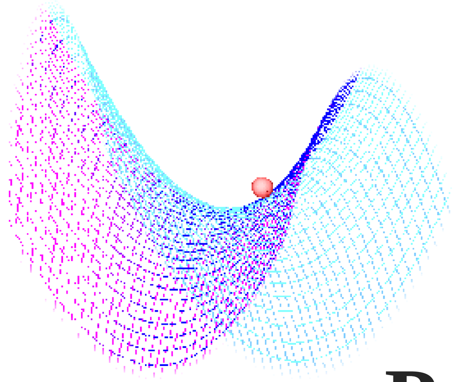
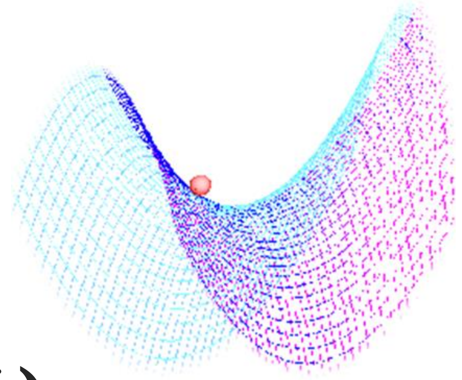




Coulomb cluster in Paul trap

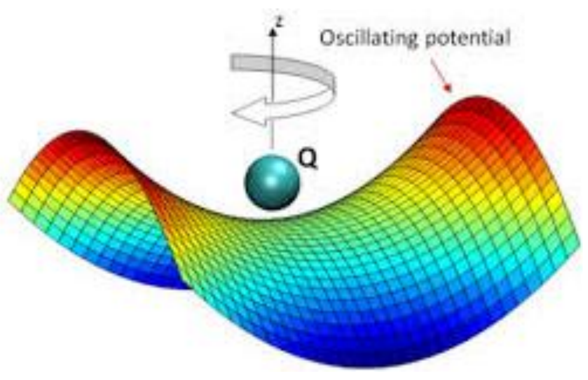
Department of Physics, National Central University, Jungli 32054, Taiwan

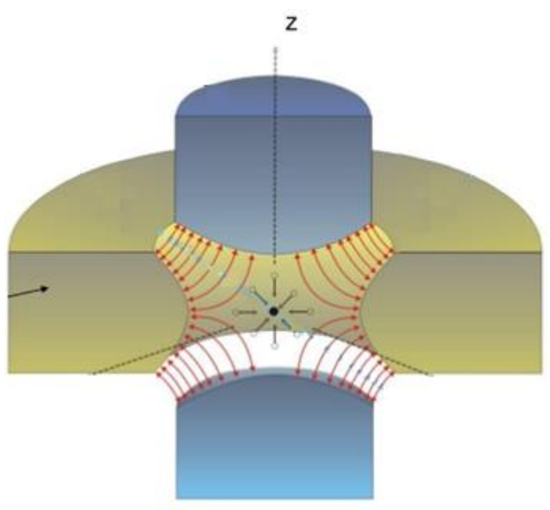
Y. C. Chang(張祐禎) Y. P. Lee(李宇平)

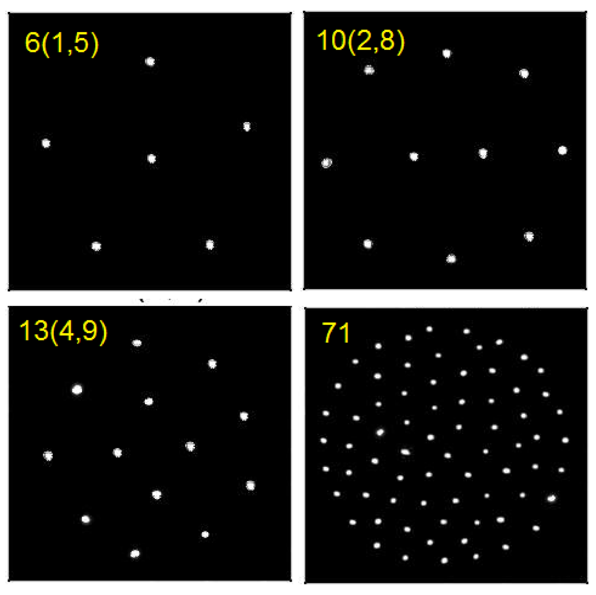
Professor : W. Y. Woon(溫偉源) TA : J. W. Liou(劉哲瑋) E. J. Hong(洪翊哲)

Introduction & Background

In order to study the interaction between particles, particles trapping becomes an important issue. In fact, there are some existing methods can trap particles, and one of them is “Paul trap”. “Paul trap” is a structure which can trap the charged particles.



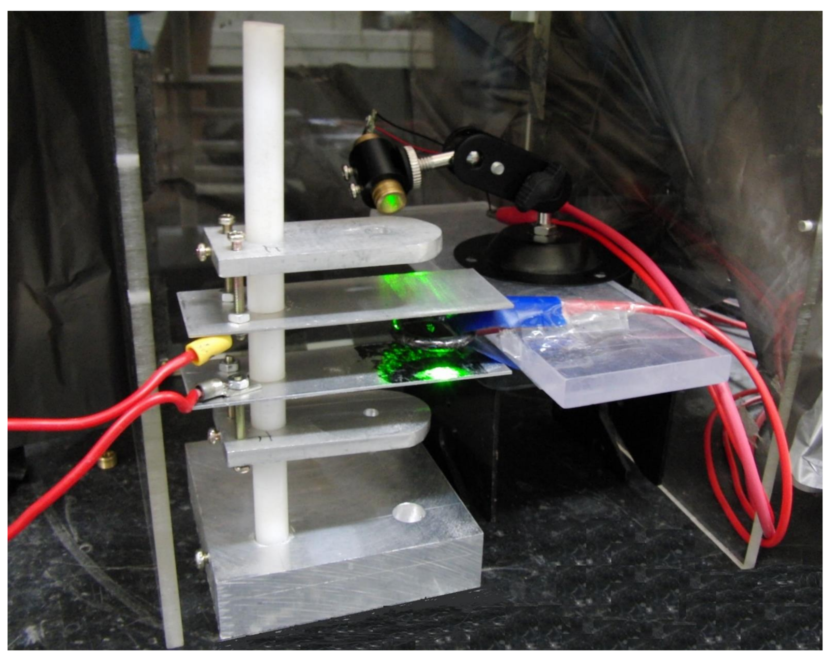




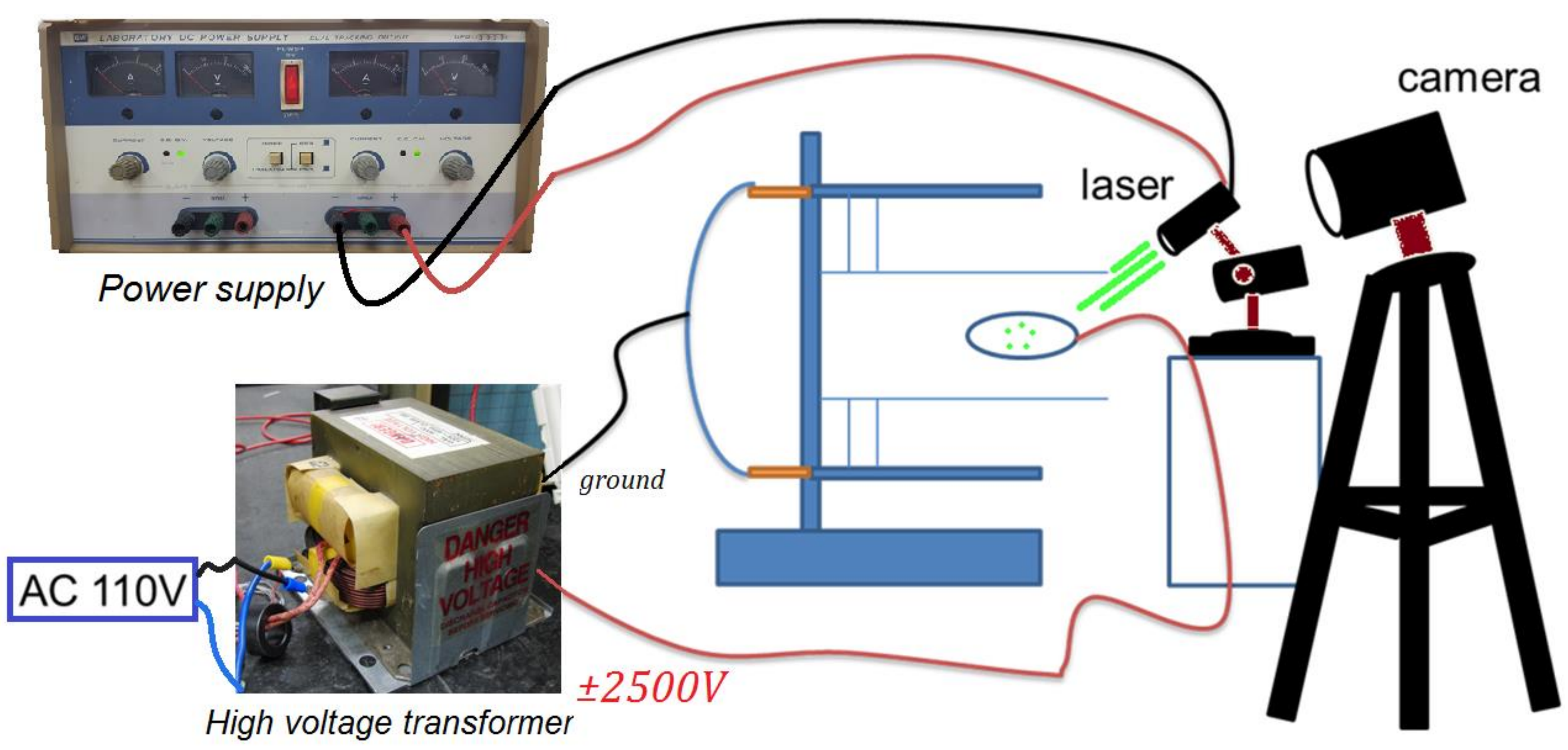
How to “trap” the charged particles? According to “Earnshaw‘s theorem” : it is not possible to create a static configuration of electric fields that traps the charged particle in all three directions. If we want to trap charged particles, we should produce an alternating potential. Due to all of the trapped particles with homogeneous charge, there are Coulomb repulsive force between each particle. So they will be mutually repulsive and arranged by force equilibrium, namely, “Coulomb cluster”.

So we want to build a Paul trap with a ring electrode and we want to observe the arrangement of 2D Coulomb cluster in different number of charged particles.

Set up & Experimental details

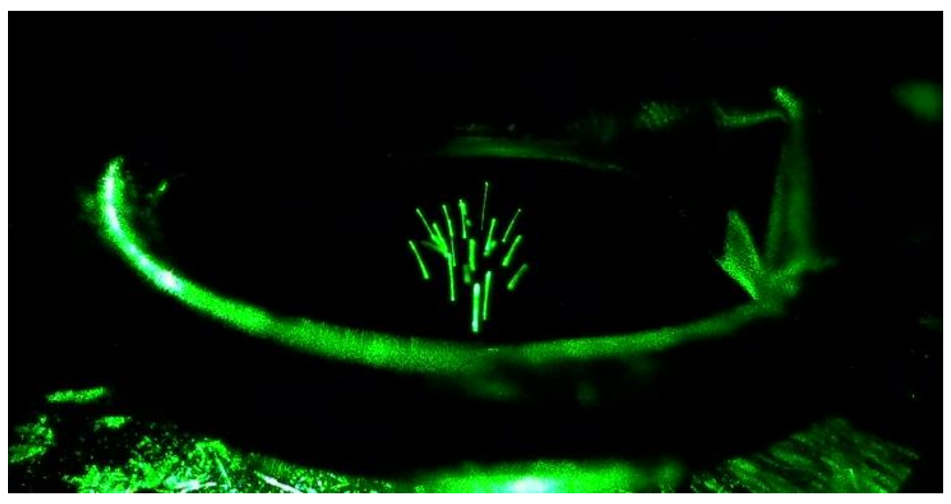


- The dielectric microparticles powder are aluminum oxide Al_2O_3 with $44.5\,\mu m$ average diameter. The particles illuminated by a sheet of green laser light with wavelength $532nm$ and average power $5mw$.
- In order to produce the strong alternating potential to trap the particles, a high voltage transformer, which can transform $110V$ to approximately peak to peak $5000V$ alternating voltage with $60Hz$ is used.
- The metal ring is placed in the middle of two aluminum plates. Both of the inner radius of metal ring and the separated distance between two aluminum plates are $20mm$.

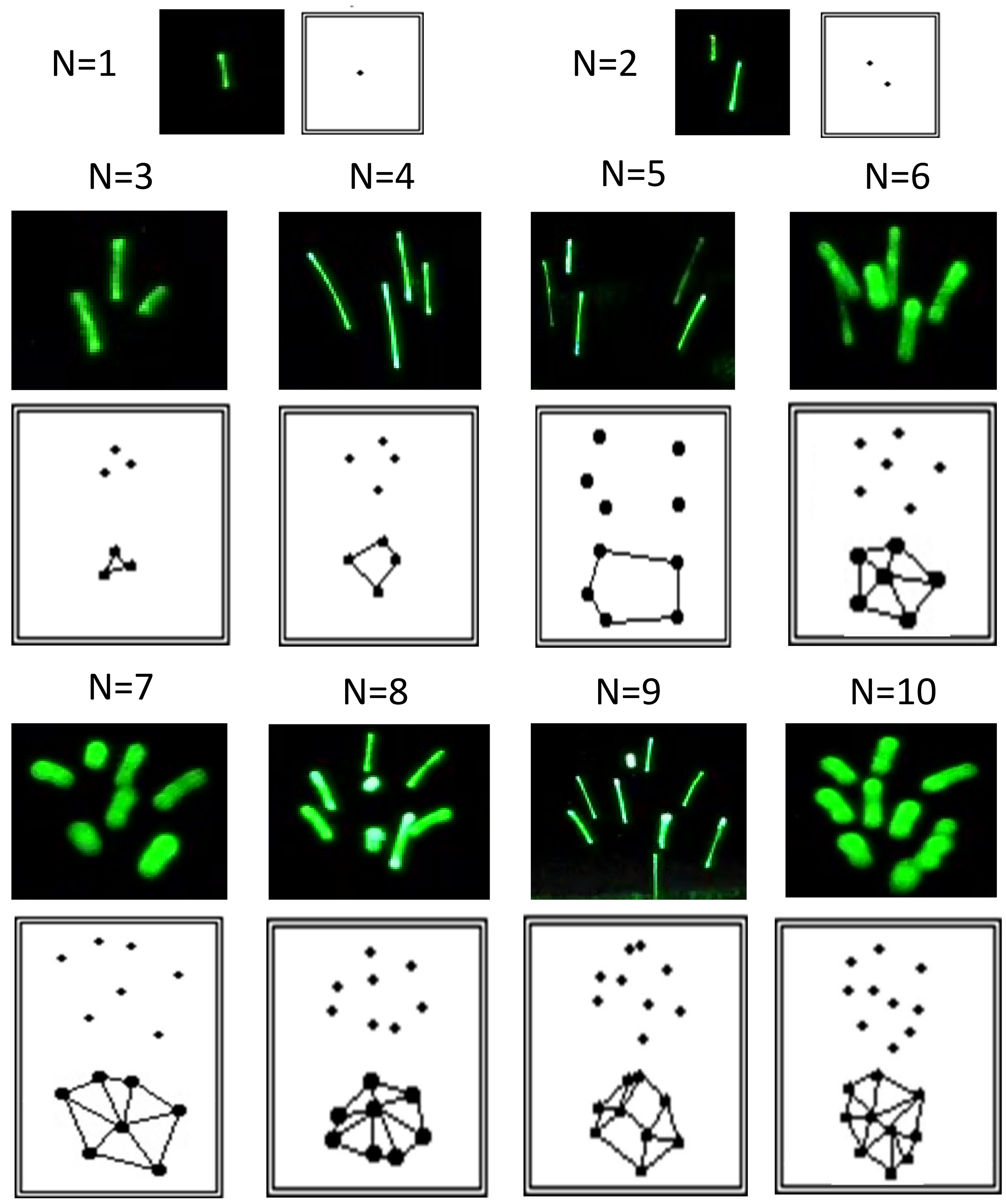


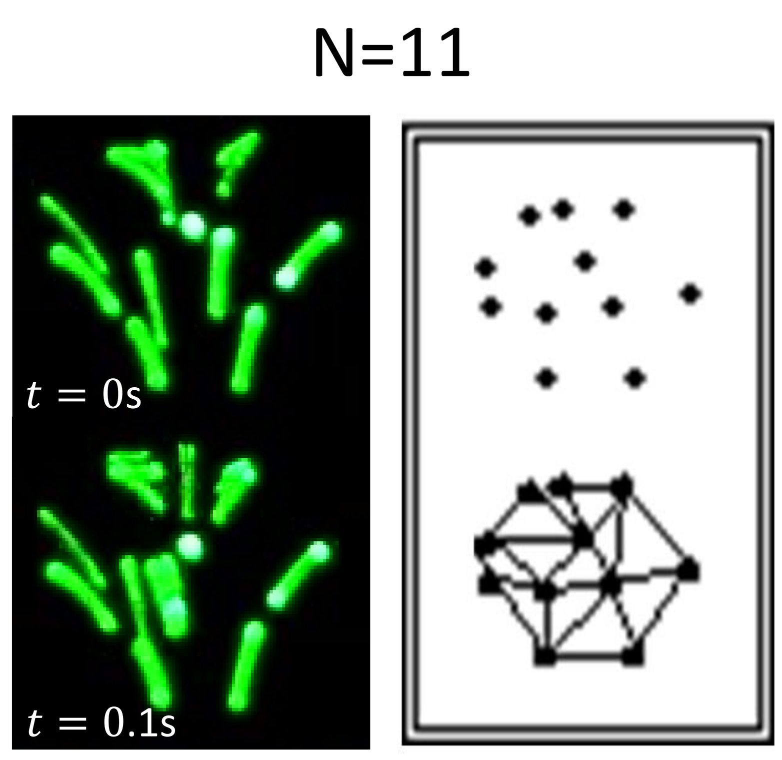
- We pick up the particles with iron wire and close to metal ring with high voltage. Static electricity makes the particles with charges and then be trapped in the alternating potential.
- Moreover, the reason why the particles looks like a straight line and not a point is that the particles would oscillate with $60Hz$. Our naked eye cannot keep up with the motion of particles.

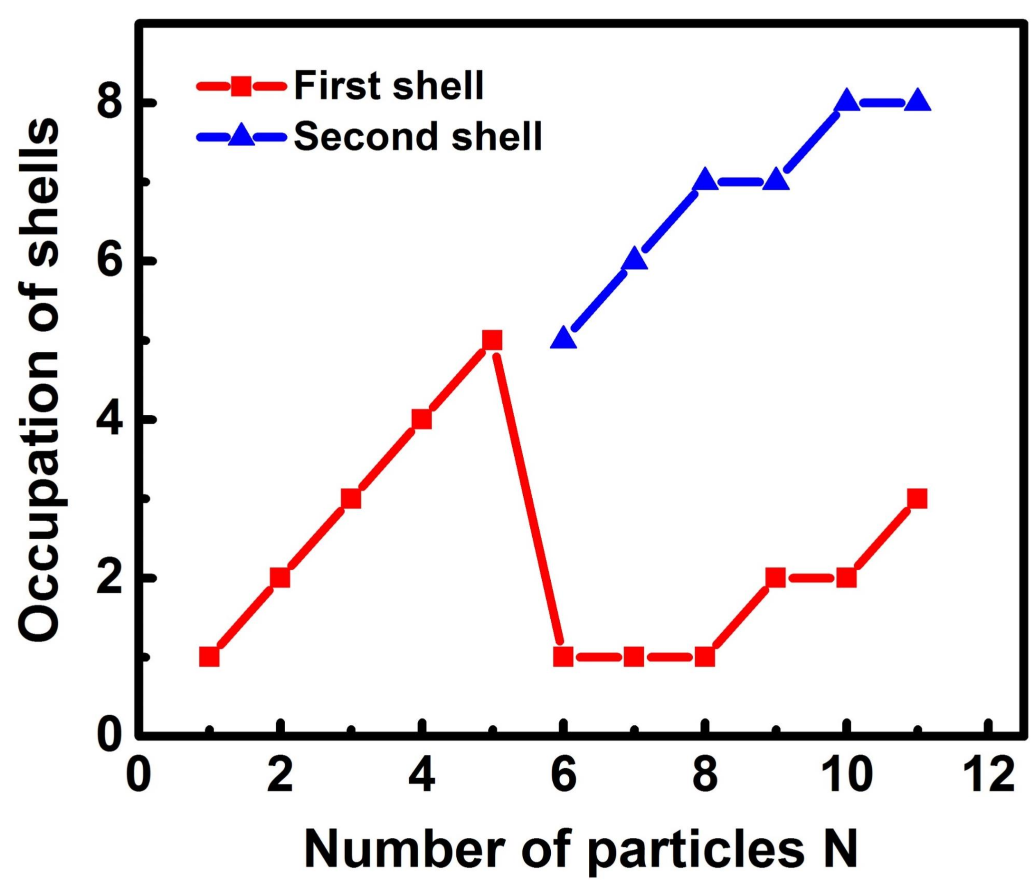
Result & Discussion



This picture shows a lot of charged particles which trapped in the potential. And we want to discuss the arrangement of a number of particles from one to eleven.







1. When $N \leq 5$, Coulomb cluster only has one shell.
2. When $N = 6\sim8$, cluster appears second shell and first shell only has one particle.
3. When $N = 9\sim11$, first shell becomes two and three particles.
4. The results are similar to the dust Coulomb clusters in a plasma trap and also correspond to the early calculation by J.J Thomson.
5. “Paul trap” shows the macroscopic system to study the interaction between particles.

Reference

[1] Wen-Tau Juan, Zen-Hong Huang, Ju-Wang Hsu, Yin-Ju Lai, and Lin I Phys. Rev. E 58, R6947(R) (1998)