Boundary layers in space plasmas are always the locations of many phenomena allowing the mixing of plasma. But for a given boundary, different mechanisms can coexist and compete one with each others. In this work, we look with fully Particle-In-Cell simulations at velocity shear boundary layers with a gradient of density and magnetic field. We observe that in presence of a density gradient, kinetic instabilities (such as the lower hybrid drift instability) develops along the layer much quicker than the Kelvin-Helmholtz instability. In particular, we observe that one of those kinetic instabilities develops into forming large scale structures that compete (and even suppress) the Kelvin-Helmholtz instability, depending on the density gradient in the layer. Such a result can make us reconsider the main mixing mechanisms in plasma layers with strong density gradient, such as the magnetopause of Mercury.

Simulations:

We made 4 simulations of a magnetopause current layer with different asymmetries of magnetic field and density and different velocity shear.

Simulation code: SMILEI (fully kinetic Particle-In-Cell)

<table>
<thead>
<tr>
<th>Simulation 0</th>
<th>Simulation 1</th>
<th>Simulation 2</th>
<th>Simulation 3</th>
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</thead>
<tbody>
<tr>
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<tr>
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</tr>
</tbody>
</table>

Expected instabilities:

- Velocity shear —> Kelvin-Helmholtz instability (KHI)
- Density gradient —> Lower-Hybrid Drift instability (LHDI)

Note: Simulation 1 models a Mercury-like magnetopause

Second phase: nonlinear LHDI

The linear LHDI saturates quickly. An inverse cascade transfers energy from small scales (fastest growing modes, k=4) to fluid scales (k=1). Another (kinetic) instability?

Conclusions:

- In its nonlinear phase of LHDI, we observe another instability (kinetic?) and a cascade from kinetic scales to fluid scales.
- The large-scales structures generated in the second phase by the instability can suppress the KHI.
- The relative importance of KHI and LHDI depends mainly on the density asymmetry and the velocity shear. Other parameters (ex: layer width) play a role.
- Published in Dargent et al. (2019, JPP)

Prospectives:

- Characterization of the second phase instability (Drift kink instability? Gradient instability?)
- Effect of the plasma composition (cold and/or heavy ions)
- Effect of the dawn-dusk asymmetry of the magnetopause on both instabilities.
- Comparison with future BepiColombo data