Dust streaming in toroidal traps

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Dust trapping in magnetized anodic plasmas results in the formation of torus-shaped dust clouds with a central void. The dust particles perform a toroidal rotational motion. Based on experimental investigations, a hierarchic model for the confinement and dynamics of the dust cloud was proposed. There, the Hall component of the ion drag force leads to the dust rotation \cite{1}. A refined observation geometry motivated an extension of the one-dimensional model to include ballistic effects as well as particle-particle interactions. With the possibility to efficiently calculate particle-particle interactions on a GPU, we have now carried out three-dimensional molecular dynamics (MD) simulations of streaming particles in toroidal traps with Yukawa interaction. We found that inside the flow, the particles arrange themselves on shells. Furthermore, depending on the strength of damping, large-scale vortices or stationary shocks can spontaneously form \cite{2}.

At the outer boundary of the vortex, Kelvin-Helmholtz instabilities occur due to different streaming velocities inside the vortex and the toroidal rotational flow (see Figure).

![Figure: Snapshot of a 3D MD simulation: At the boundary between fast streaming particles and slow vortex particles, a Kelvin-Helmholtz instability is present.](image)

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\cite{1} Pilch et al., Phys. Plasmas \textbf{15}, 103706 (2008)
\cite{2} Reichstein and Piel, Phys. Plasmas \textbf{18}, 083705 (2011)