Effect of a floating circular aperture on a dc glow discharge dusty plasma

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ABSTRACT

We have investigated novel effects observed when a floating aperture, either 6 mm or 8 mm in diameter, is placed 1–2 cm in front of an anode disk (4 cm diameter) that is used to form a dc glow discharge dusty plasma. Dust is incorporated into the anode glow plasma from a tray located below the anode which contained kaolin powder. The glow discharge traps particles with an average size of 1 micron. When the aperture is placed in front of the disk, well-defined pear-shaped or spherical dust clouds are formed, depending on the diameter of the aperture and its distance from the anode. The dust interacts with the aperture through the potential structure associated with the floating (negative) plate in which

the aperture is located. The dust cloud is imaged using a CCD camera and a thin sheet of 532 nm laser light. Some of the effects observed include: outwardly expanding spherical dust acoustic waves and shocks, dust rotation around a void formed at the aperture, and a dust/discharge instability in which the discharge is periodically quenched and reignited while the dust cloud expands and contracts, with the dust retaining a residual charge.

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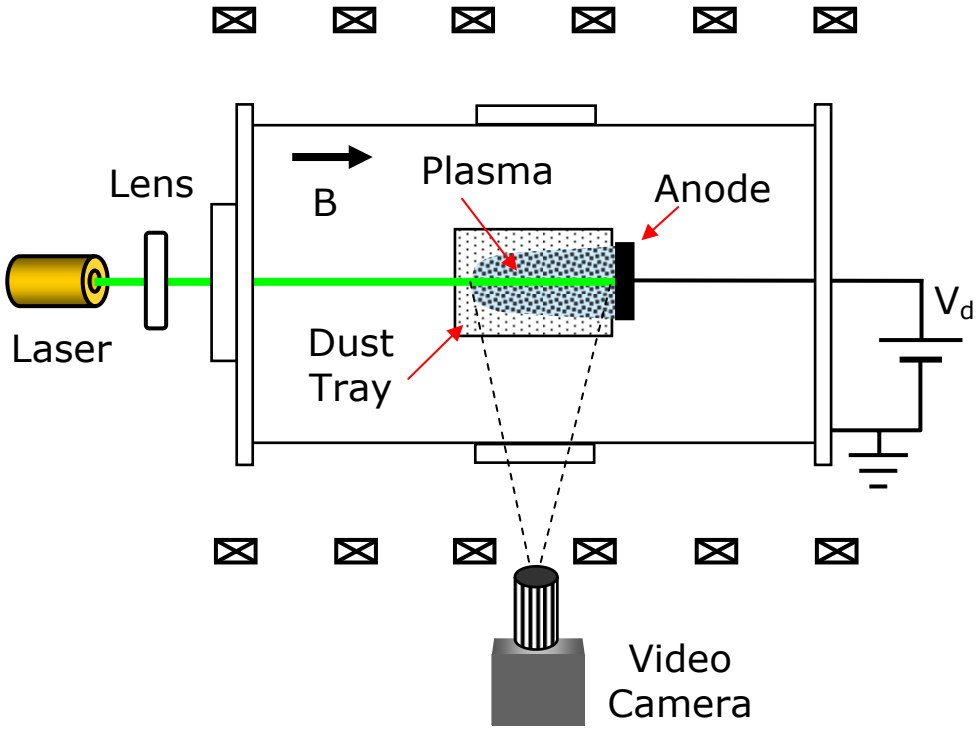
Formation of a Dusty Plasma in a DC Glow Discharge Device



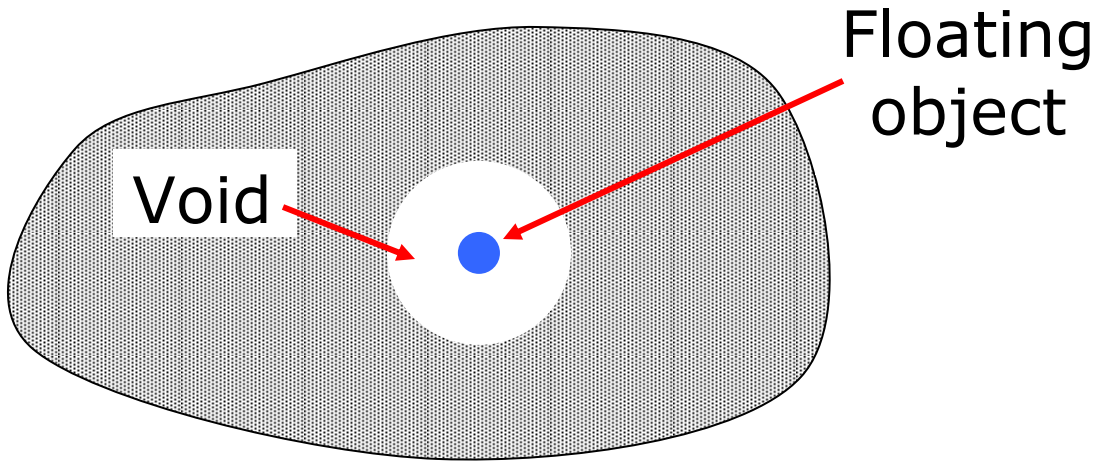
Parameters

- V_d = 300–400 V
- I_d = 1- 30 mA
- P = 70–200 mtorr
- gas: argon
- $n_i = 10^{14}$–10^{15} m^{-3}
- T_e = 2–3 eV
- T_i = 0.03 eV
- B = 0–0.01 T
- dust: kaolin powder ~ 1 μm

Interaction of a Dusty Plasma with an Electrically Floating Object

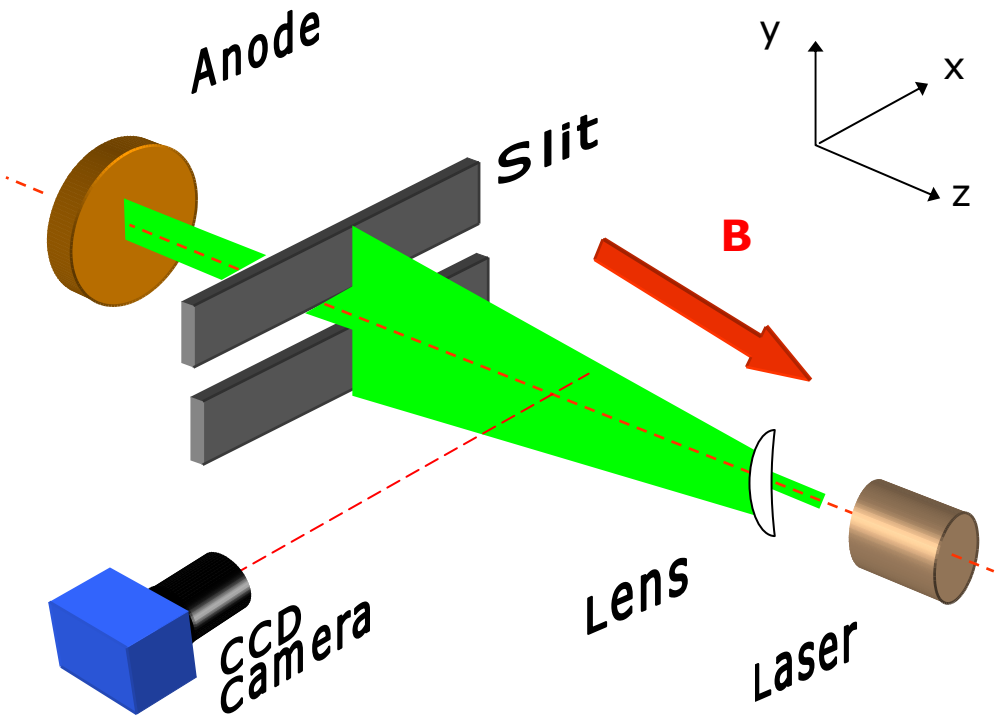
- When an insulator or electrically floating object is inserted into a dusty plasma, it acquires a negative charge.

- Negatively charged dust particles will be repelled by the floating object, and a dust void will form around it.

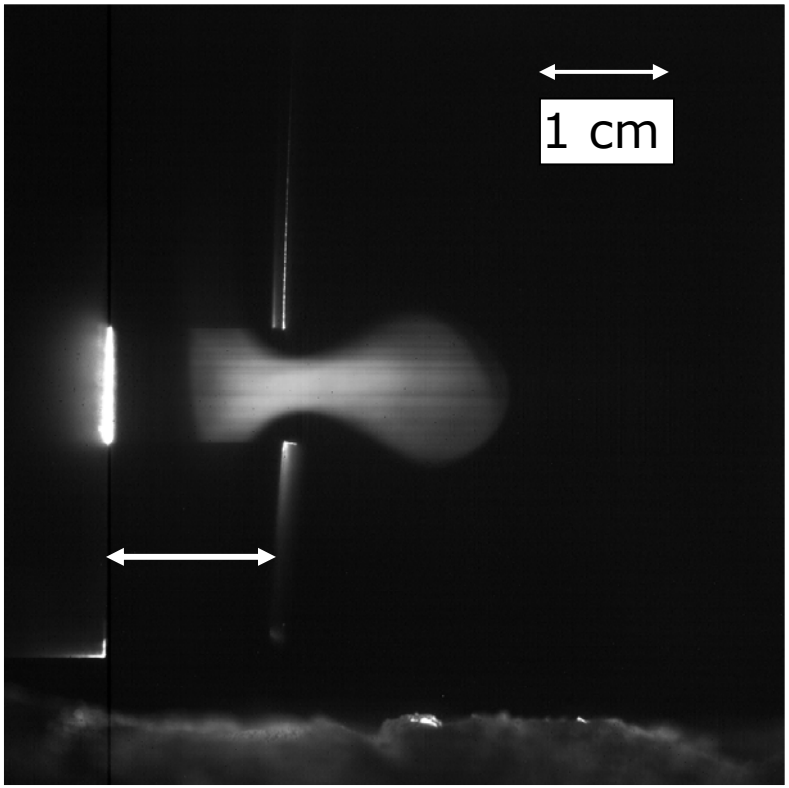


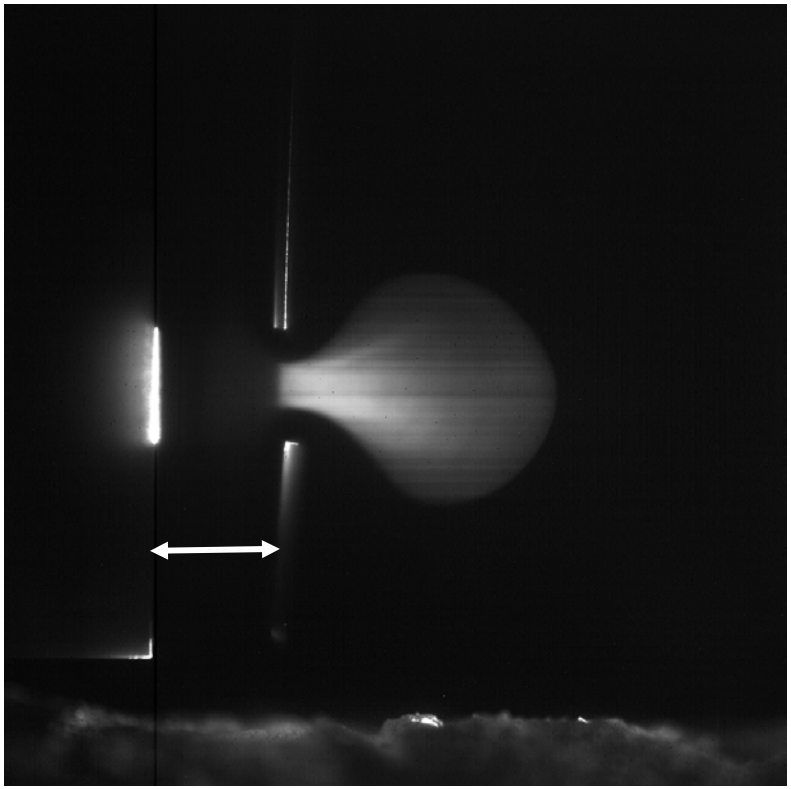
Floating Objects Inserted into a Dusty Plasma can be used to Modify its Shape

RECTANGULAR SLIT

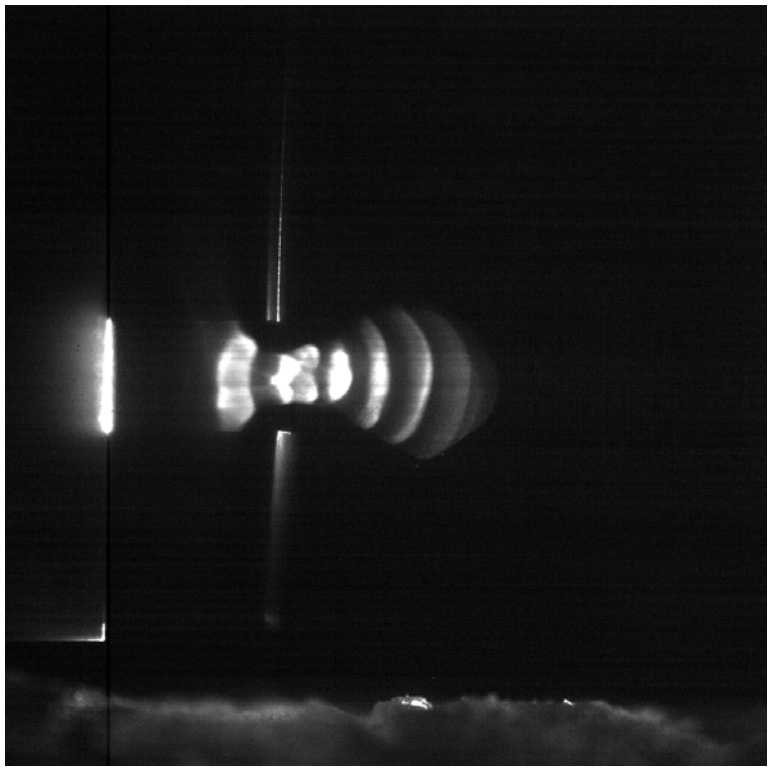


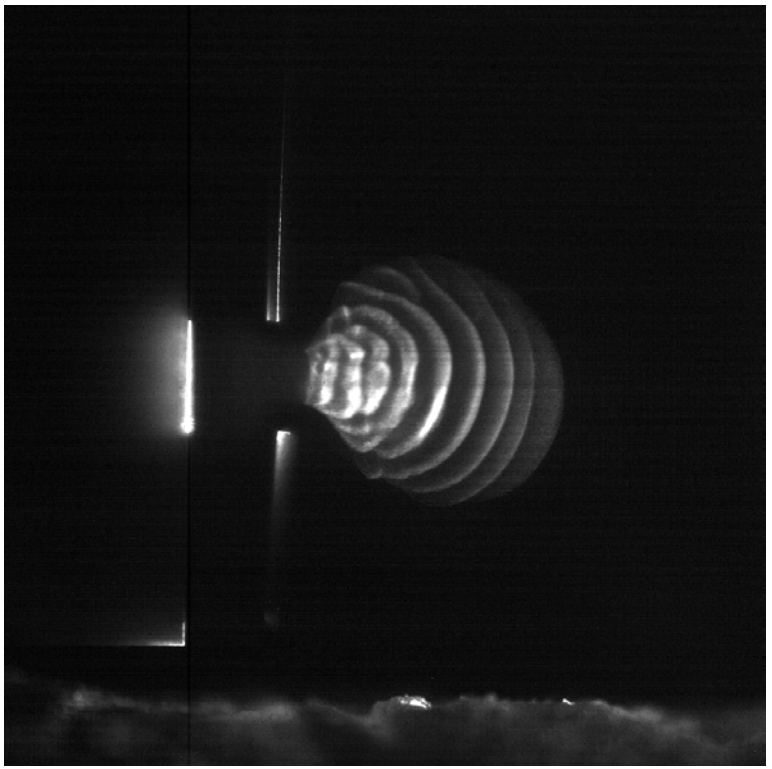
The shape of the dust cloud can be controlled by changing the distance between slit and anode.



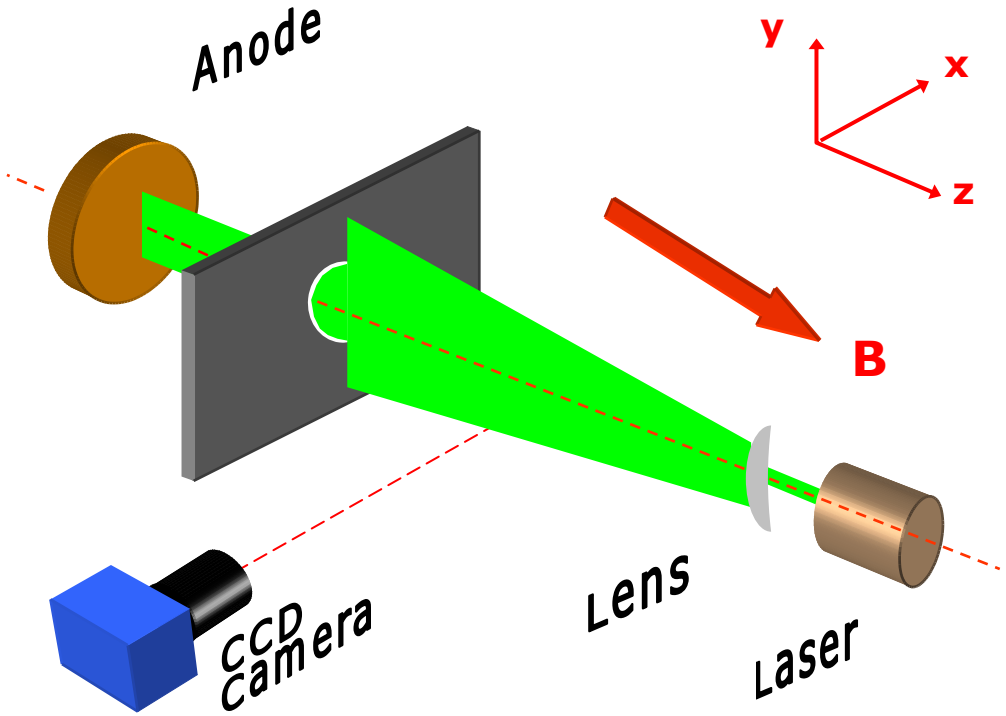


FORMATION OF DUST ACOUSTIC WAVES AND SHOCKS

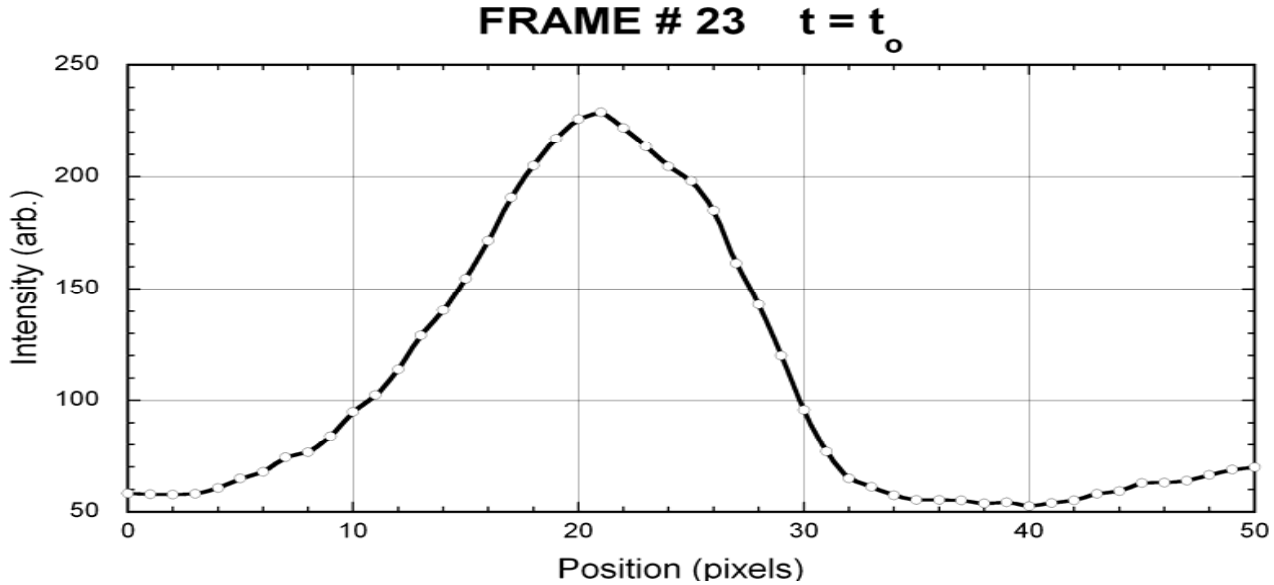


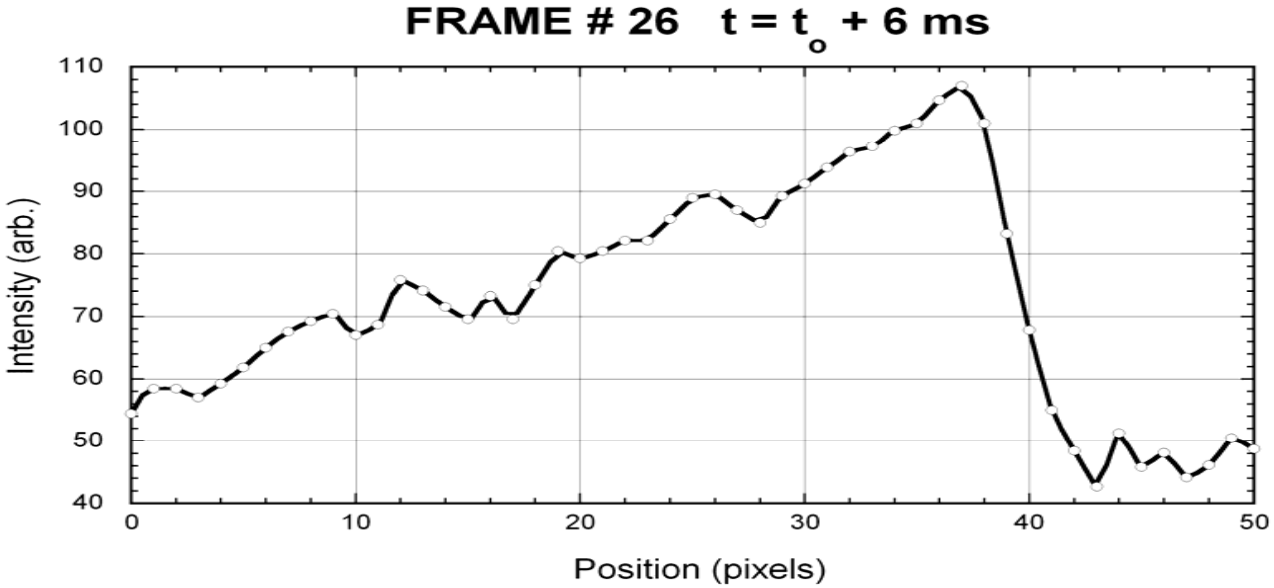


CIRCULAR APERTURE

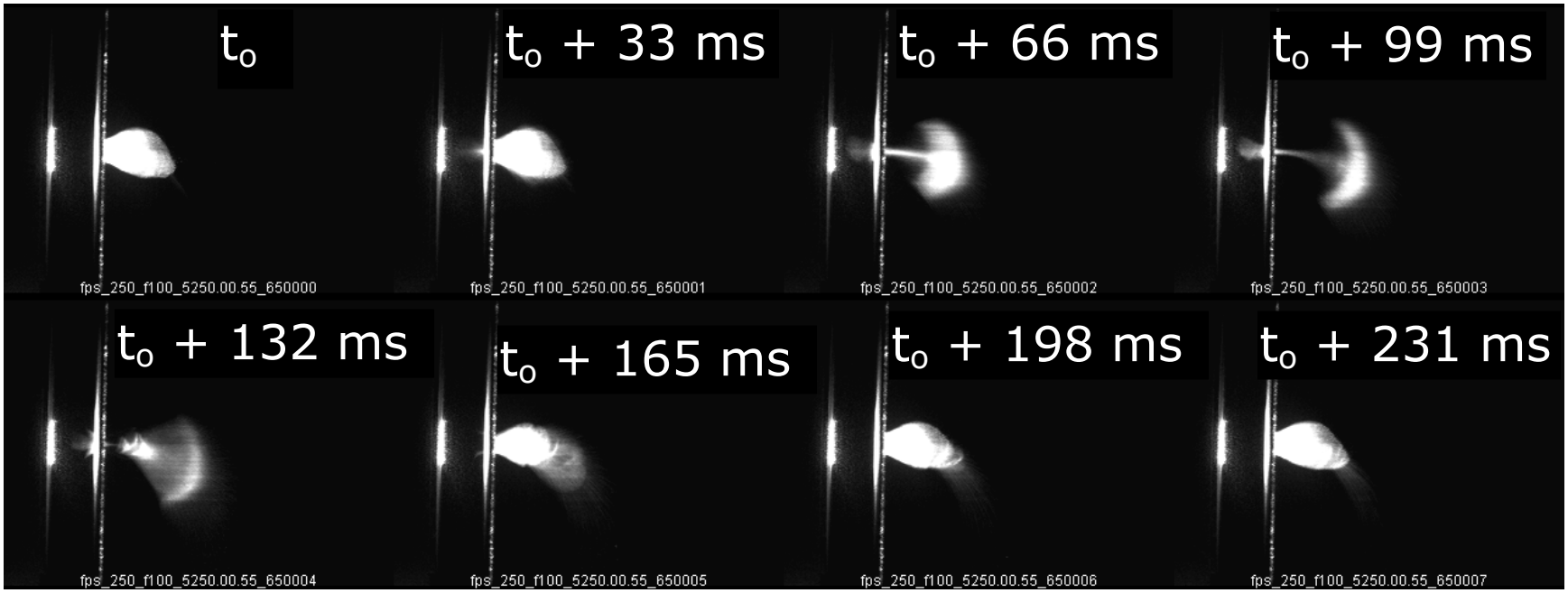


SHOCK WAVE FORMATION



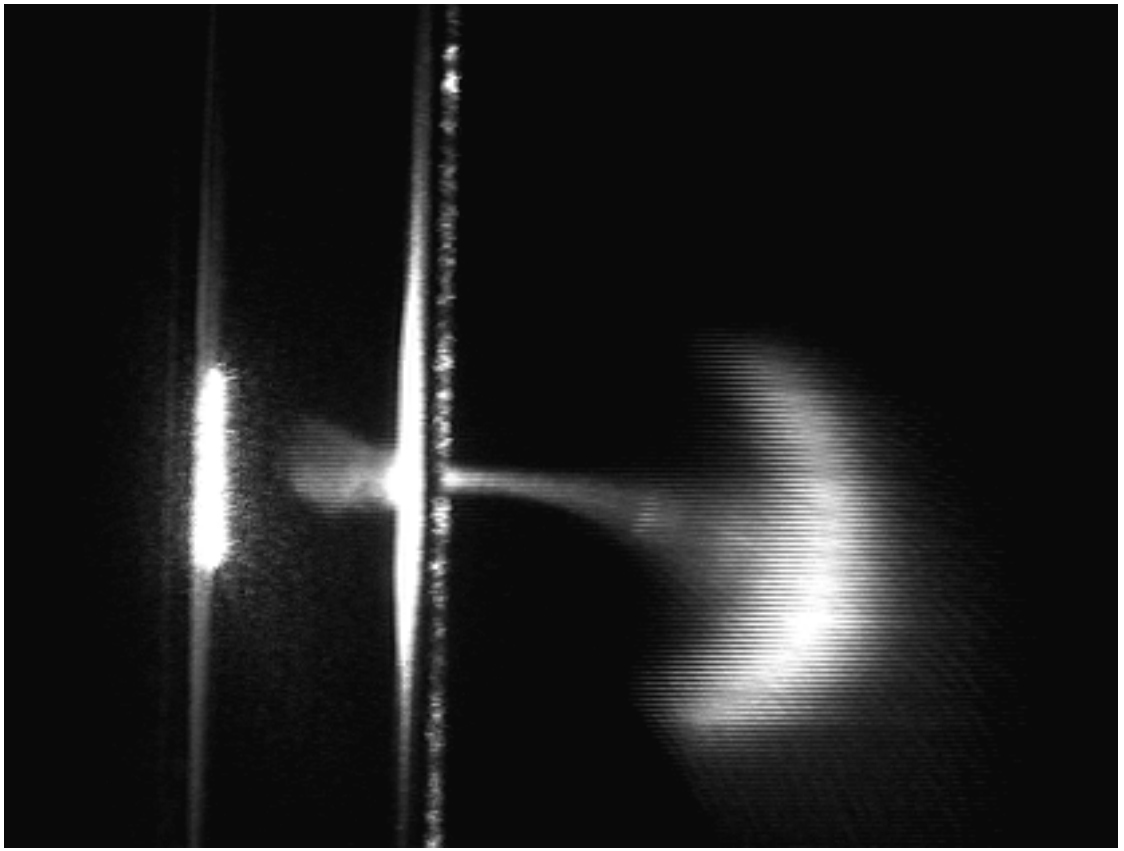


DUST JETS WITH CIRCULAR APERTURE

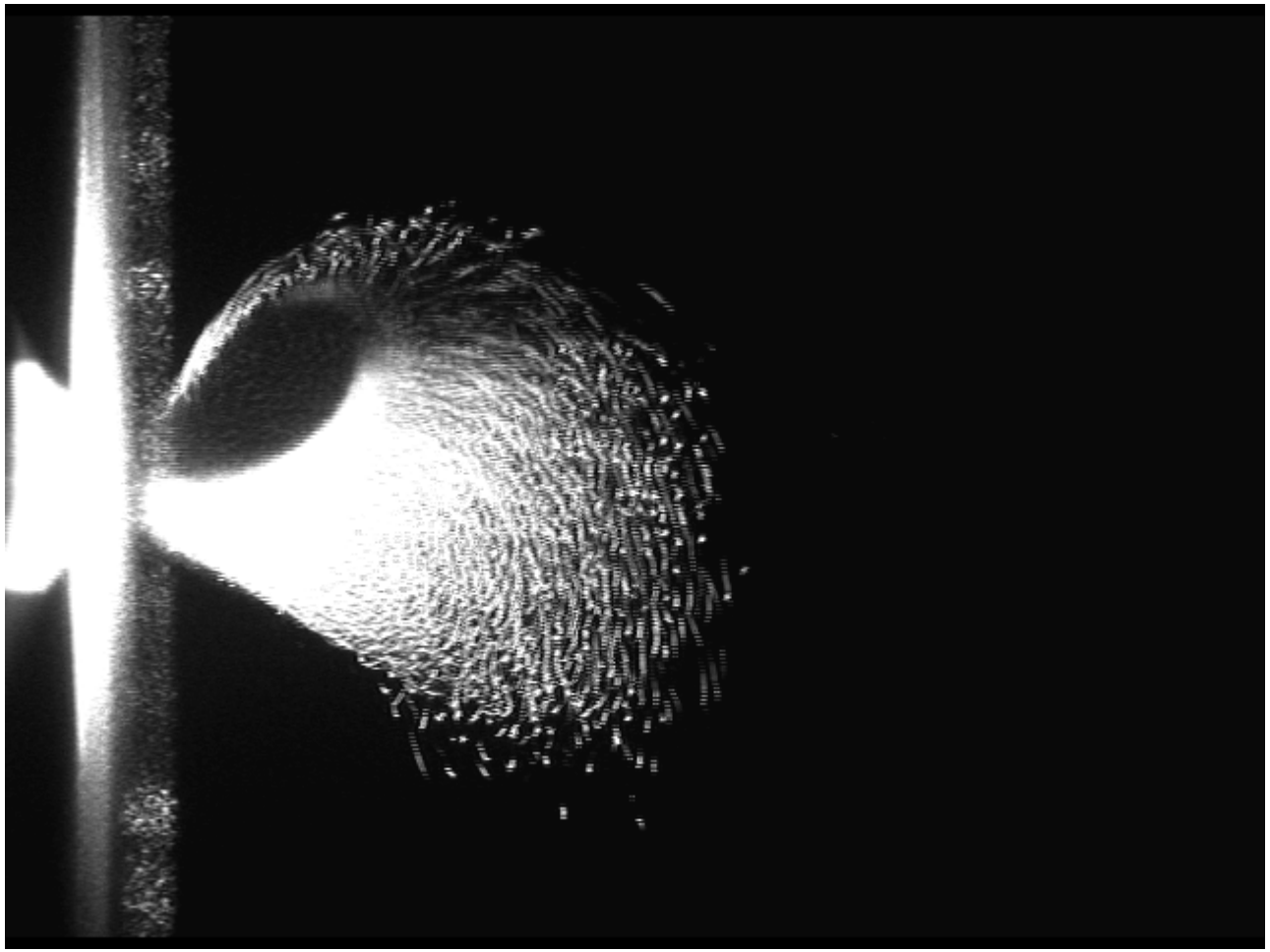


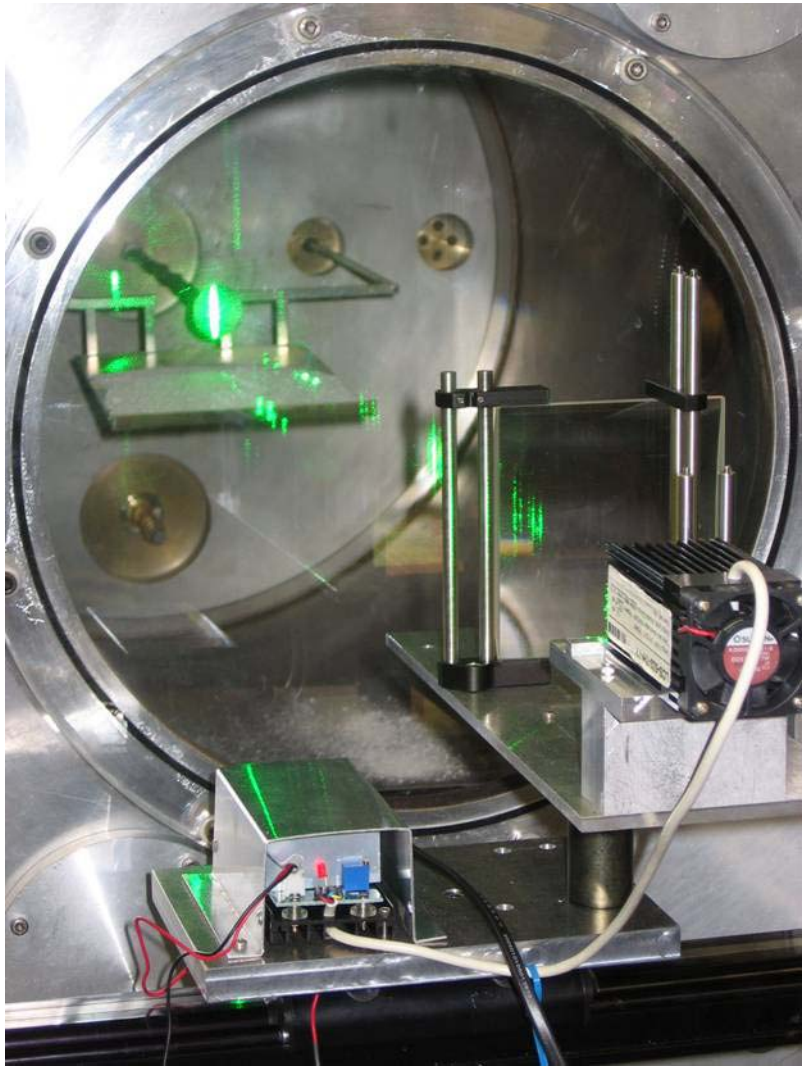
Under certain conditions, the dusty plasma is subject to an instability in which the dust suspension periodically jets forward and then snaps back to its original position.

Dust jet at $t = t_o + 99$ ms



VOID AND VORTEX FORMATION WITH CIRCULAR APERTURE





SUMMARY

- We have studied the effect of floating apertures on dusty plasmas
- The apertures can alter the geometry of a dusty plasma by forming an electrostatic barrier to the negatively charged dust
- Phenomena that have been observed are:
  - nonlinear wave collision and confluence
  - shock wave formation
  - dust jets
  - dust void and vortex formation