Particle charge and ion drag force in PK-4 DC discharge from ground and microgravity experiments

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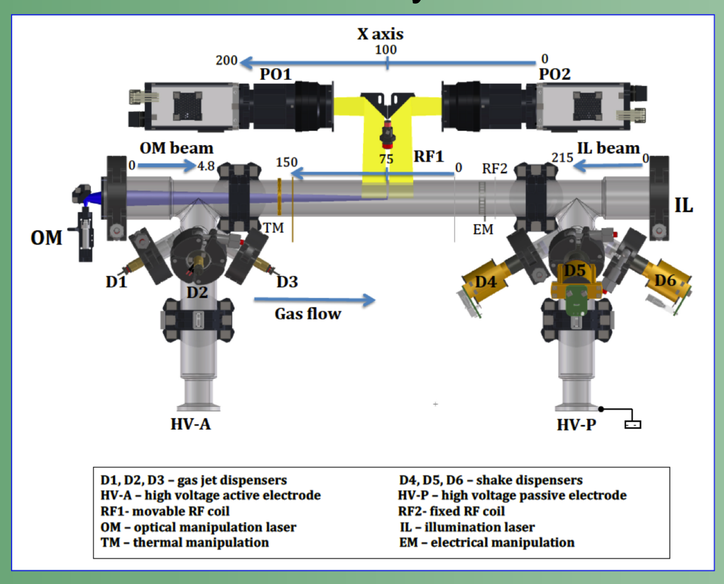
Abstract

The estimation of dust particle charge in the discharge tube of the Plasmakristall-4 (PK-4) facility has been made from the measurements of the drift flow velocity of particles on ground and under microgravity conditions on International Space Station (ISS). Argon and Neon gases were used to ignate DC discharge in the pressure range from 20 to 100 Pa varying the discharge current from 0.5 to 1.5 mA. Drift velocity of dust particles from experimental data were compared with the results of theoretical model, which yielded the estimation of particle charge. In the developed model the vatiation of the discharge parameters in radial direction was taken into account and the results were compared with the experimentaly measured positions of dust particles with respect to the radial axis of the discharge tube.

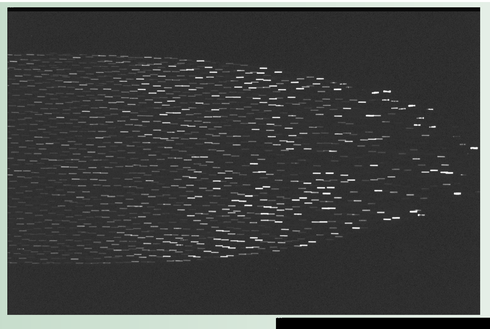
PK-4 Facility



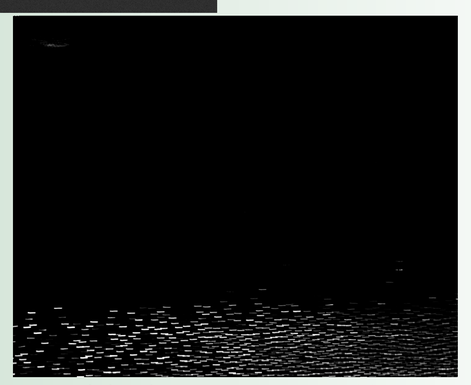
Science Reference Model 1

The Flight Model of PK-4 was installed in the Columbus module of the International Space Station (ISS). The experiments analysed here were performed on orbit in 2015 and in ground laboratory using PK-4 Scienece Reference Model 1

ISS



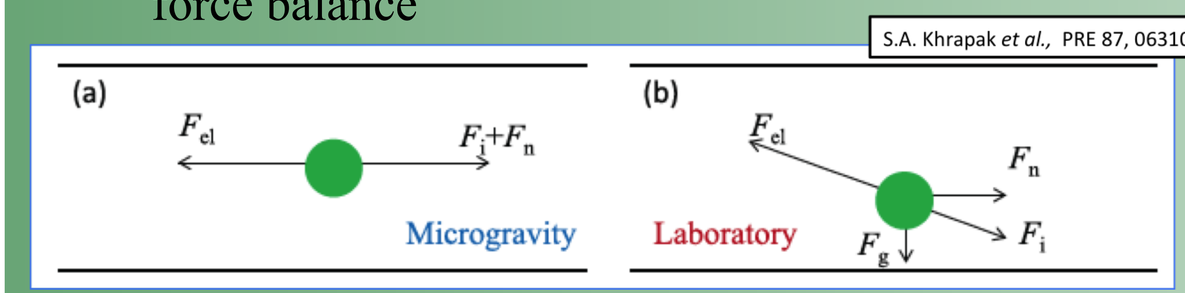
Ground



3.4μm dust particles in Argon gas at 100 Pa pressure and 0.7mA discharge current in ground laboratory and under microgravity contions on ISS

Theoretical background: forces acting on particles

force balance



higher u_i gives higher particle charge, which gives higher F_{el}, and, hence, higher particle velocities

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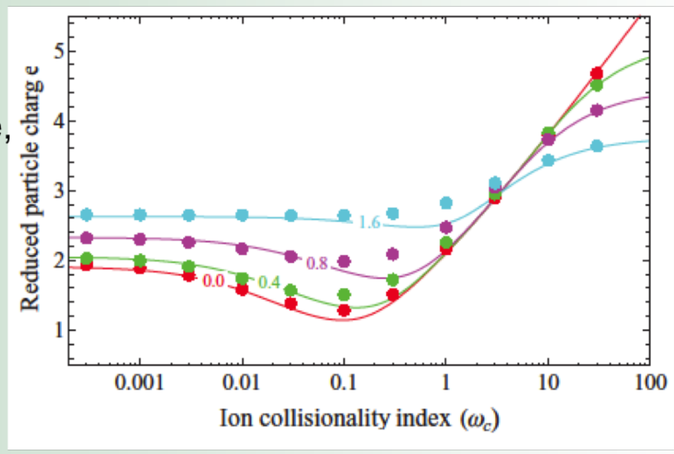


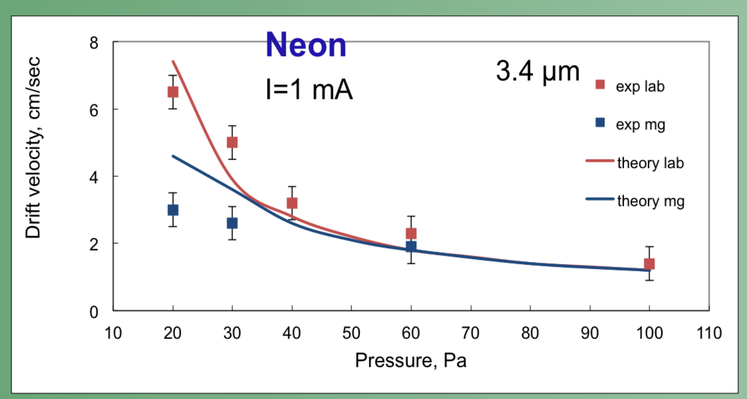
$F_{el} = QE$ electric force acting on a particle

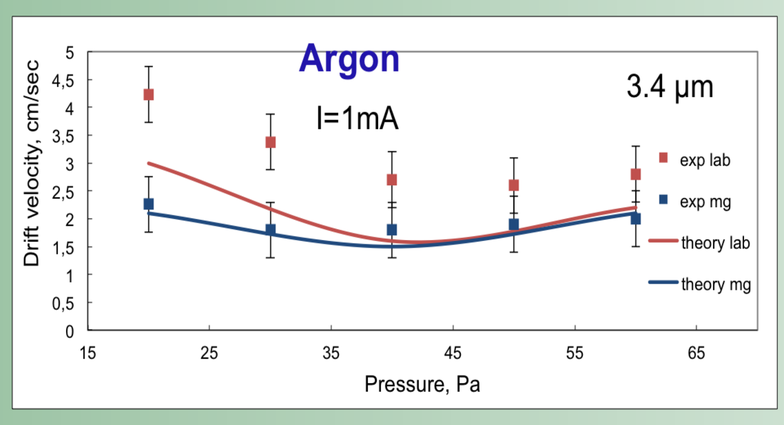
$E = \sqrt{E_{hor}^2 + E_{rad}^2}$ electric field acting on a particle under gravity

$u_i = \mu E$ ion drift velocity

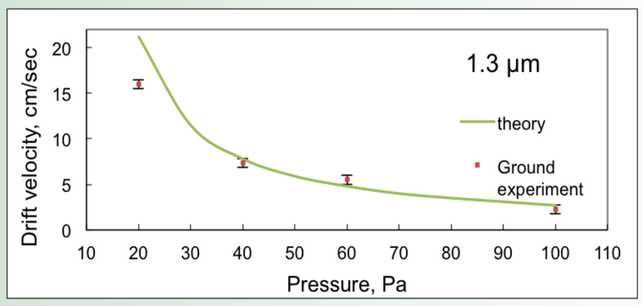
Results

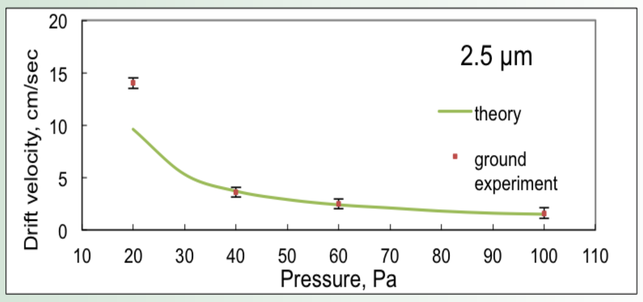
Particle drift velocities with gas pressure in neon and argon DC discharge at 1 mA discharge current

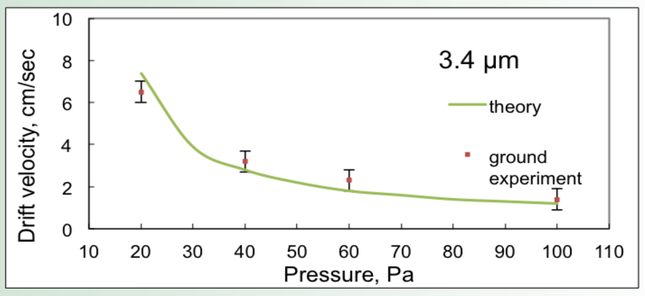




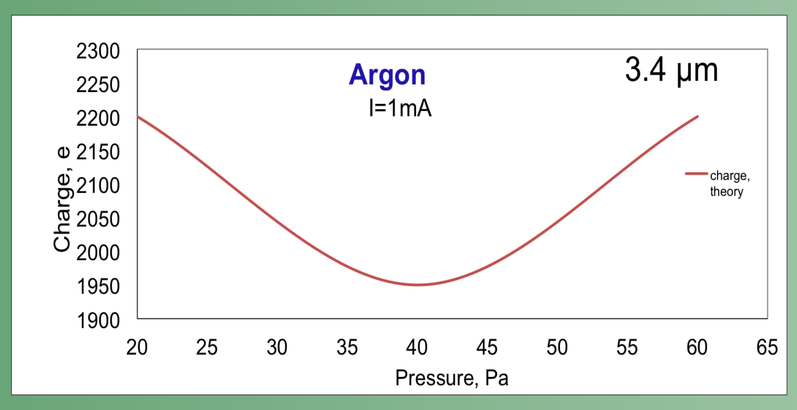
Particle drift velocities with gas pressure in neon DC discharge at 0.5 mA discharge current



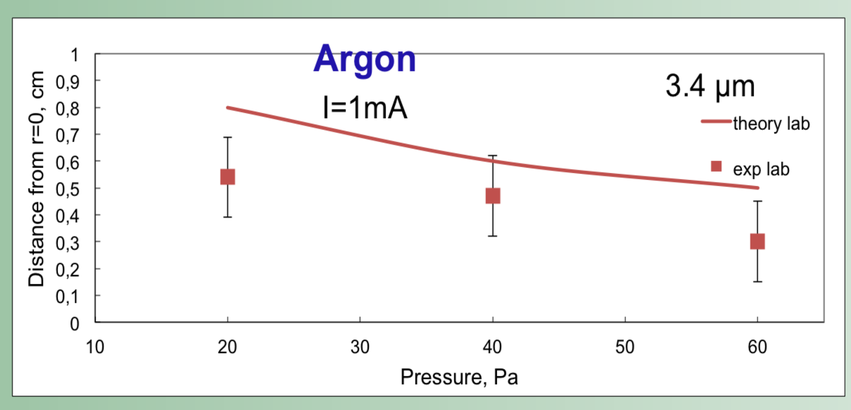




Theoretical estimations of the particle charge at the tube axis



Distance of the upper particle layer from the center of the tube r=0



Conclusion

The particle drift velocities were measured in DC discharge of PK-4 facilities on ground and under microgravity conditions. The results were compared with the theoretical model, which takes into account the distribution of the discharge parameters in the radial direction of the discharge tube. The model alows to estimate partcile charge and predicts particle positions in the discharge.