Hands-On Session: Kevin-Helmholtz Instability

In this exercise, we use the numerical code Ramses to explore the onset and evolution of the Kevin-Helmholtz instability in a flow. To get up and running with the code, follow the instructions at `http://cheleb.net/dokuwiki/ramses`.

(a) Look at the velocity field (v_x, v_y) in the first output. We see that v_y in the two zones differ (as expected), but we also see that $v_x \neq 0$, as we may have expected. Why is it not?

(b) Look at the videos you have generated. What are the main features the Kevin-Helmholtz instability evokes in the flow?

(c) Recall the vorticity

$$\vec{\omega} = \nabla \times \vec{v}. \tag{1}$$

Derive the expression for the 2D vorticity ω, where $\vec{v} = (v_x, v_y, v_z) = (v_x, v_y, 0)$.

(d) Recall from the lecture that we can rewrite the 2D vorticity equation as

$$\frac{\mathrm{D}\omega}{\mathrm{D}t} = \nu \nabla^2 \omega. \tag{2}$$

Given that (for our particular simulation) Ramses is solving the Euler equations (i.e., there is no explicit viscosity ν specified anywhere in the code), how would you expect ω to evolve?

(e) Take a look at the videos of ω and the y-averaged vorticity $\langle\omega\rangle_y$ you have created. How does $\langle\omega\rangle_y$ evolve? Does this contrast with your expectations? What does this imply in terms of ν? How come?