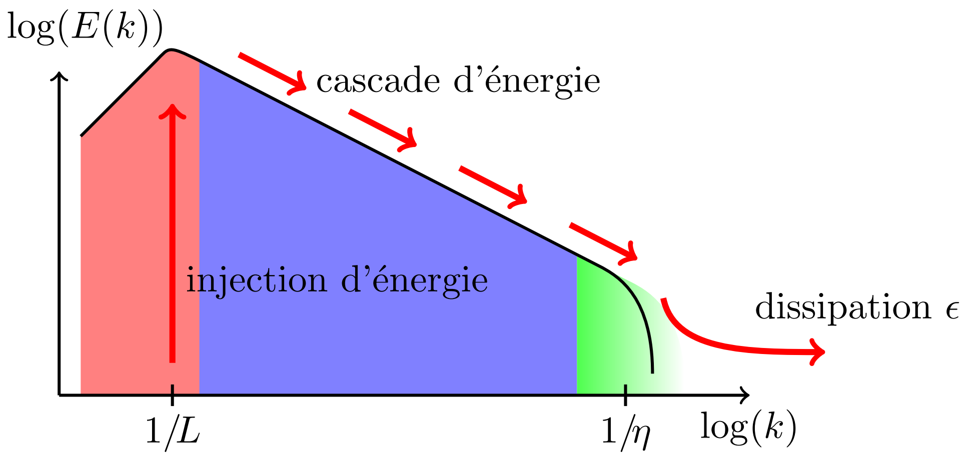
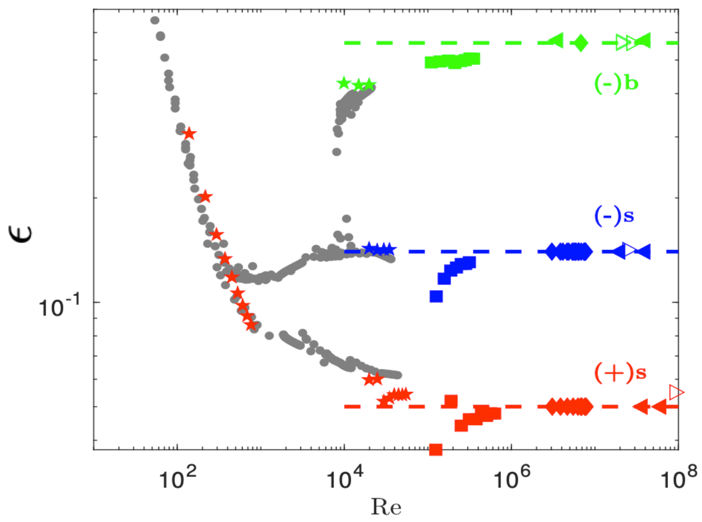
RNL 2023

Vortex Interaction : Source of Irreversibility & Singularity in turbulence ?

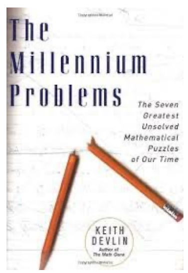
Dissipative anomaly in turbulence





« … *in three dimensions a mechanism for complete dissipation of all kinetic energy, even without the aid of viscosity, is available.* »

L. Onsager [1949]



Are the Navier-Stokes equations well-posed ?
Are the solutions regular and unique ?

A. Cheminet, D. Geneste, H. Faller, V. Valori, T. Chaabo, F. Nguyen, Y. Ostovan, P. Debue, C. Cuvier, C. Wiertel, V. Padilla, J-P, Laval, J-M.Foucaut, F. Daviaud, B. Dubrulle

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Euleriann & Lagrangian investigations

Eulerian framework

Duchon-Robert [2000]

$$\partial_t E^\ell(\boldsymbol{x}) + \partial_j J_j = -\mathscr{D}^I_\ell - \mathscr{D}^\nu_\ell$$

Inertial Dissipation:

$$\mathcal{D}^I_\ell(x,t) \;=\; \frac{1}{4}\int d\boldsymbol{\xi}\;\nabla\phi^\ell(\xi)\cdot\delta_\xi\boldsymbol{u}(\delta_\xi\boldsymbol{u})^2$$

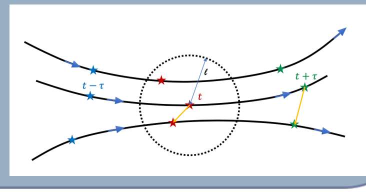
Viscous Dissipation :

$$\mathcal{D}^\nu_\ell(x,t) \;=\; \frac{\nu}{2}\int d\boldsymbol{\xi}\;\nabla^2\phi^\ell(\xi)(\delta_\xi\boldsymbol{u})^2$$

Lagrangian framework

***Local'* Lagrangian irreversibility indicator :**

$$D^L_{\ell,\tau}(x,\mathrm{t}) = \left\langle\left(\delta X_\ell^{t-\tau}\right)^2\right\rangle - \left\langle\left(\delta X_\ell^{t+\tau}\right)^2\right\rangle/4\tau^3$$ Drivas [2019]



Drivas Theorem [*JNL* 2019]

$$\mathcal{D}^I_\ell + \mathcal{D}^\nu_\ell = \epsilon(x,t) = D^L_{\ell,\tau}$$

Under conditions of : $\lim_{\Delta x\to 0}$ $\lim_{\ell\to 0}$ $\lim_{\nu\to 0}$ $\lim_{\tau\to 0}$