

Dust particles under the influence of crossed electric and magnetic fields in the sheath of an rf discharge

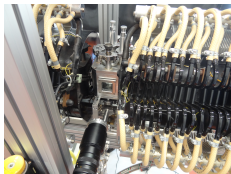
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14th WPDP
Auburn, USA
May 27, 2015

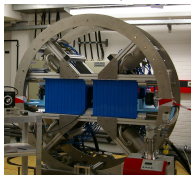


Dusty plasmas in magnetic fields

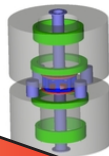
Greifswald



Dustwheel, Kiel



Gießen; Suleiman, Kiel;
 MDPX, Auburn



$p \sim 10 \text{ Pa}$



magnetized
 electrons

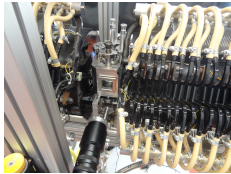
magnetized
 electrons
 + ions

magnetized
 electrons
 + ions
 + dust

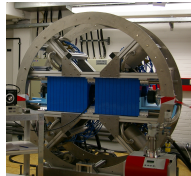
dust particles indirectly
 influenced via plasma

Dusty plasmas in magnetic fields

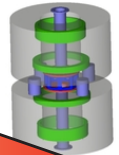
Greifswald



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$p \sim 10 \text{ Pa}$



study effect on:

- horizontal dust monolayers
- vertically aligned dust pairs

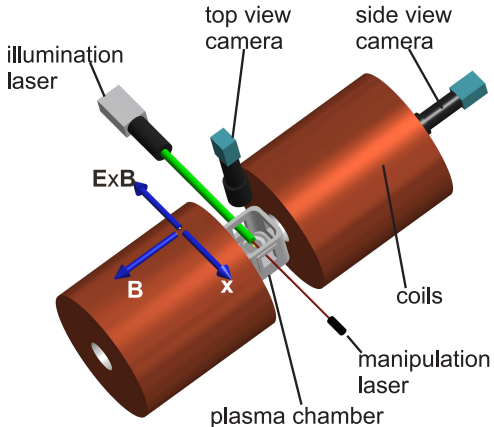
magnetized
electrons

magnetized
electrons
+ ions

magnetized
electrons
+ ions
+ dust

dust particles indirectly
influenced via plasma

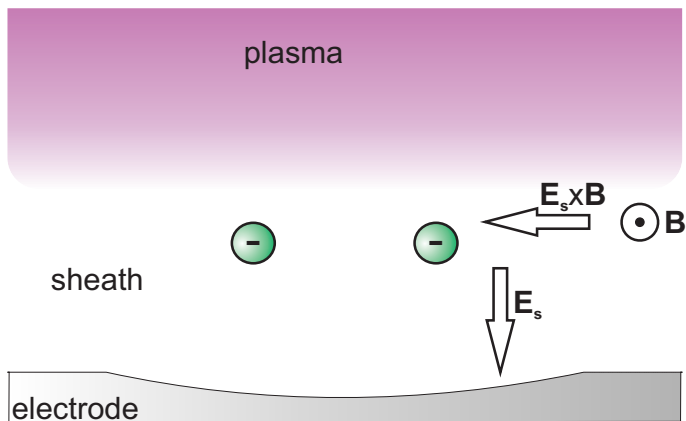
Experimental setup



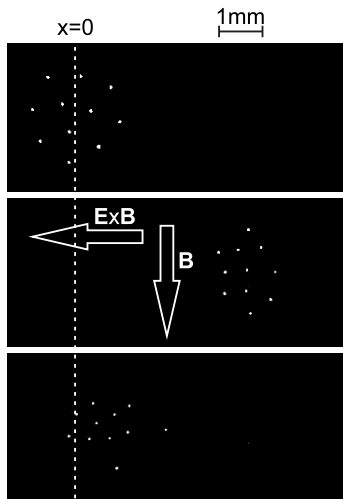
[coil system is a loan from the work group of Prof. Meichsner]

- magnetic field
 - $B_{center, max} \approx 100 \text{ mT}$
- plasma
 - argon-rf-discharge
 - $p = 1 \dots 30 \text{ Pa}$
 - $P = 6 \text{ W}$
- dust particles
 - melamine-formaldehyde
 - $\varnothing \sim \mu\text{m}$

Laboratory dusty plasmas



Displacement \perp B



$$B = 0$$

parameters:

- dust size: $12.26 \mu\text{m}$
- $p = 4.5 \text{ Pa}$

$$B = 17 \text{ mT}$$

$$B = 26 \text{ mT}$$

Figure: top view camera images

Displacement \perp B

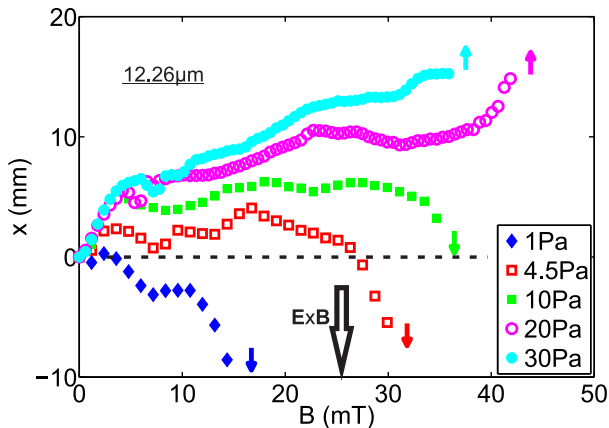
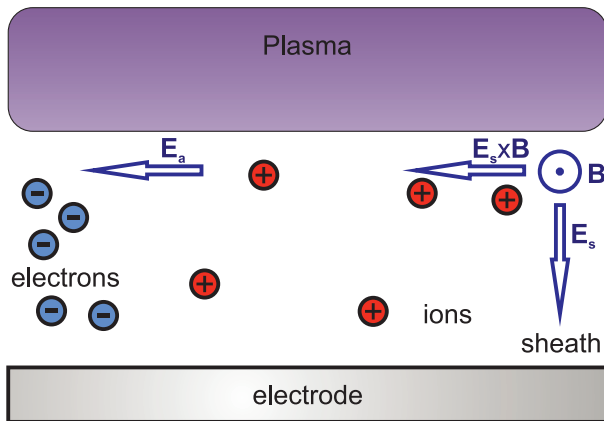
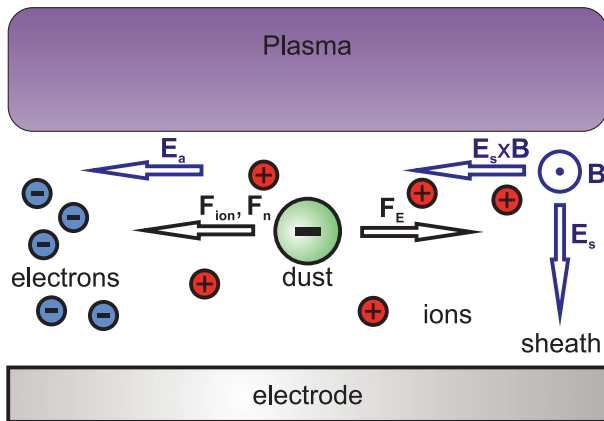


Figure: displacement perpendicular to the magnetic field

Horizontal force balance model



Horizontal force balance model



$$x(E_a) = \frac{F_E - F_{ion} - F_n}{m_d \omega_0^2}$$

Model results for displacement $\perp \mathbf{B}$

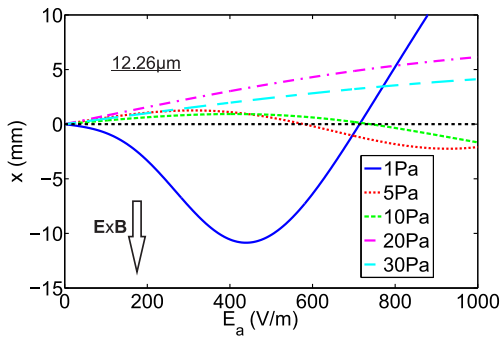


Figure: calculated displacement perpendicular to the magnetic field

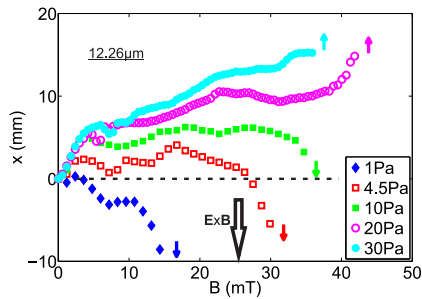
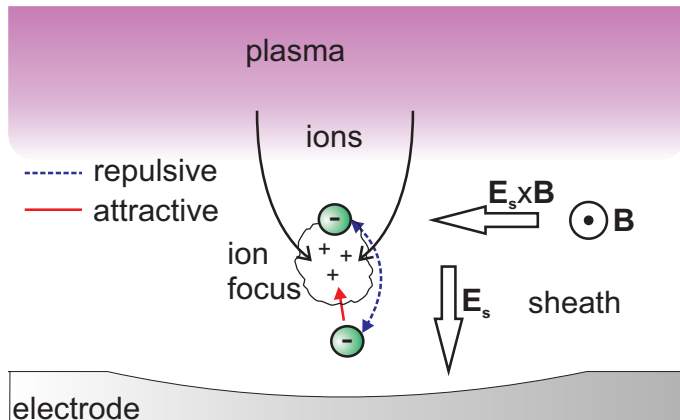
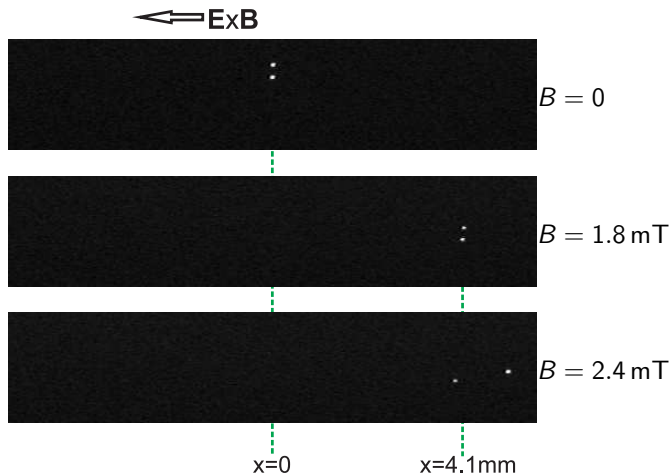


Figure: measured displacement perpendicular to the magnetic field

Ion focus - experiments



Ion focus - magnetic field experiments



parameters:

- dust sizes:
10.2 μm and
12.26 μm
- $p = 30 \text{ Pa}$

Figure: side view camera images

Ion focus - magnetic field experiments

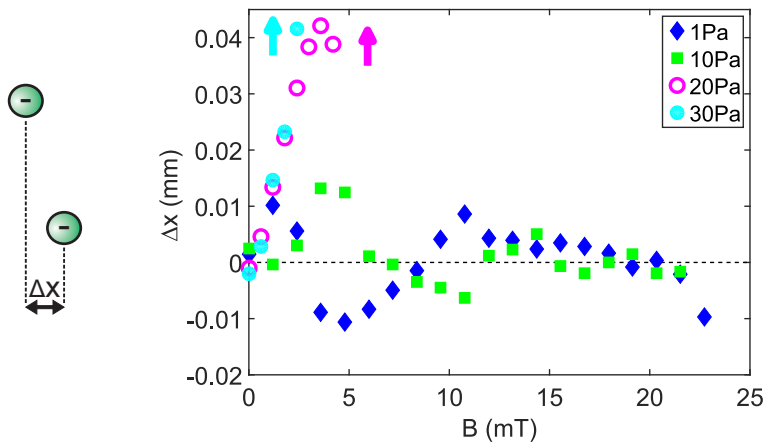


Figure: horizontal distance between upper and lower particle

Ion focus - laser manipulation experiments

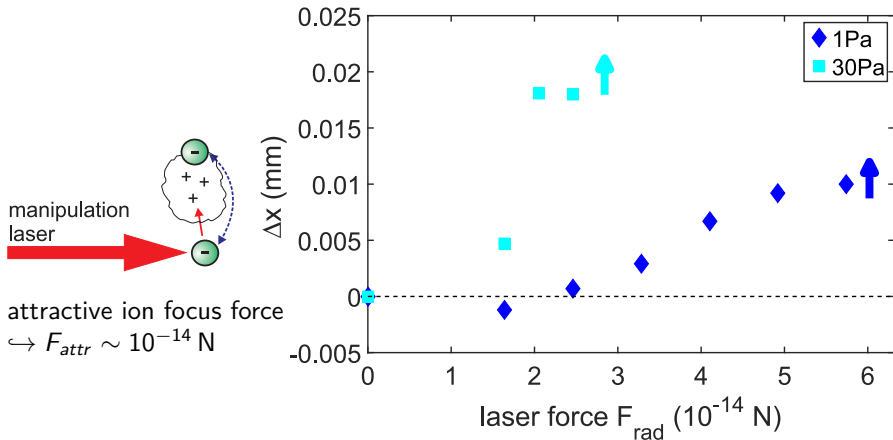
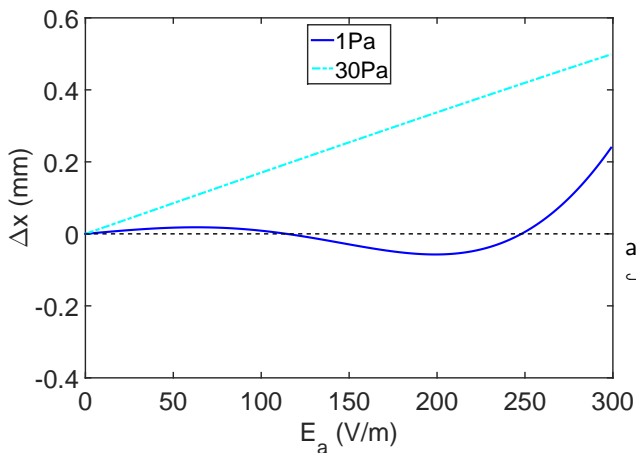


Figure: horizontal distance between upper and lower particle

Ion focus - horizontal force balance



attractive ion focus force
 $\hookrightarrow \Delta x \sim F_{attr} \approx 10^{-13} \text{ N}$

Figure: calculated horizontal distance between upper and lower particle

Summary

- investigations on dust particles in plasma sheaths with external horizontal magnetic fields
- B-field \rightarrow magnetized electrons
- horizontal forces: F_E , F_{ion} , F_n
 - dust particle displacement on the $\vec{E} \times \vec{B}$ -axis
 - break up of vertical alignment of dust pairs
- associated publications:
 - M. Puttscher and A. Melzer, New J. Phys., 2014
 - M. Puttscher and A. Melzer, Phys. Plasmas, 2014
 - M. Puttscher and A. Melzer, submitted to Phys. Plasmas

