Elbereth conference 2021
Turbulence and Heating in space plasma

Theory and in-situ observations

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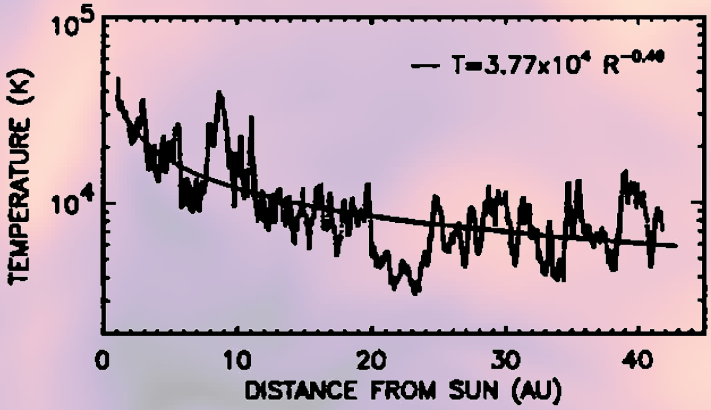
Heating problem in the solar wind

Missions launched to the Solar Wind reported a **non-adiabatic temperature profil** *[Barnes 1992, Richardson 1995]*.



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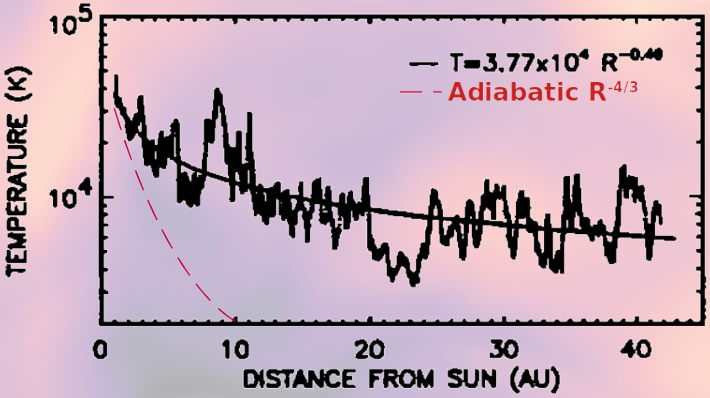

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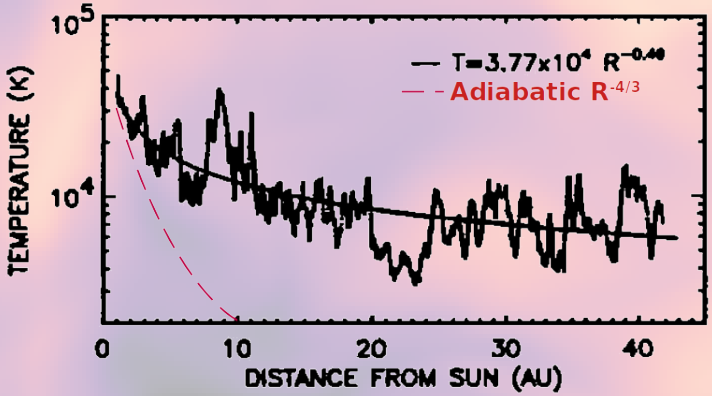
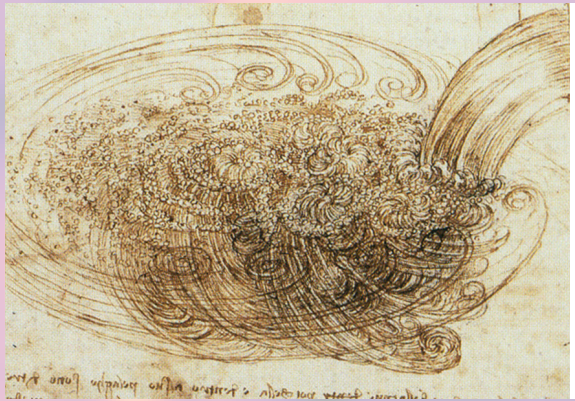
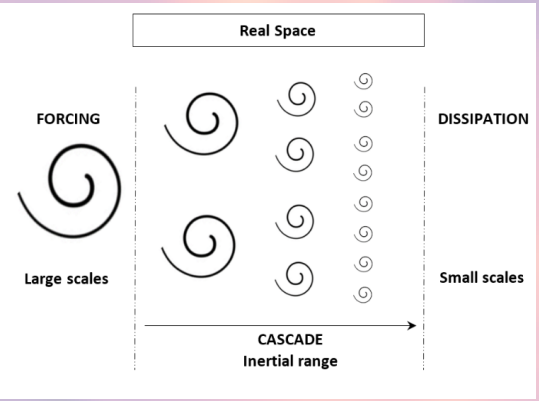


Solution : local heating allowed by **turbulence**.

Turbulence : What is it ?

Turbulence = cascade of a quantity through scales *[Shekochihin 2009, Galtier 2016, Sahraoui 2020]*.





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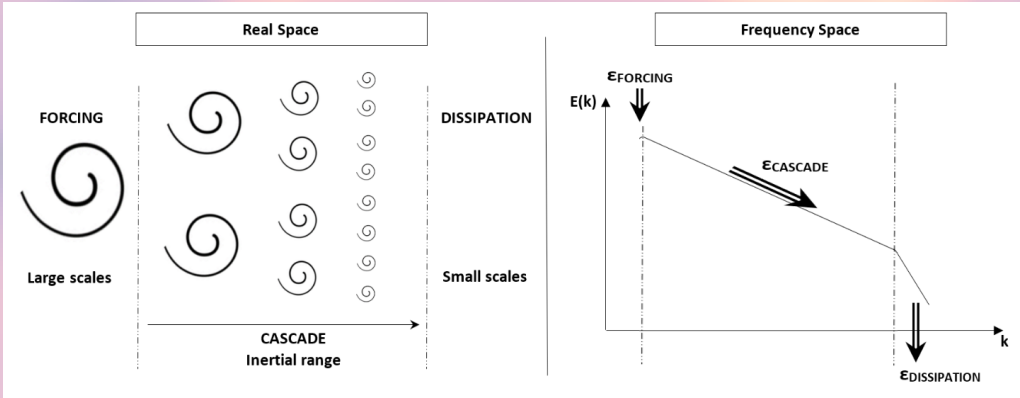
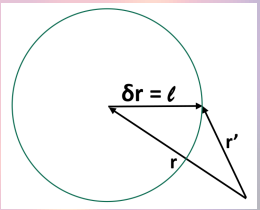


Quantification : the **cascade rate** $\epsilon_{cascade}$ and the Kolmogorov theory of **exact laws** applied in magnetized fluid models.

Recipe to derive an exact law *[Kolmogorov 1941]*

Hypothesis:

- Statistical stationarity
- Statistical homogeneity
- Forcing at large scales and constant rate
- Dissipation at small scales



Model (ex : incompressible Navier-Stokes):

$$\partial_t \rho = -\nabla \cdot (\rho \mathbf{v}) = 0 \quad (1)$$

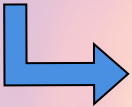
$$\partial_t \mathbf{v} = -\mathbf{v} \cdot \nabla \mathbf{v} - \nabla P + \nu \nabla^2 \mathbf{v} + \mathbf{f} \quad (2)$$

Statistical derivation with a correlation function between two points separated by the scale ℓ ($\boldsymbol{\delta r} = \boldsymbol{\ell}$)

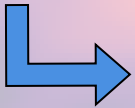
$$\Rightarrow \textbf{Exact law: } -4\frac{\epsilon_{cascade}}{\rho_0} = \nabla_\ell \cdot \left\langle |\boldsymbol{\delta v}|^2 \boldsymbol{\delta v} \right\rangle \quad (3)$$

Work steps to study turbulence with fluid models

Theory
derivation of an exact law



Simulation
validation of the exact law in simulation data

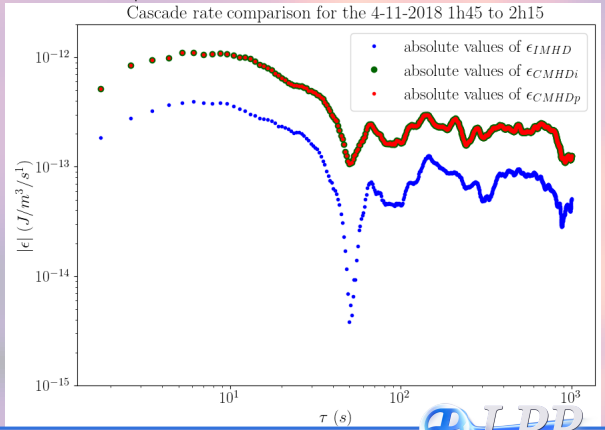


Observation
computation of the exact law in observational data

Internship work *[Simon/Sahraoui 2021]*

	HD	MHD
Incompressible	*[Kolmogorov 1941]*	*[Politano/Pouquet 1998]*
Isothermal	*[Galtier 2011]*	*[Banerjee 2013, Andrés 2017]*
Polytrope	*[Banerjee 2014]*	**Internship goal**

Example : observational results with PSP data for incompressible, isothermal and polytrope exact laws.



This is the end !

Thank you for your attention !!!

Feel free to ask a question !!

And continue to enjoy this conference !