction

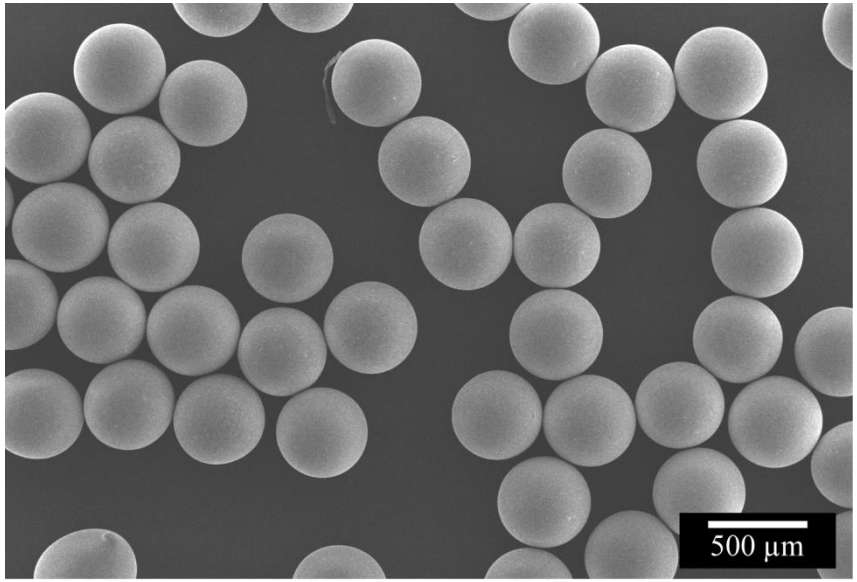
The formation of planets requires growth of dust gains from micrometer to kilometer sized planetesimals .

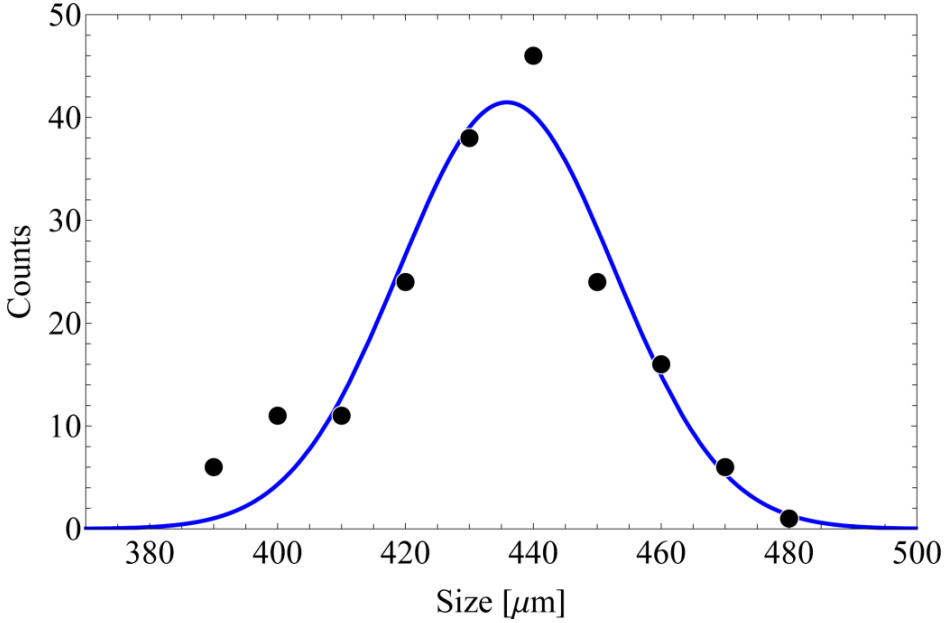
- The growth from micrometer to millimeter size aggregates is mainly controlled by van der Waals forces and other forces.
- Once the aggregate size exceed centimeter scale concentration mechanism like streaming instabilities results .
- But the mechanism of growth from millimeter to centimeter scale aggregates is not known clearly.

They propose that collision charging due to collision between dust grains allow for the formation of large grain. To prove there idea

1. Charge based aggregation of millimeter-sized dust grain is studied in microgravity.
2. To understand the mechanism of aggregation combination of theoretical and computational studies were conducted.

Particle characterization

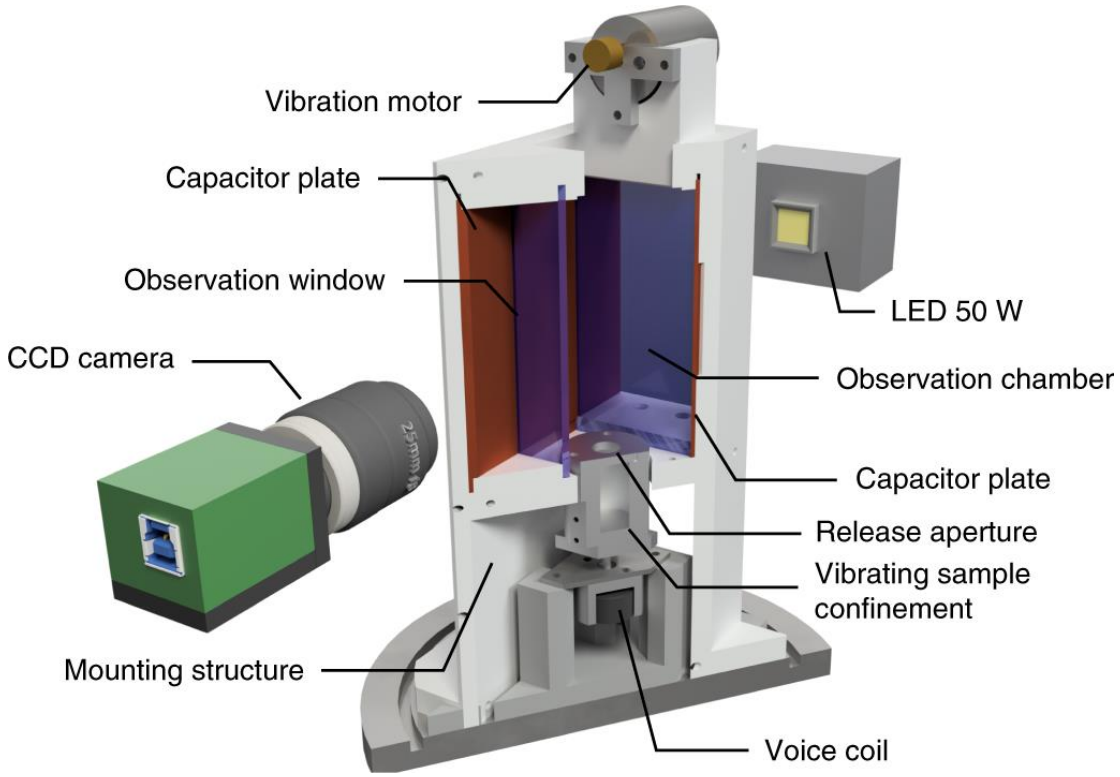




Left: Scanning electron microscope (SEM) image of sample particles.
Right: Size distribution of the sample particles.

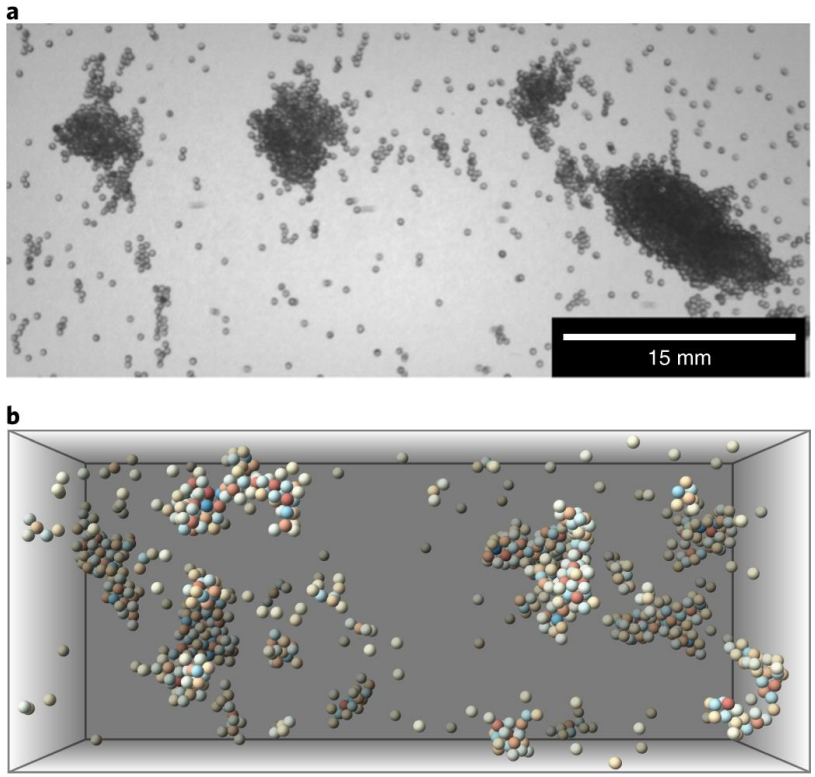
- Mean grain diameter is 434 µm with the standard deviation of ± 17 µm.

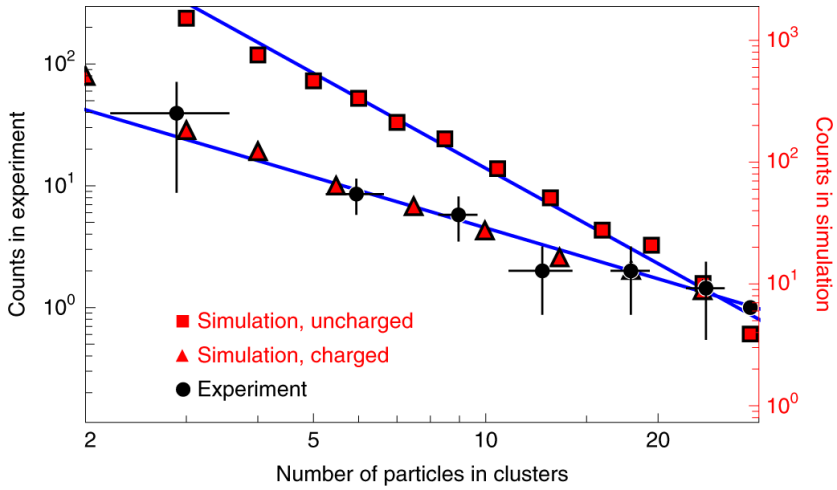
Bremen drop tower



Sketch of the apparatus used in microgravity.
Charged grains are released from below (in this view) into the observation chamber, where they are photographed at 180 f.p.s., 75 µm pixel^{-1}.

Particles size distribution

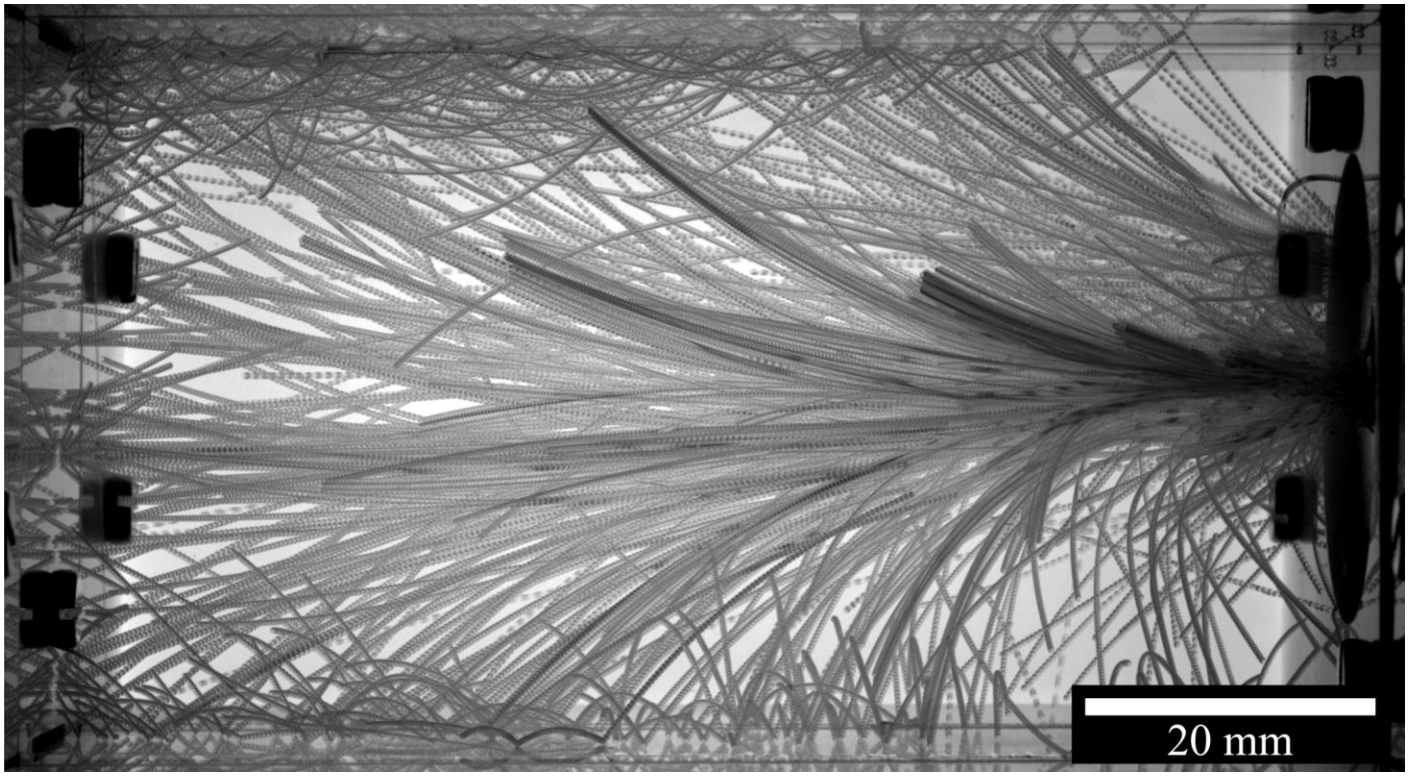




Charging leads to multiple size scales aggregation from dimers to hundreds and even thousand particle aggregates.

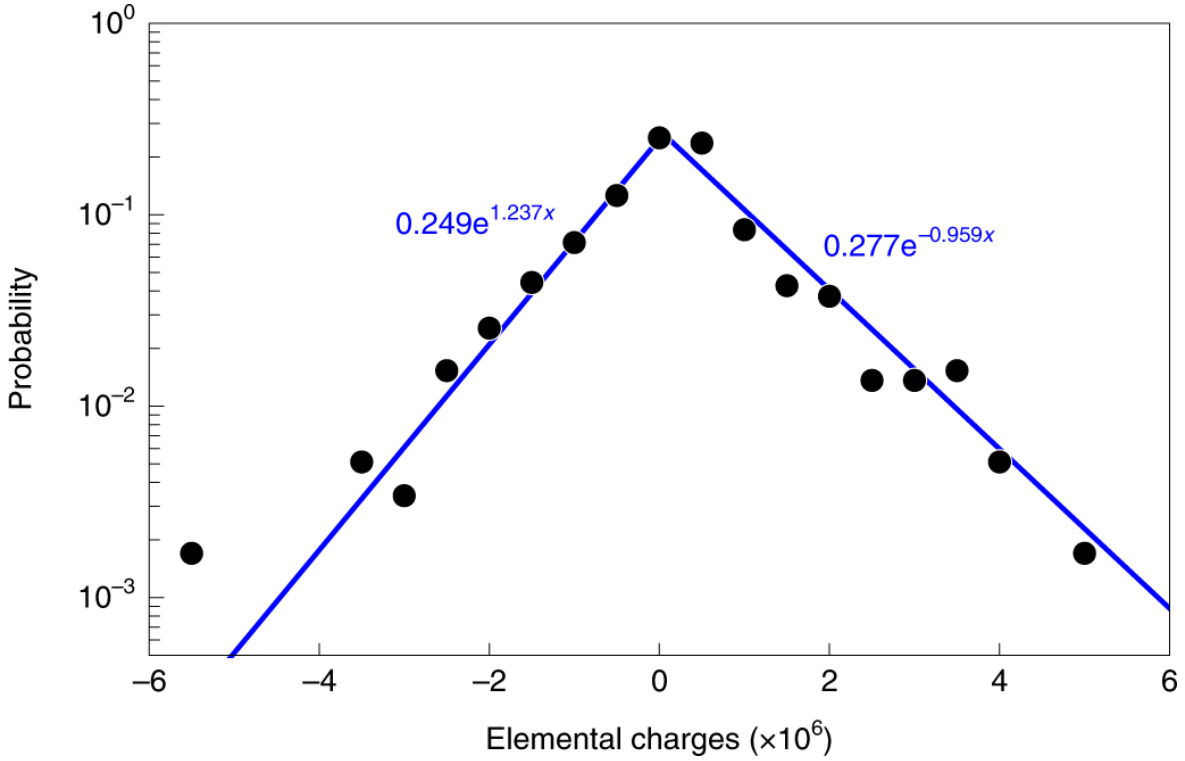
Both the experimental and simulated data in the presence of electrostatics produce size distributions described by a power law $N(n) \propto n^m$ with slope $m = -1.39 \pm 0.08$.

Particle tracking



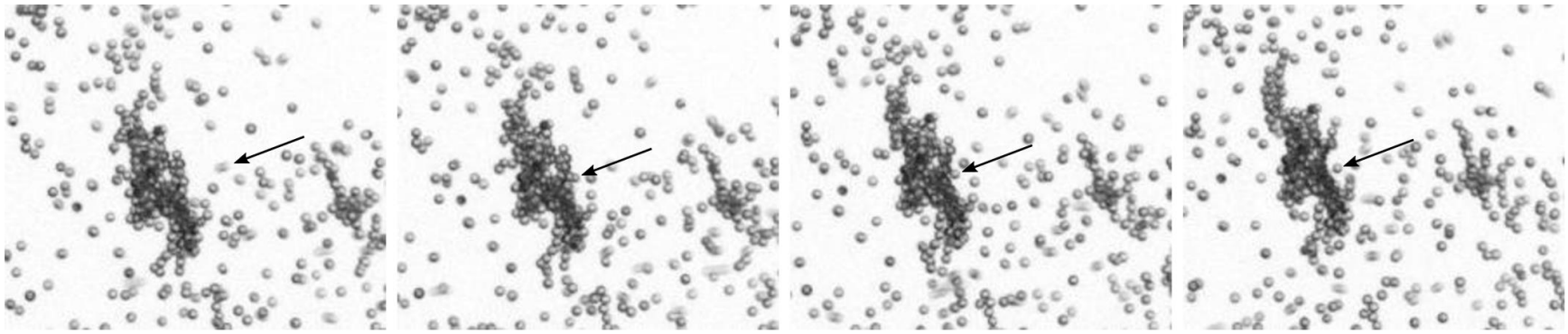
Particle tracks in the electrical field. Tracks of individual charged grains between capacitor plates in microgravity. Particles enter from the shaker at the right. Tracks are made visible by superimposing a stack of 180 frames

Charge distribution



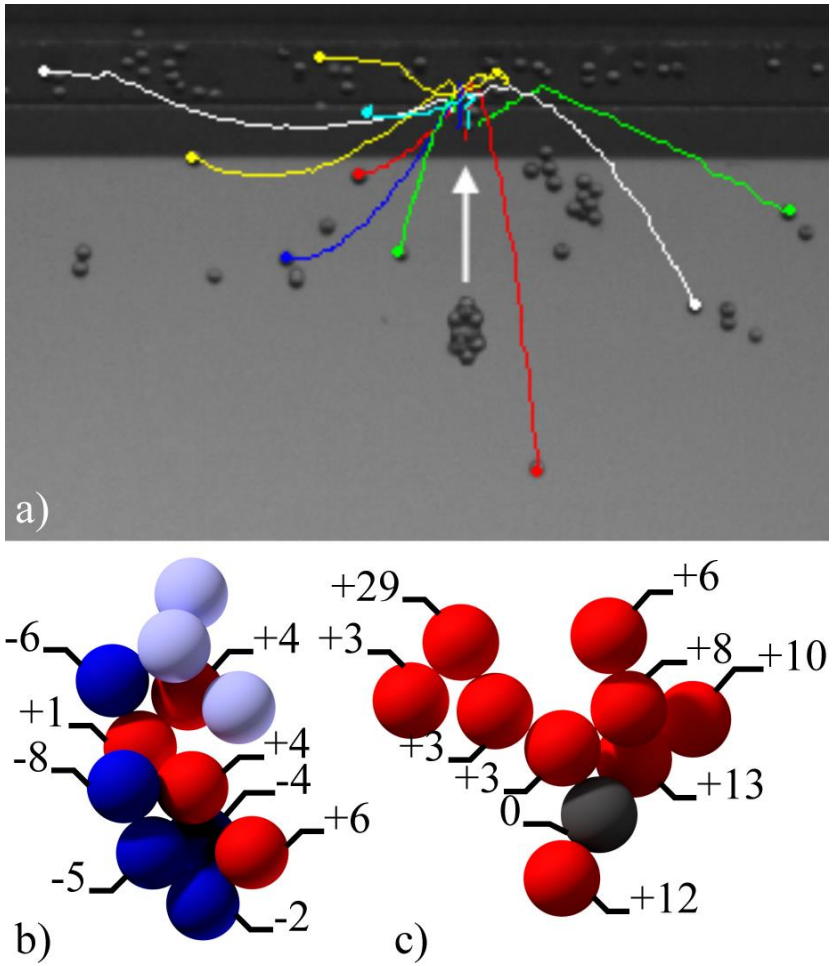
Charge distribution of individual grains. The uncertainties in the charge measurements are 15%. Blue lines are exponential fits.

Impact on aggregates



Impact of individual grain into larger cluster. Marked by the arrow, an individual grain impacts a charged cluster at 0.13 m s^{-1}. The cluster only deforms but stays intact.

Fragmentation studies



Conclusion

1. It is possible to form aggregates of several centimeters in size form millimeter size particles in velocity range typical in protoplanetry disk provided particles are electrically charged.
2. The aggregation depends on material charging (both charge density and period of charging and discharging) and dispersion (decide how frequently particles will collide).
3. Apart from collision charging other effects like charging from cosmic radiation and radioactive decay, changes in acceleration and contact cohesion is also considered but the effects of these processes are several order below than with charging.