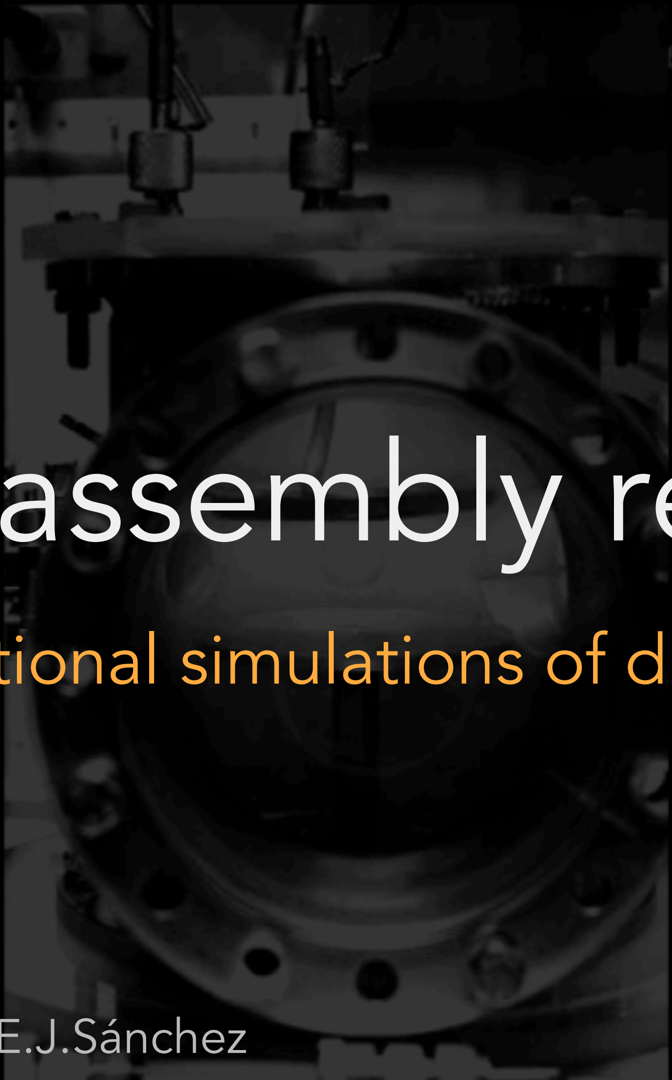
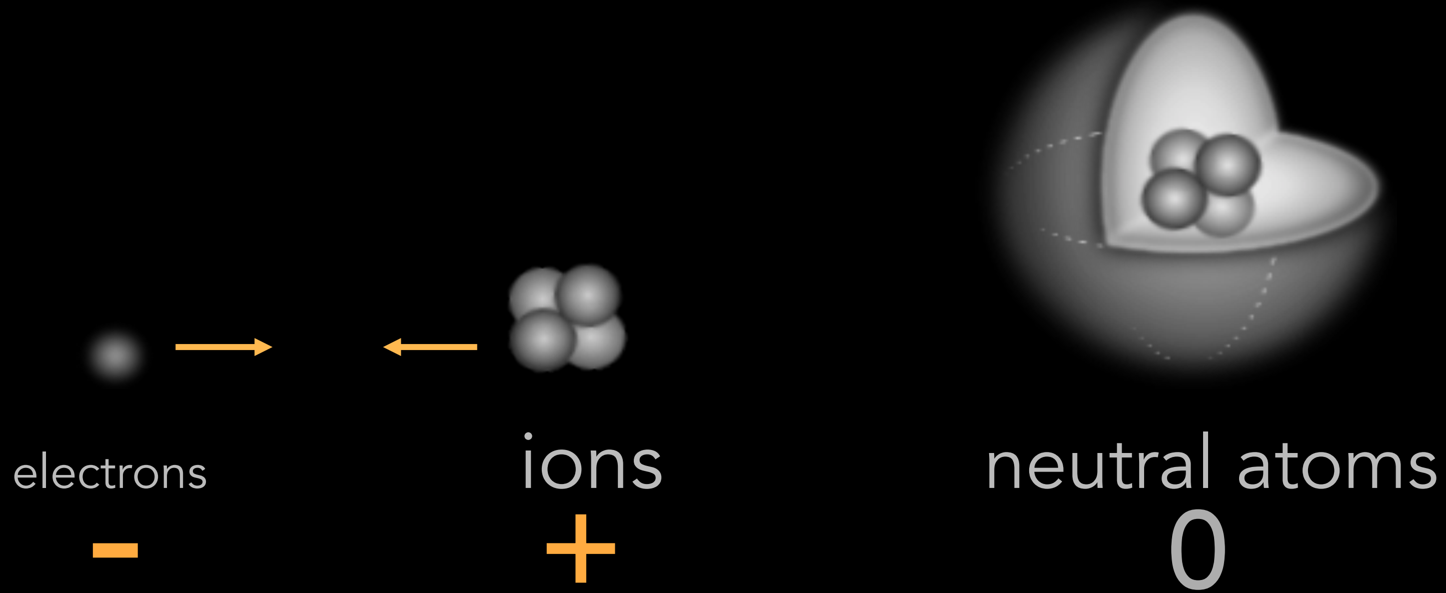
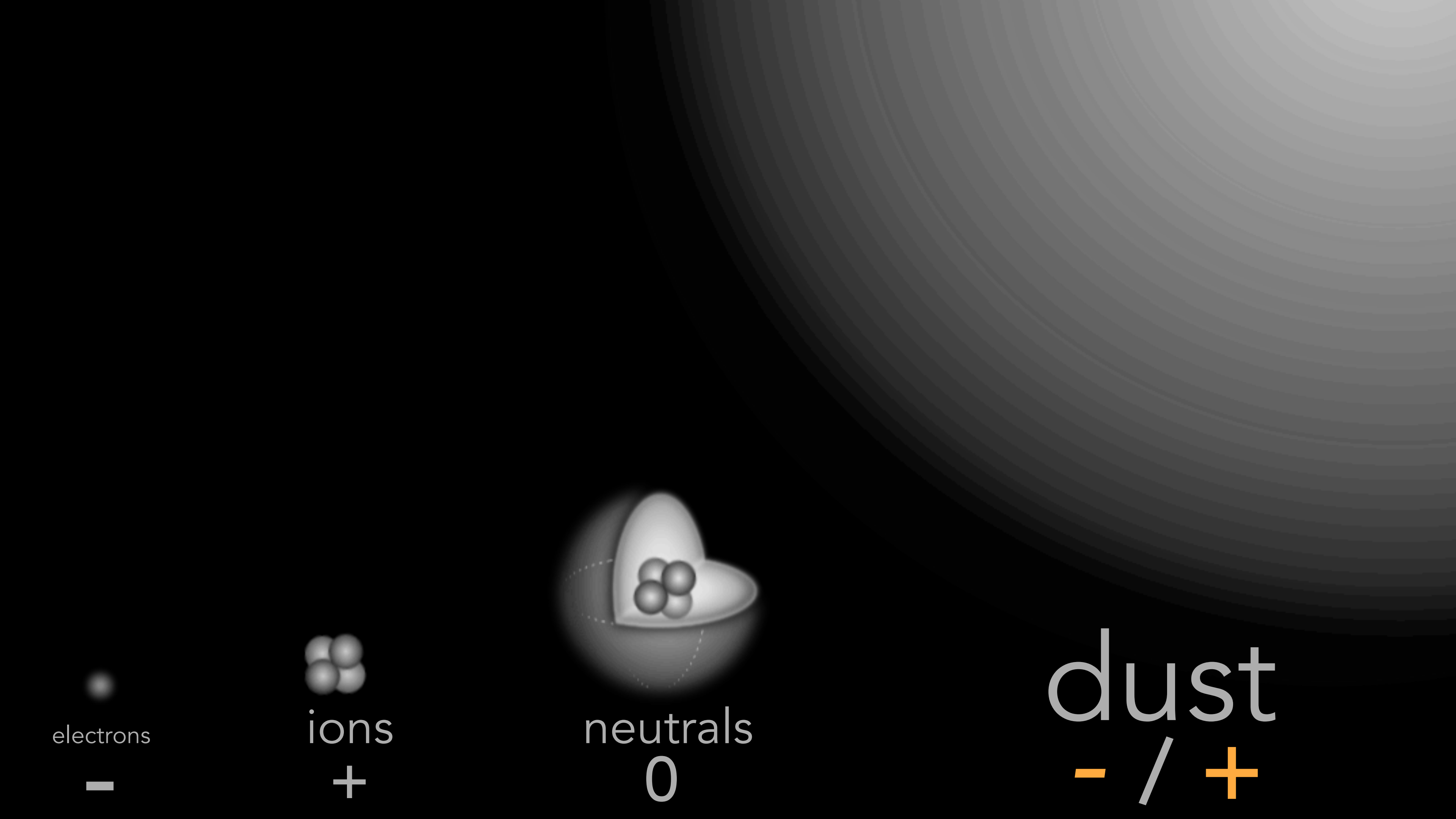


Some assembly required

Computational simulations of dusty plasma

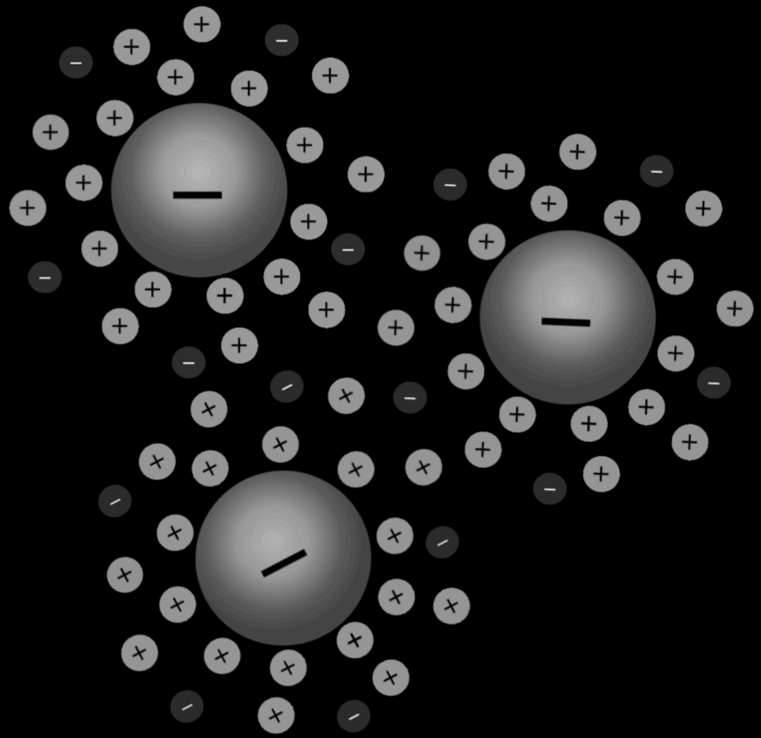
I.J. Rodriguez | J.Black, E.J.Sánchez


electrons
-
ions
+
neutral atoms
0

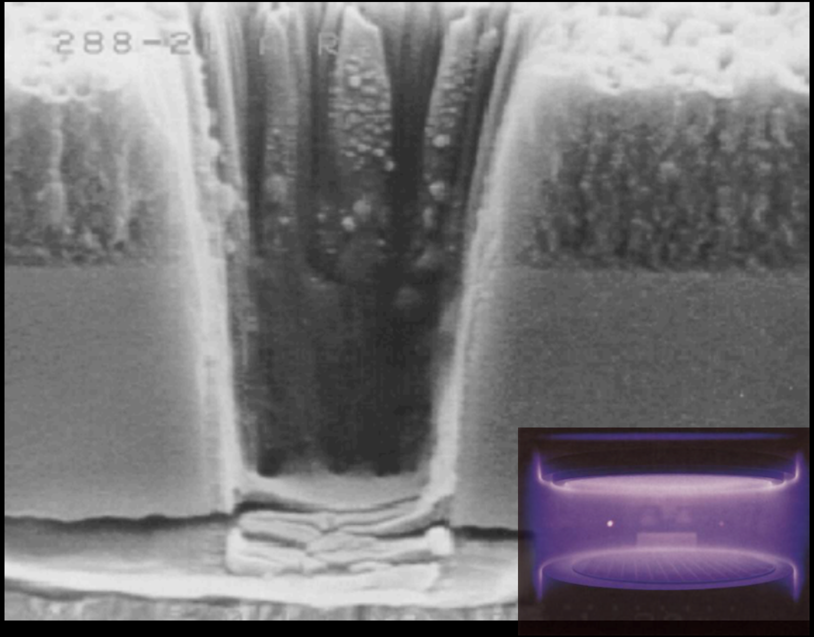

electrons
−
ions
+
neutrals
0
dust
- / +

Dust tends to:

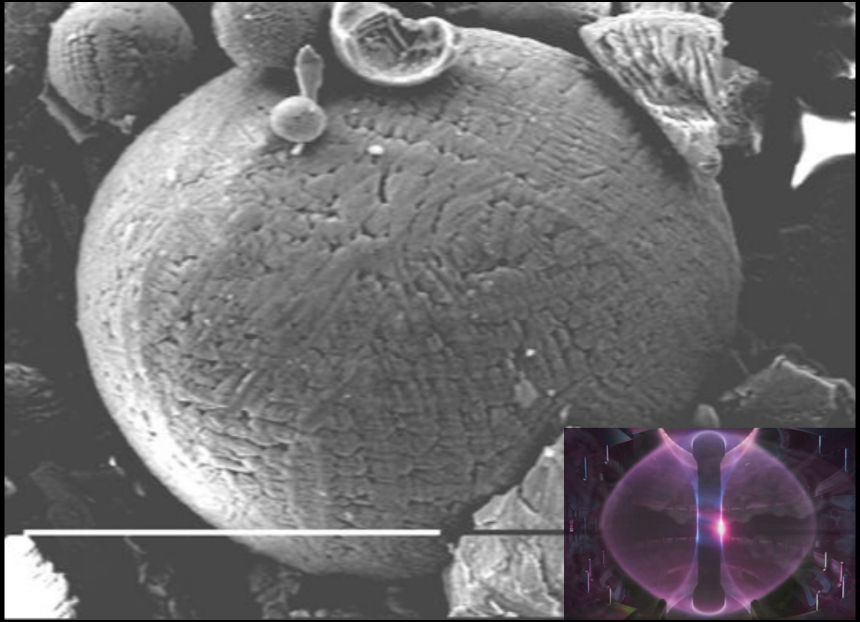
- acquire a net charge
- cluster and grow
- accumulate at boundaries



The presence of dust in plasmas can be problematic.



Layers of contamination on silicon wafers.



Ejected debris in tokamak fusion devices.

$$\vec{\nabla} \cdot \vec{B} = 0$$

$$\vec{\nabla} \times \vec{E} + \frac{1}{c}\frac{\partial B}{\partial t} = 0$$

$$\vec{\nabla} \cdot \vec{E} = 4\pi\rho$$

$$\vec{\nabla} \times \vec{B} - \frac{1}{c}\frac{\partial E}{\partial t} = \frac{4\pi}{c}\vec{J}$$

$$\vec{B} = \vec{\nabla} \times \vec{A}$$

$$\vec{E} = -\vec{\nabla}\phi - \frac{1}{c}\frac{\partial A}{\partial t}$$

Theory

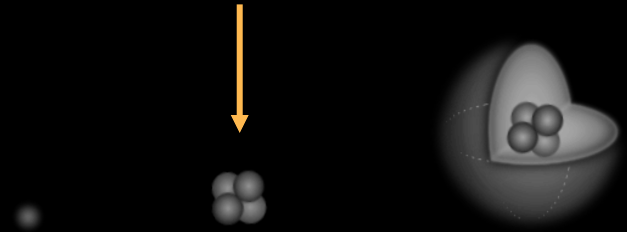
```
E_from_V(rho, J, dx):
"""Uses the finite differenc

source = rho[0:J-1]*dx**2
M = np.zeros((J-1,J-1))

for i in range(0, J-1):
    for j in range(0, J-1):
        if i == j:
            M[i,j] = 2.
        if i == j-1:
            M[i,j] = -1.
        if i == j+1:
            M[i,j] = -1.

M[0, J-2] = -1.
M[J-2, 0] = -1.

V = np.linalg.solve(M, sourc

E = np.zeros((J,1))

for i in range (1,J-2):
    E[i] = (V[i+1] - V[i-1])
E[J-2] = (V[0] - V[J-3]) / 2
E[0] = (V[1] - V[J-2]) / 2.
E[J-1] = E[0]
```

Computation

Experiment

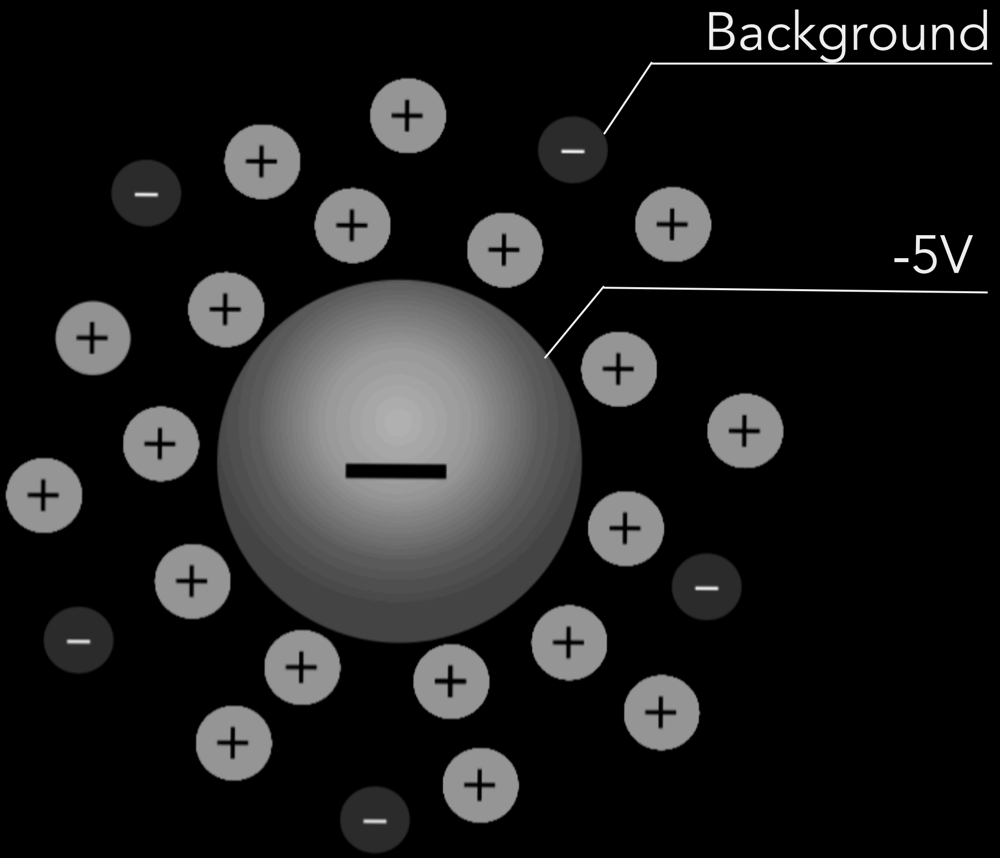
Goal

Use a budget-friendly computational platform to simulate the dynamics of plasma particles around a dust grain.

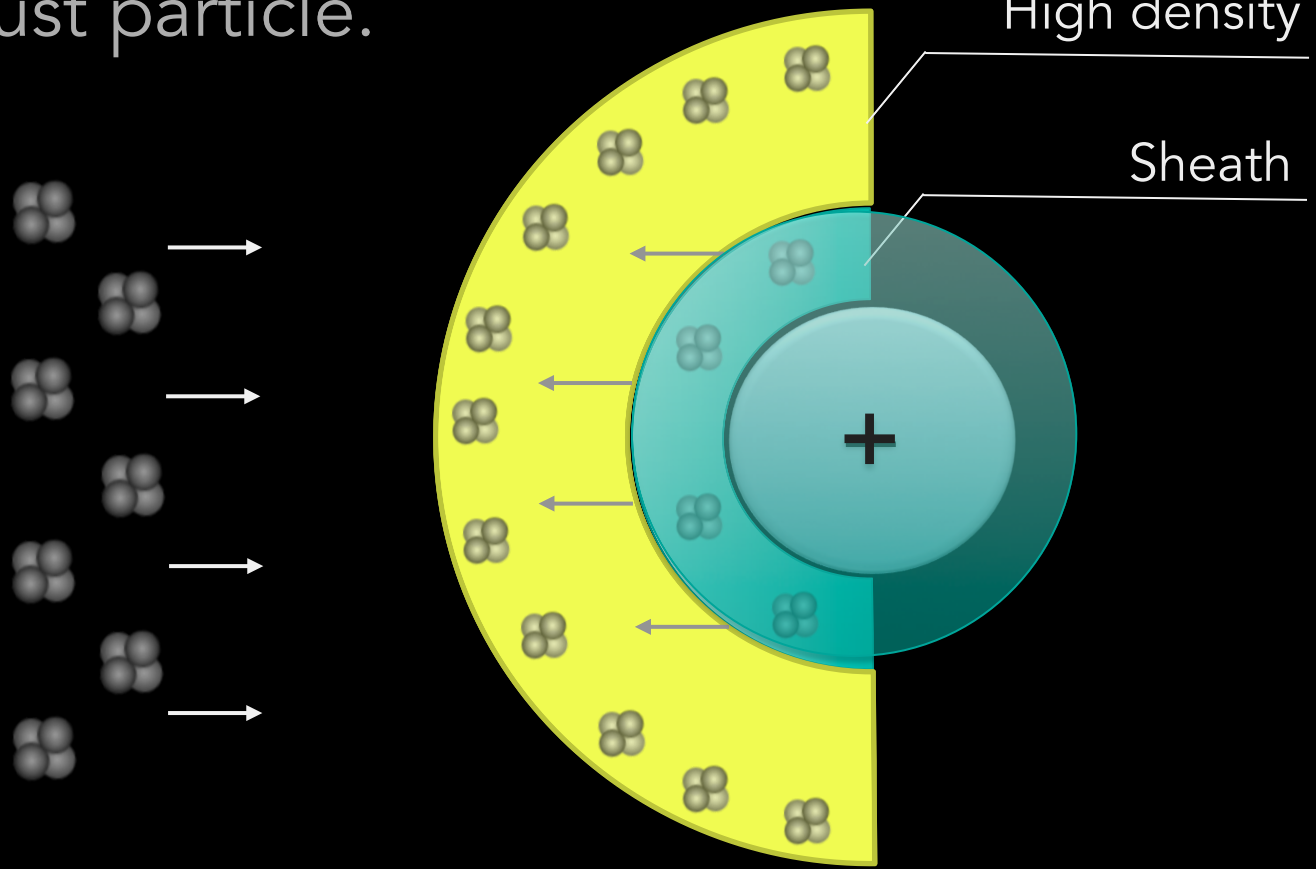


The ion drag force is responsible for the collective effects that lead to arrangements of dust particles.

The model:
An electrostatic,
low temperature,
low density
Argon plasma



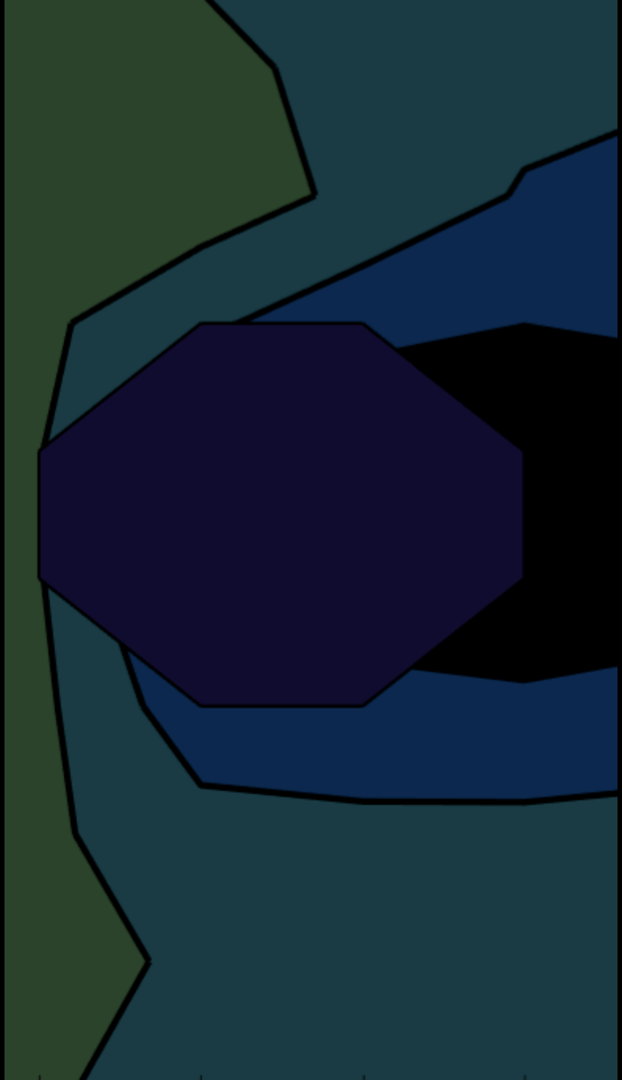
Ion density around a negatively charged dust particle.

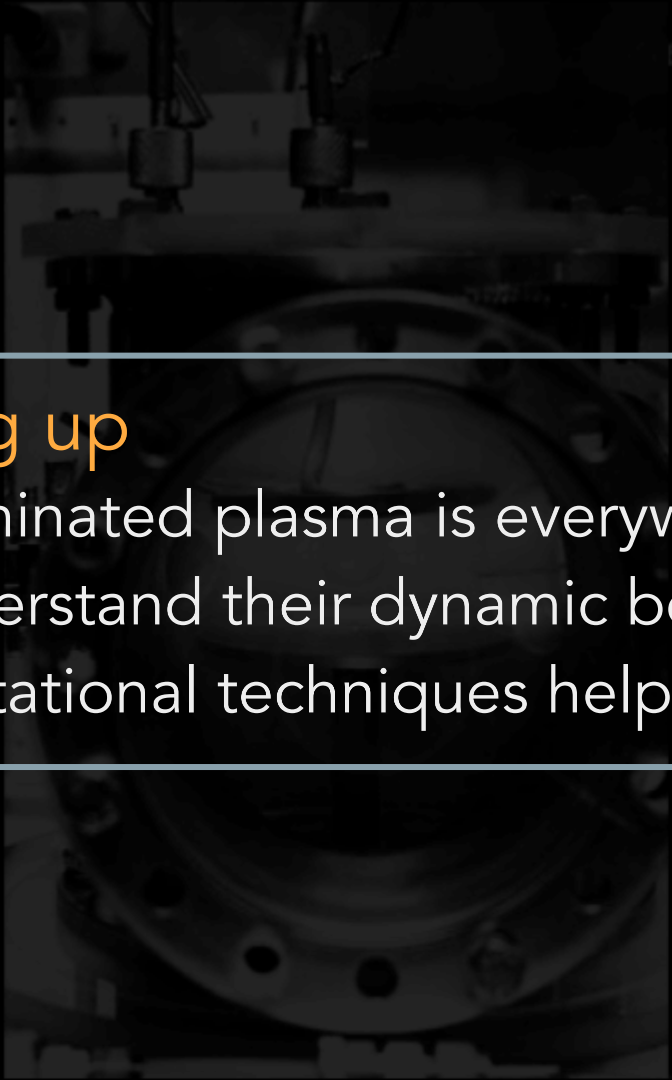


…the point?

To develop and share open-source code that can be used to explore:

Fundamental science
Ion engines
Space dust
Plasma processing technology
Coulomb crystals
Solar wind effects…





Wrapping up

- Contaminated plasma is everywhere!
- To understand their dynamic behavior, computational techniques help fill in the gaps.

Sánchez Research Group

Portland State LSAMP

Oregon Space Grant

University Honors College

All of you!

Thank you