Noise statistics and physical mechanisms

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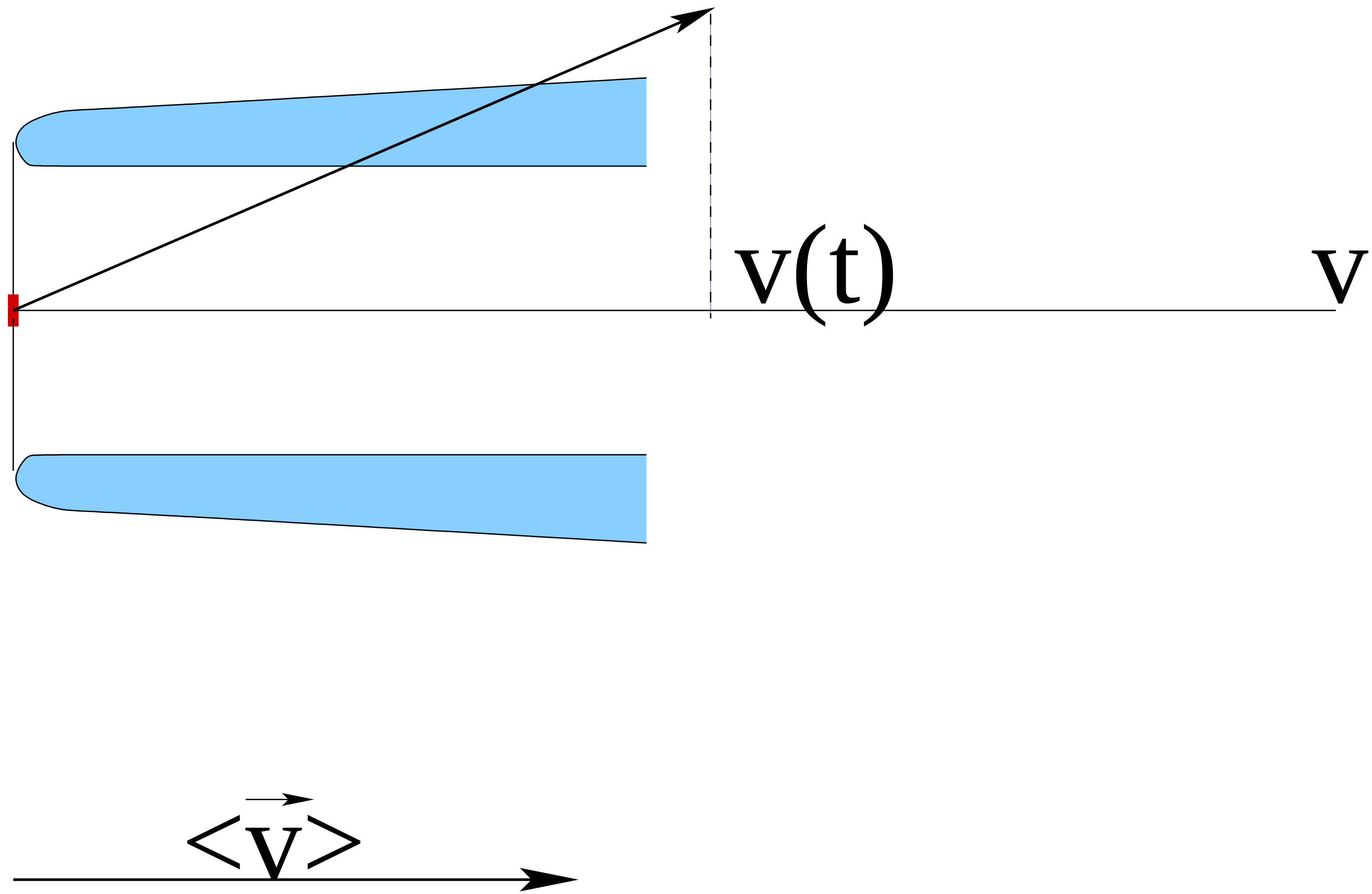
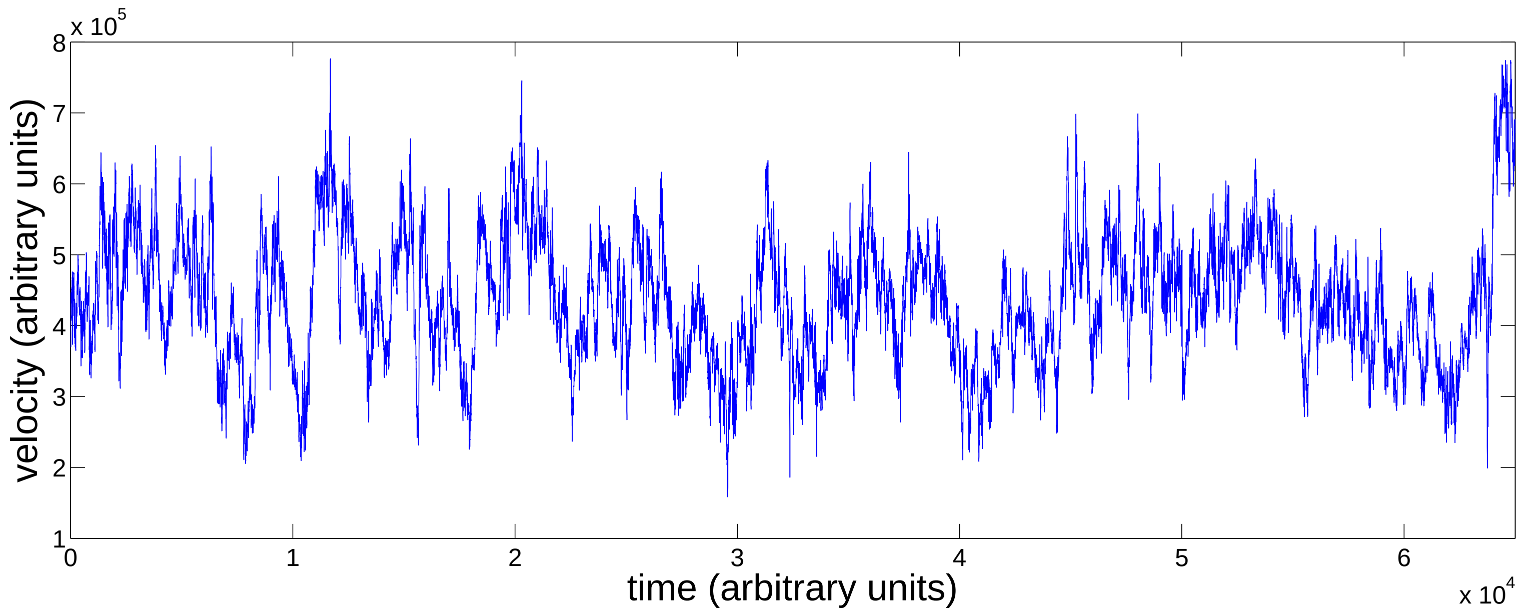
Overview

- Turbulent velocity
  More than 50 years of statistical studies
- Energy cascade and intermittency
  Non linear effects
- Branly effect
  Electrical complex noise

Turbulent velocity



Turbulent velocity



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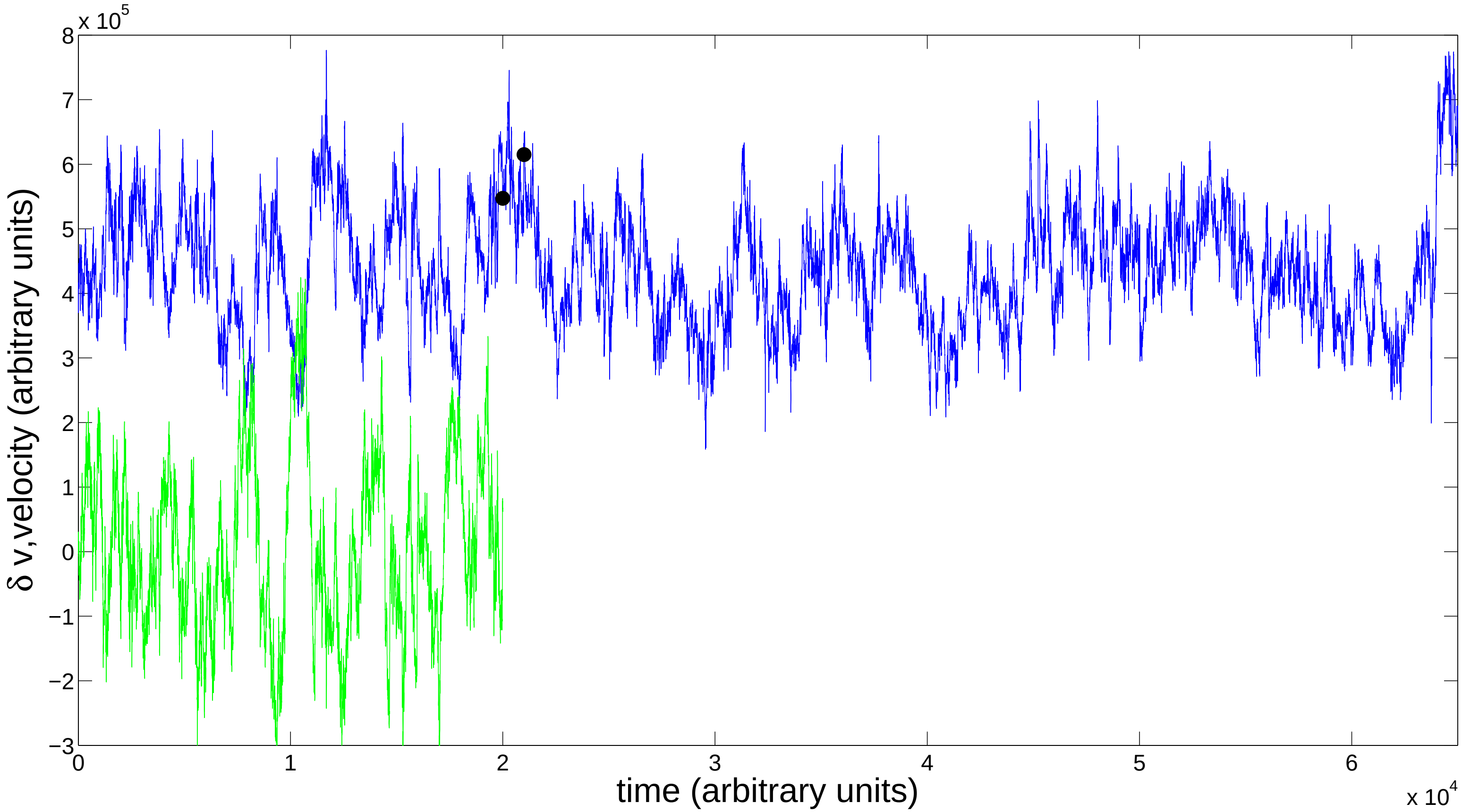

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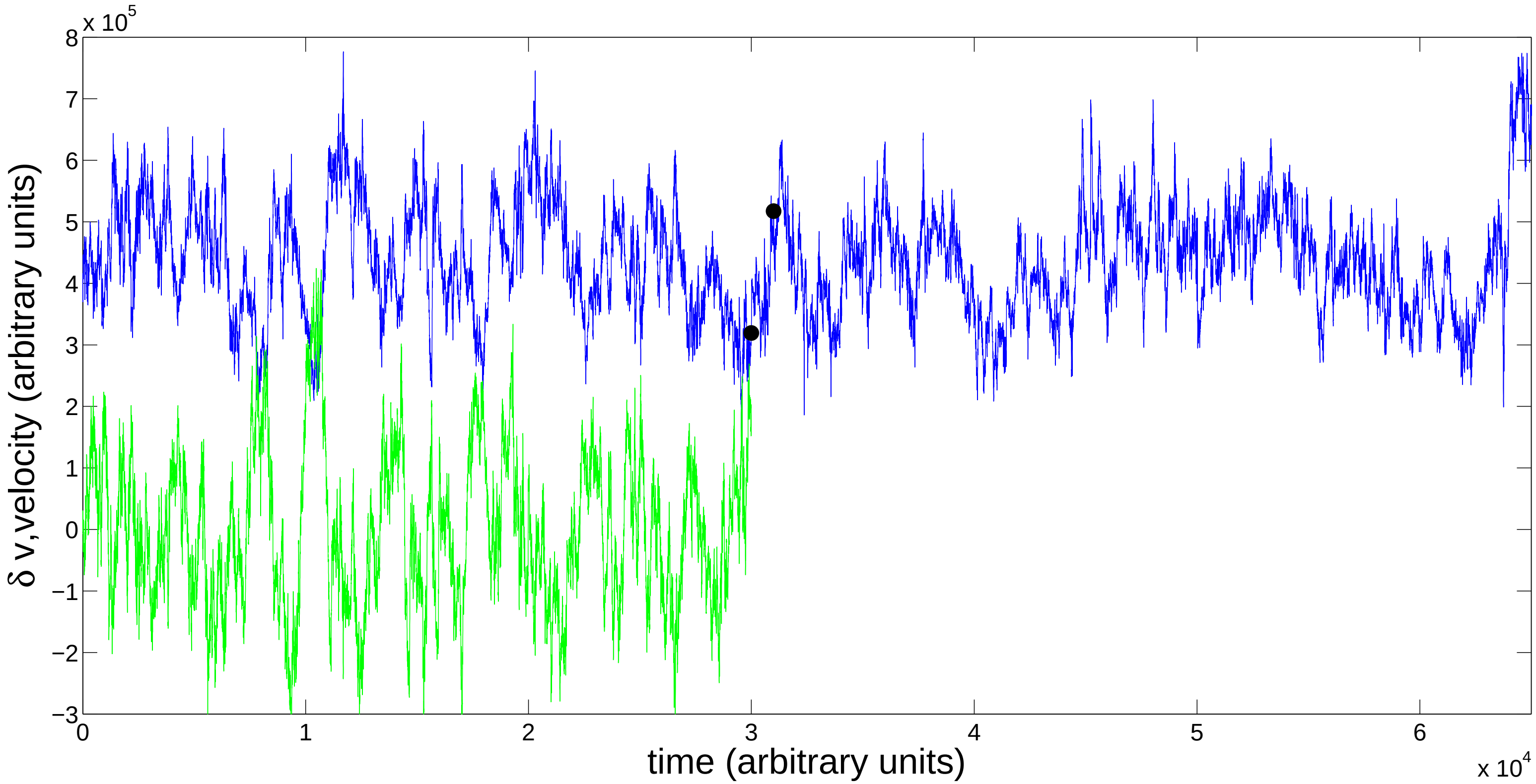

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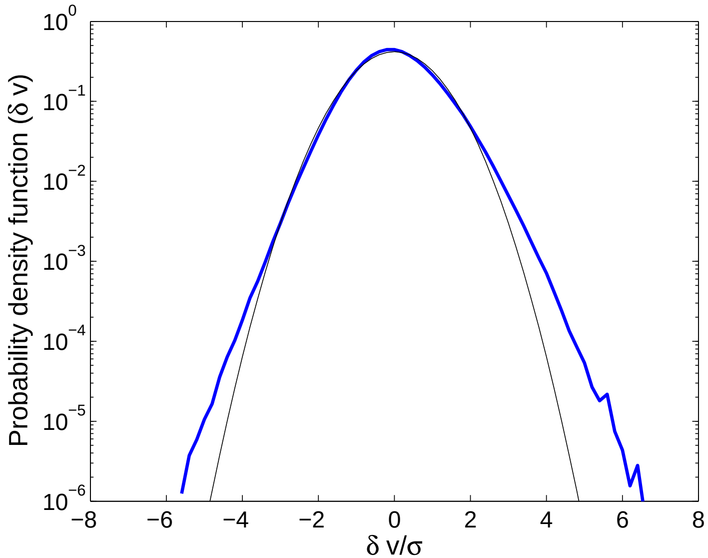


$$< \delta v^3 > \simeq -\frac{4}{5}\epsilon r$$

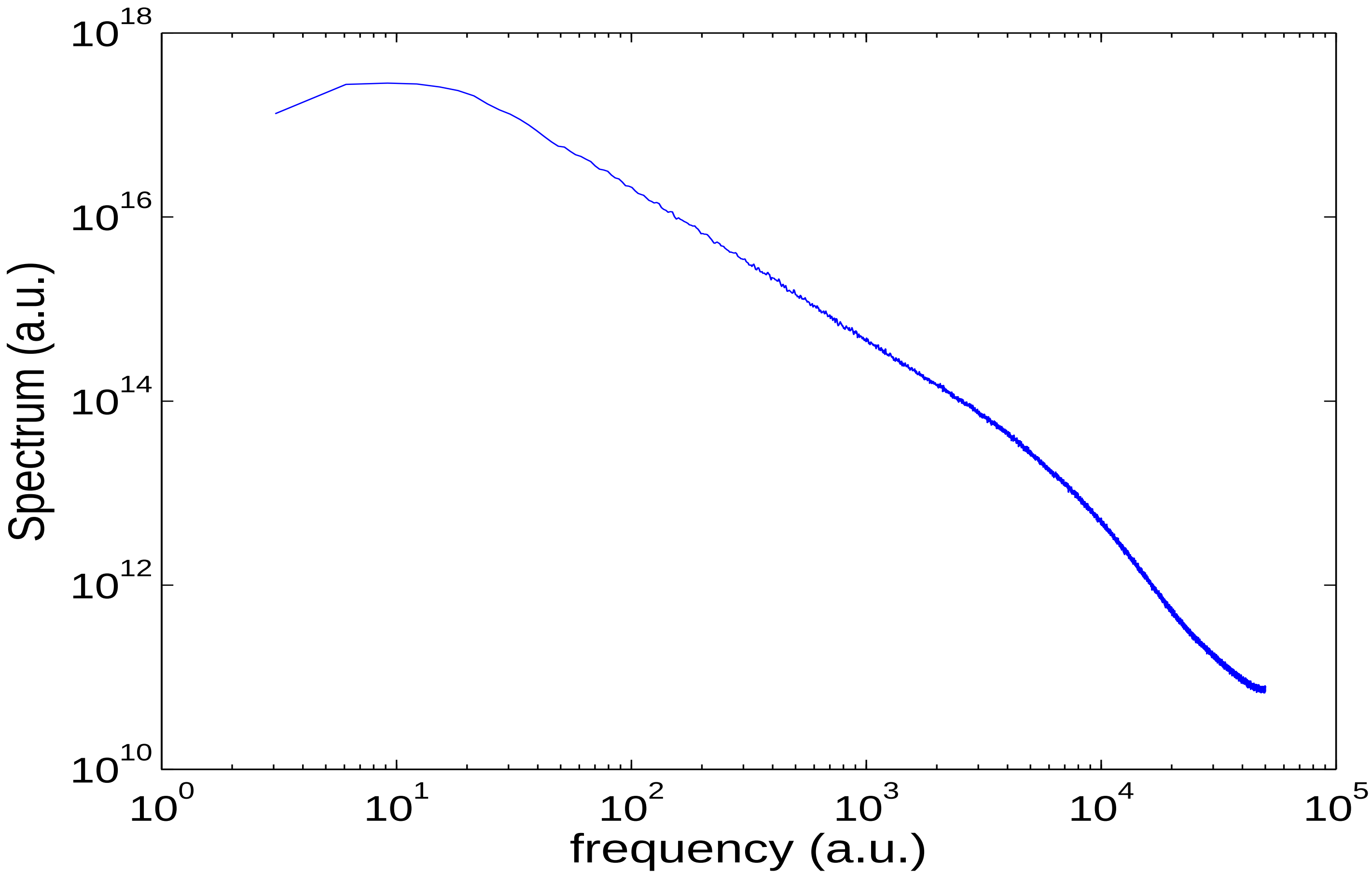
Kolmogorov 1941

$$r = -V\tau \text{ ; } x = Vt$$

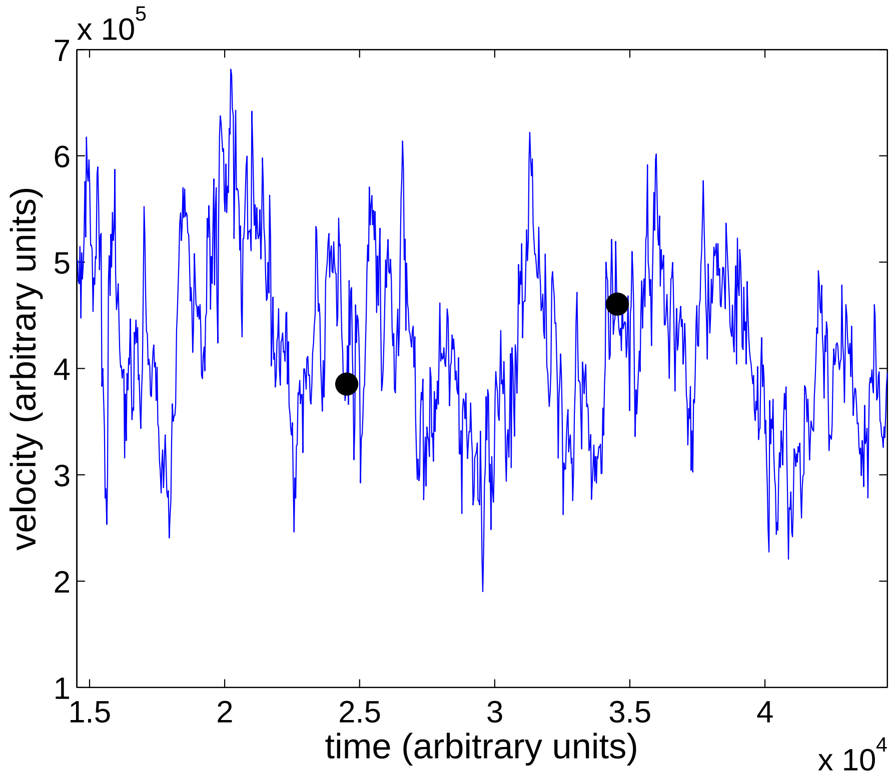
$$\delta v = v(t+\tau) - v(t)$$

$$\epsilon \propto < (\frac{\partial v}{\partial x})^2 >$$

Turbulent velocity



Turbulent velocity



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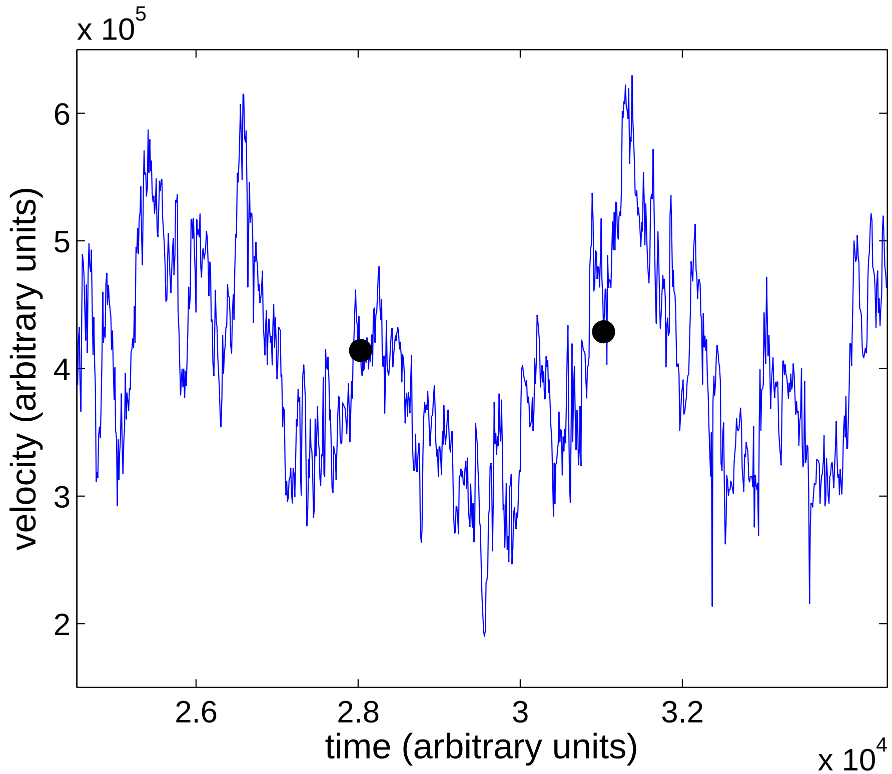
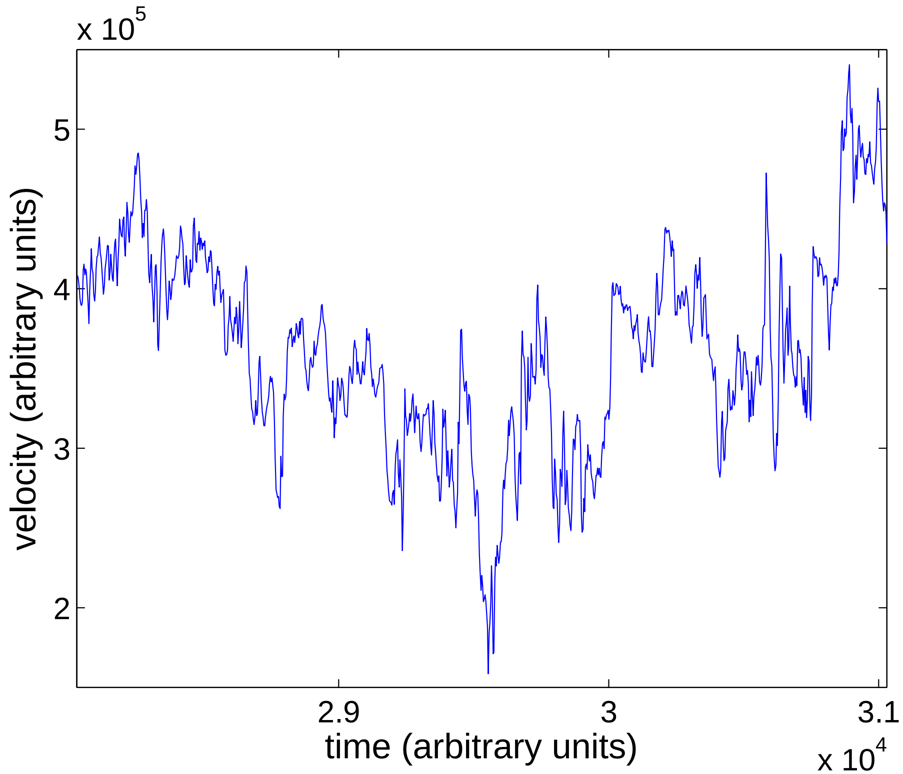
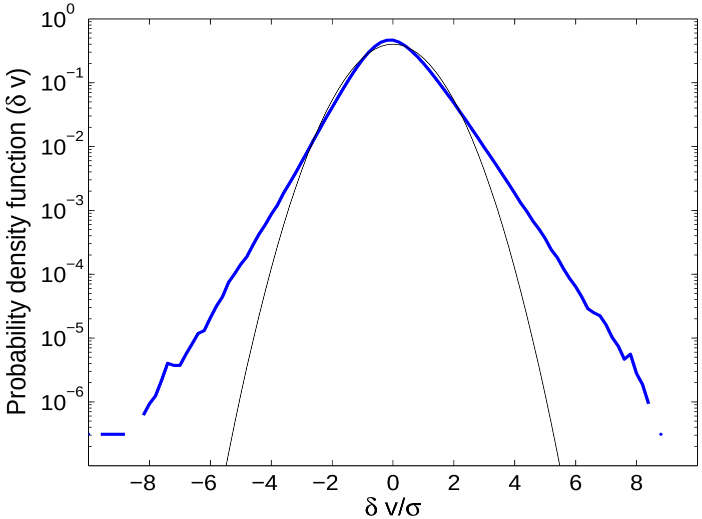


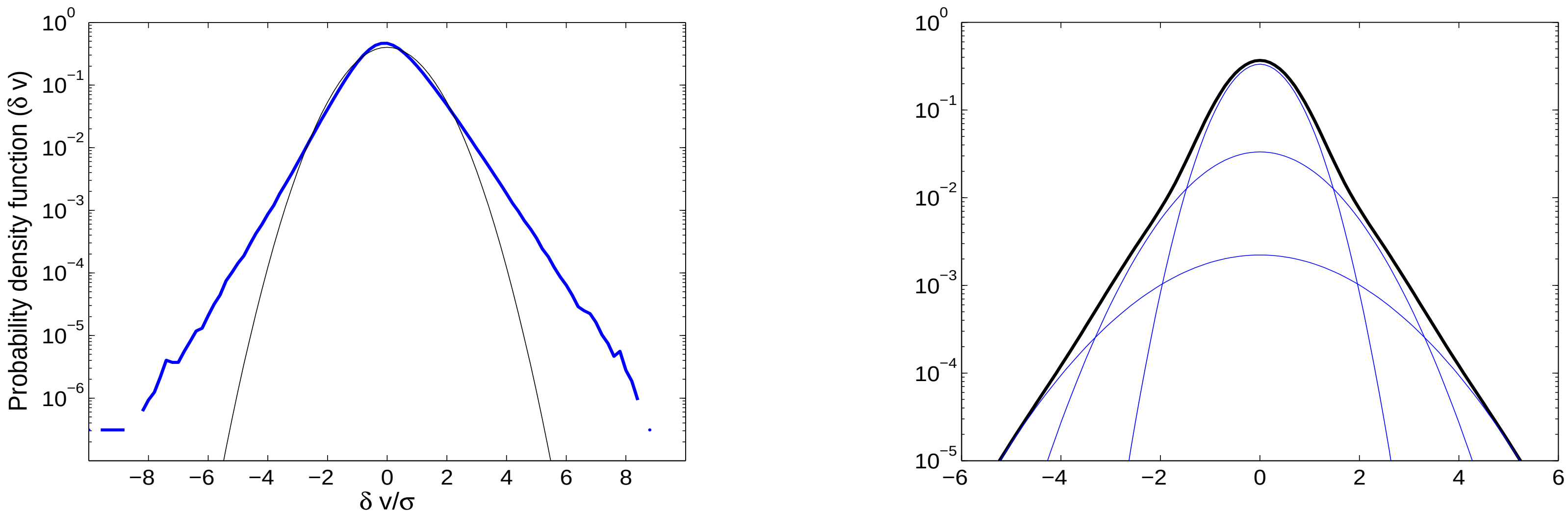
Turbulent velocity



Energy cascade



Energy cascade

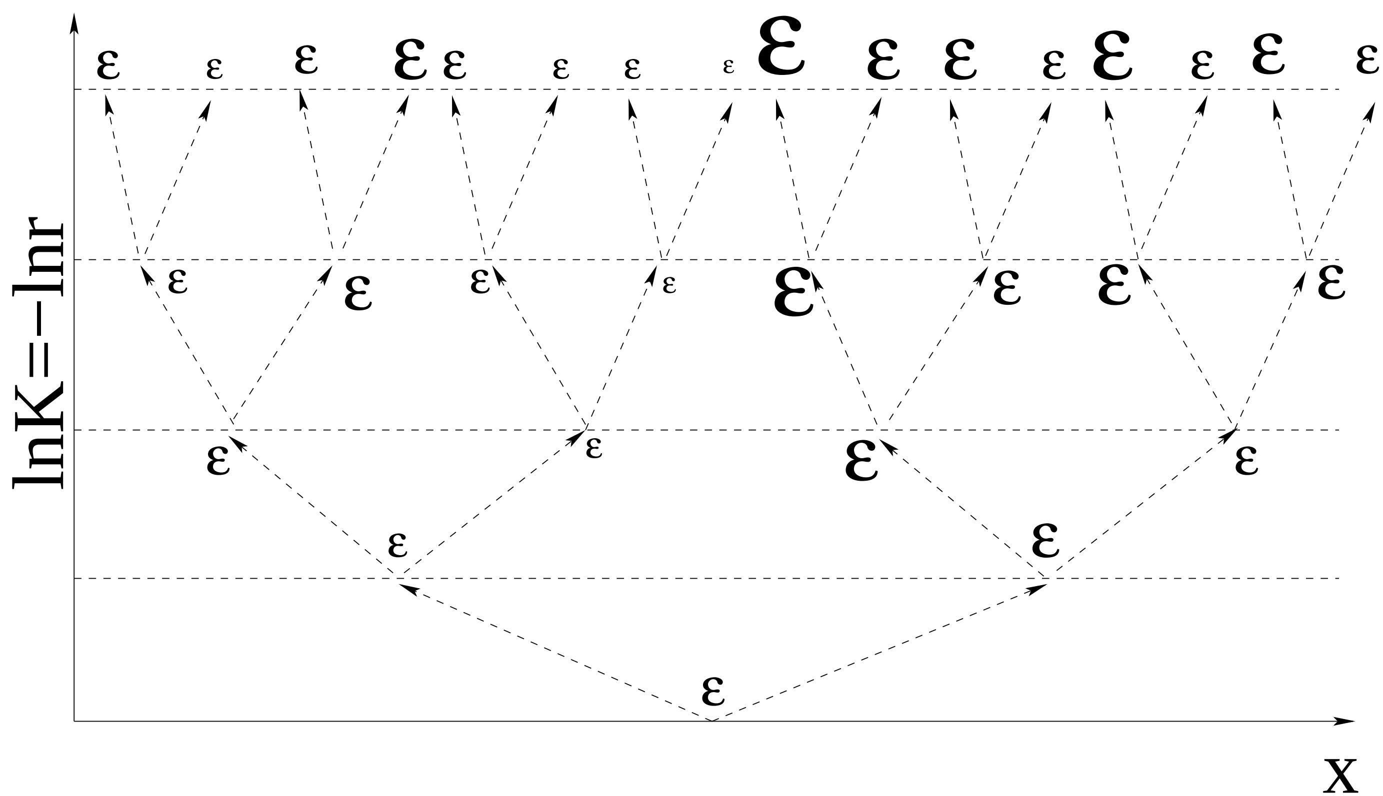


$$\delta v = \sigma s \qquad \sigma = \sigma_L \left(\frac{r}{L}\right)^h \qquad P(h) = \left(\frac{r}{L}\right)^{1-D(h)}$$

G. Parisi, U. Frisch, Proc. Int. School of Phys. Enrico Fermi, Varenna, 84-87, 1983

(North-Holland, 1985)

Energy cascade



$$\sigma \propto \epsilon^{1/3}$$

Energy cascade

$$\delta v_\theta = v(t+\theta) - v(t) = \sigma s \quad ; \quad \delta l_\theta = ln(|\delta v_\theta|) - < ln(|\delta v_\theta|) >$$

$$C_\theta(\tau) = < (\delta l_\theta(t+\tau))(\delta l_\theta(t)) >$$

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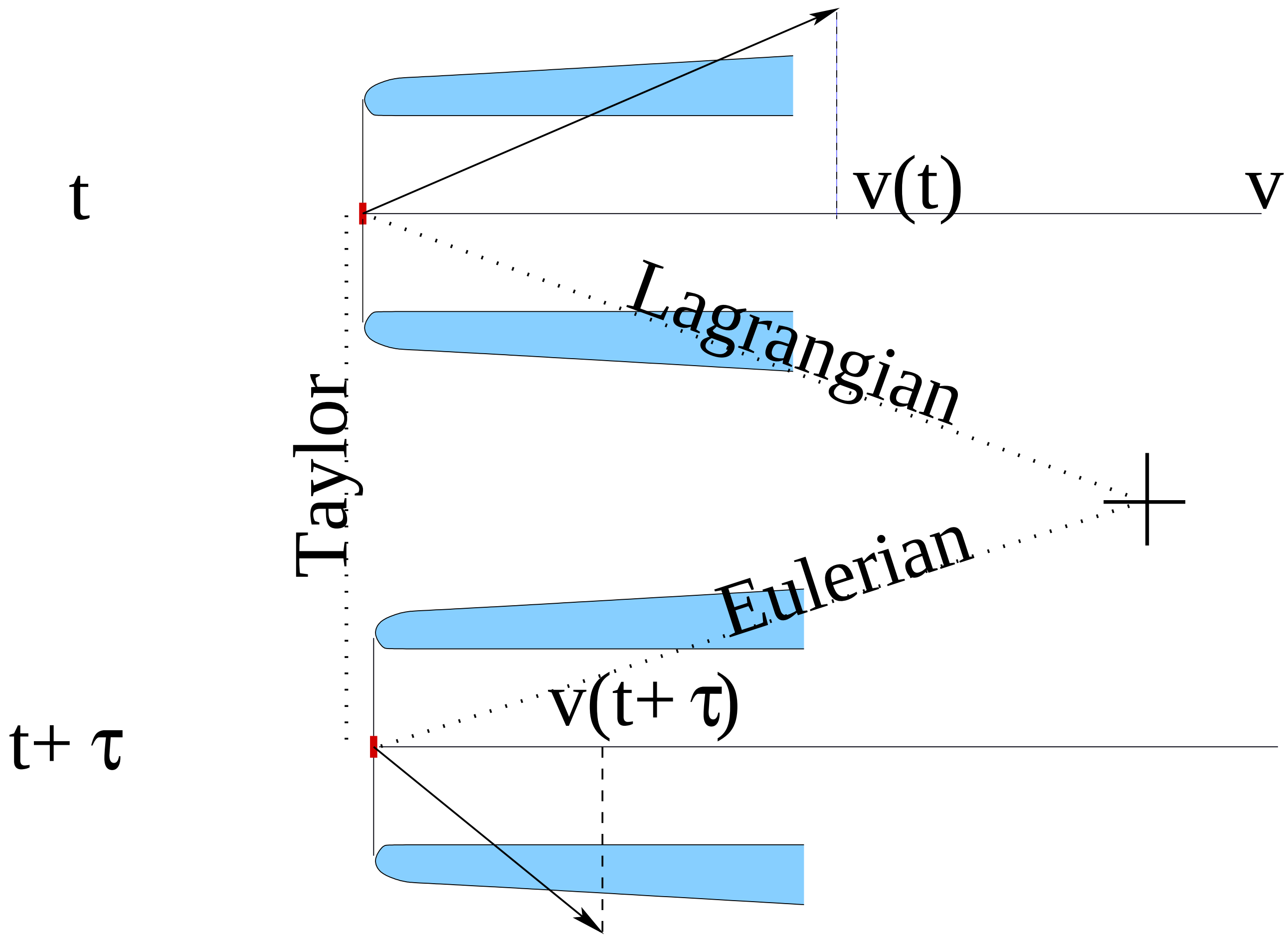
Lagrangian case: $C_\theta(\tau)$ linear in $\ln\tau$

Hot wire case: $C_\theta(\tau)$ quadratic (?) in $\ln\tau$

J. Delour, J.F. Muzy, A. Arneodo, EPJB 23, 243, 2001.

The hot wire measure is not Eulerian!

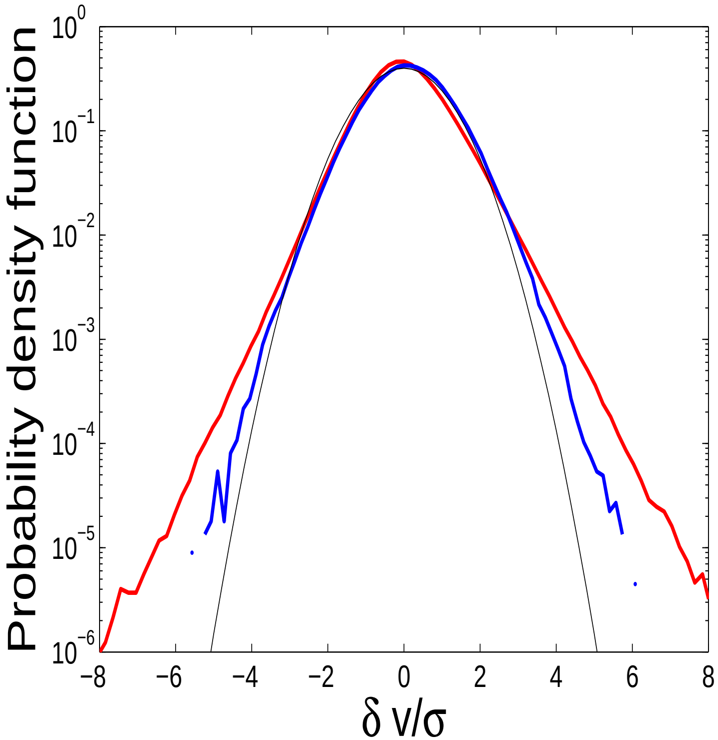


Energy cascade

"If the theory and the experiment disagree, redo the theory, “If the theory and the experiment disagree, redo the theory,

but if they agree, redo the experiment.” (Wigner?)

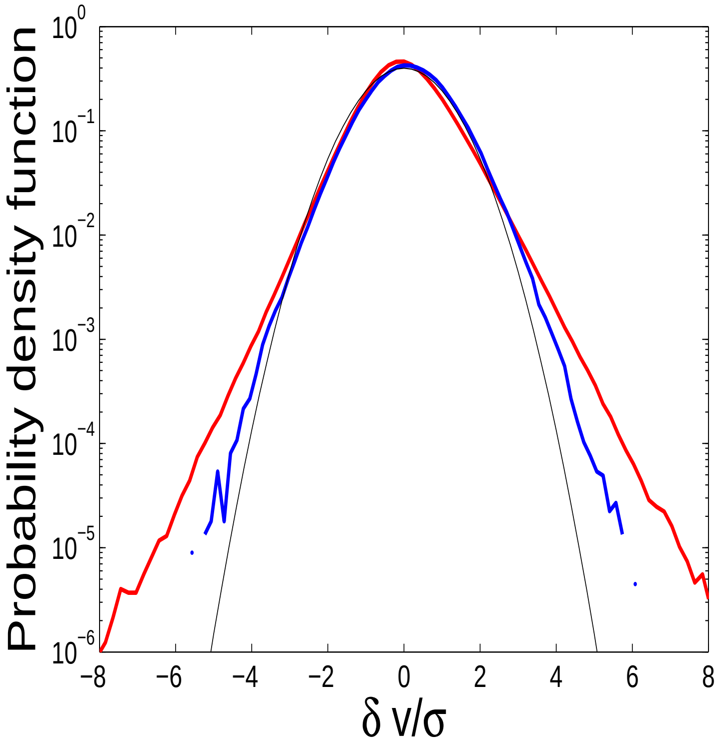
Energy cascade



$$\epsilon'_{tot} = \int_t^{t+\tau} (\frac{\partial v}{\partial t})^2 dt'$$

$$\epsilon' = \epsilon'_{tot} - \frac{(\delta v)^2}{\tau}$$

Energy cascade



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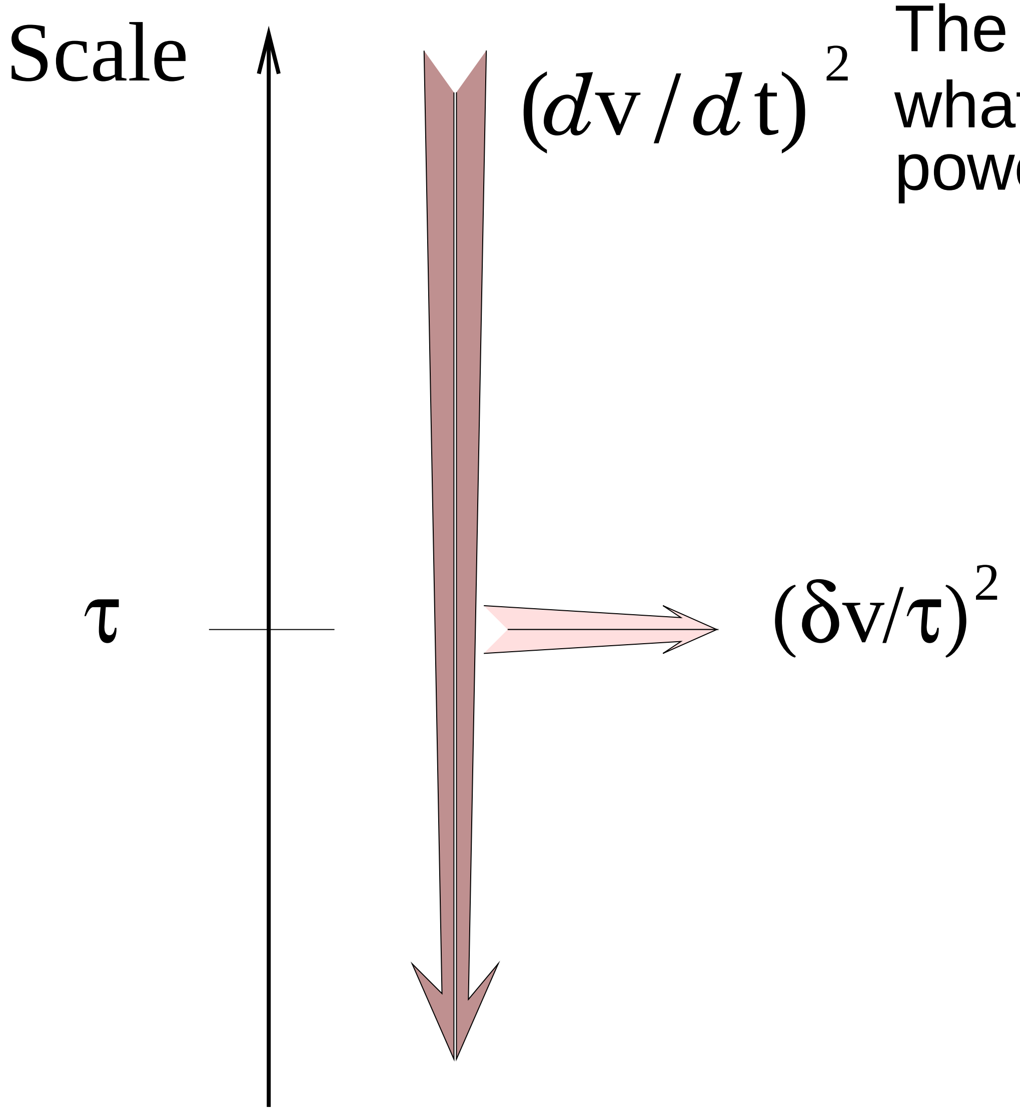
Small scales: ϵ'_{tot} is dominated by $\frac{(\delta v)^2}{\tau}$

Energy cascade

The important parameter is what remains of the input power



The agreement is perfect

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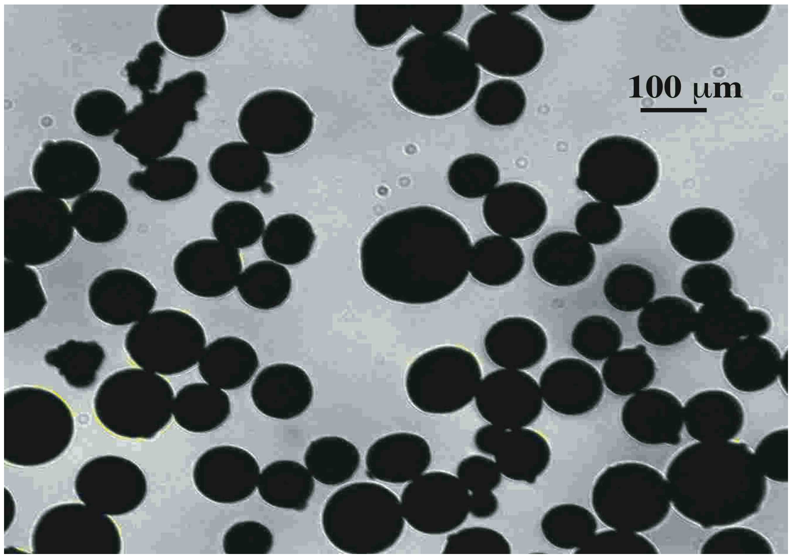
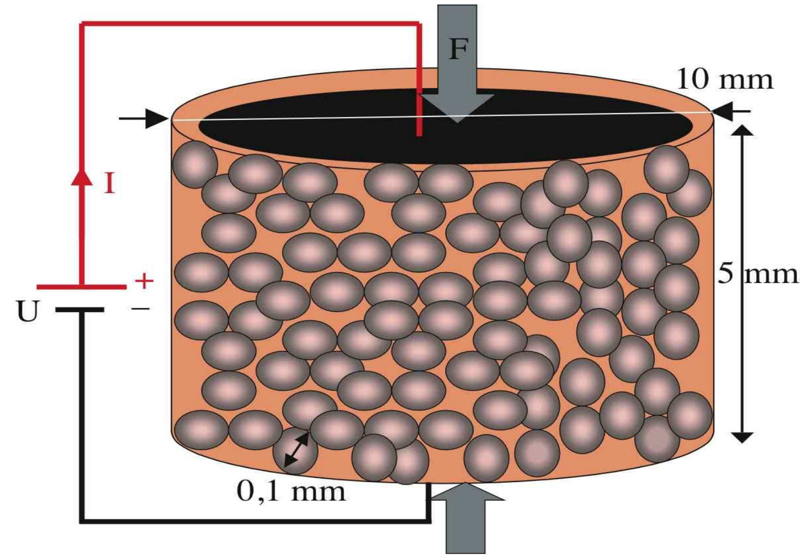
but a passive scalar (temperature) noise shows the same effect.

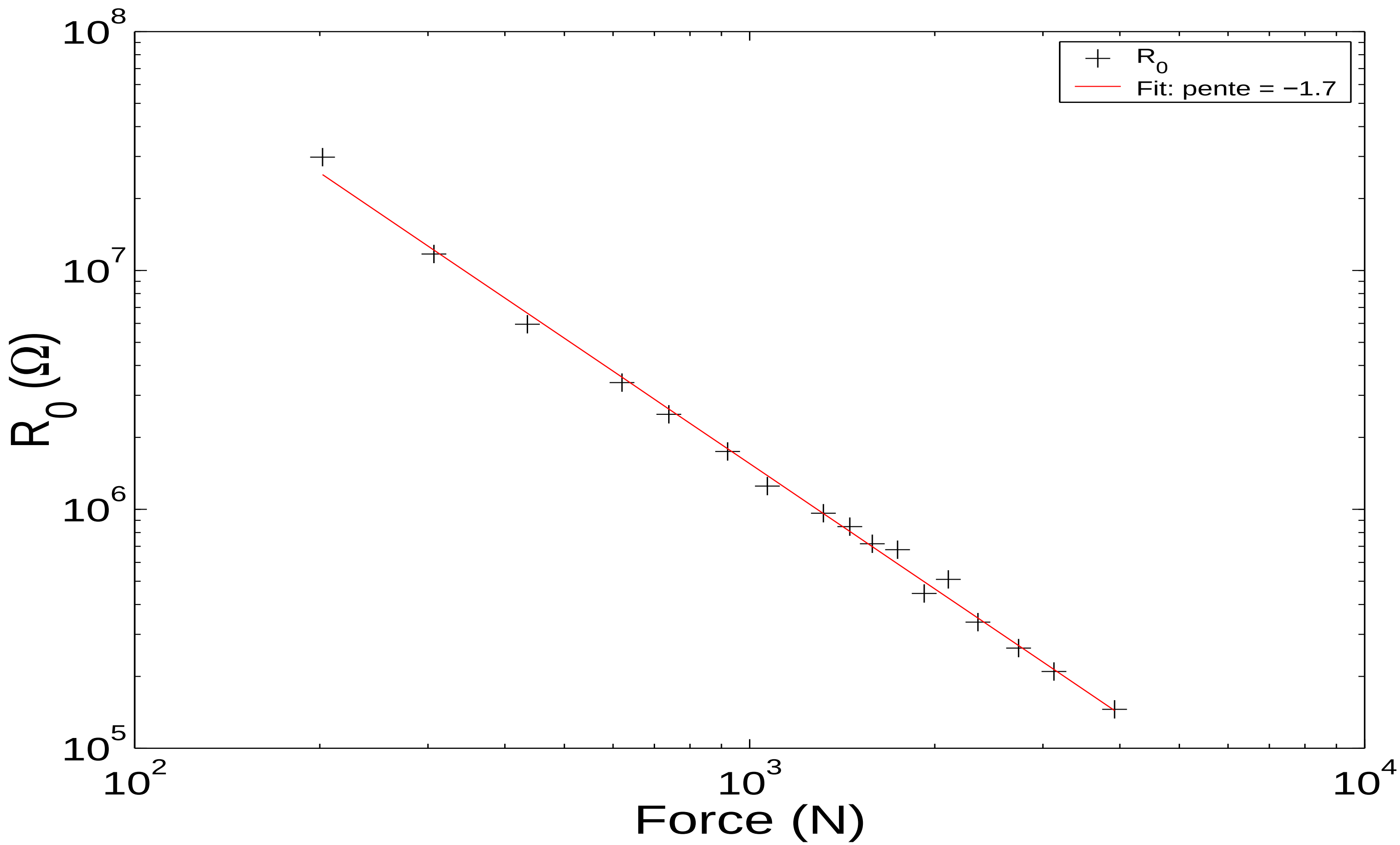
M. Marchand, PhD Thesis UJF Grenoble, (1994).

Branly effect





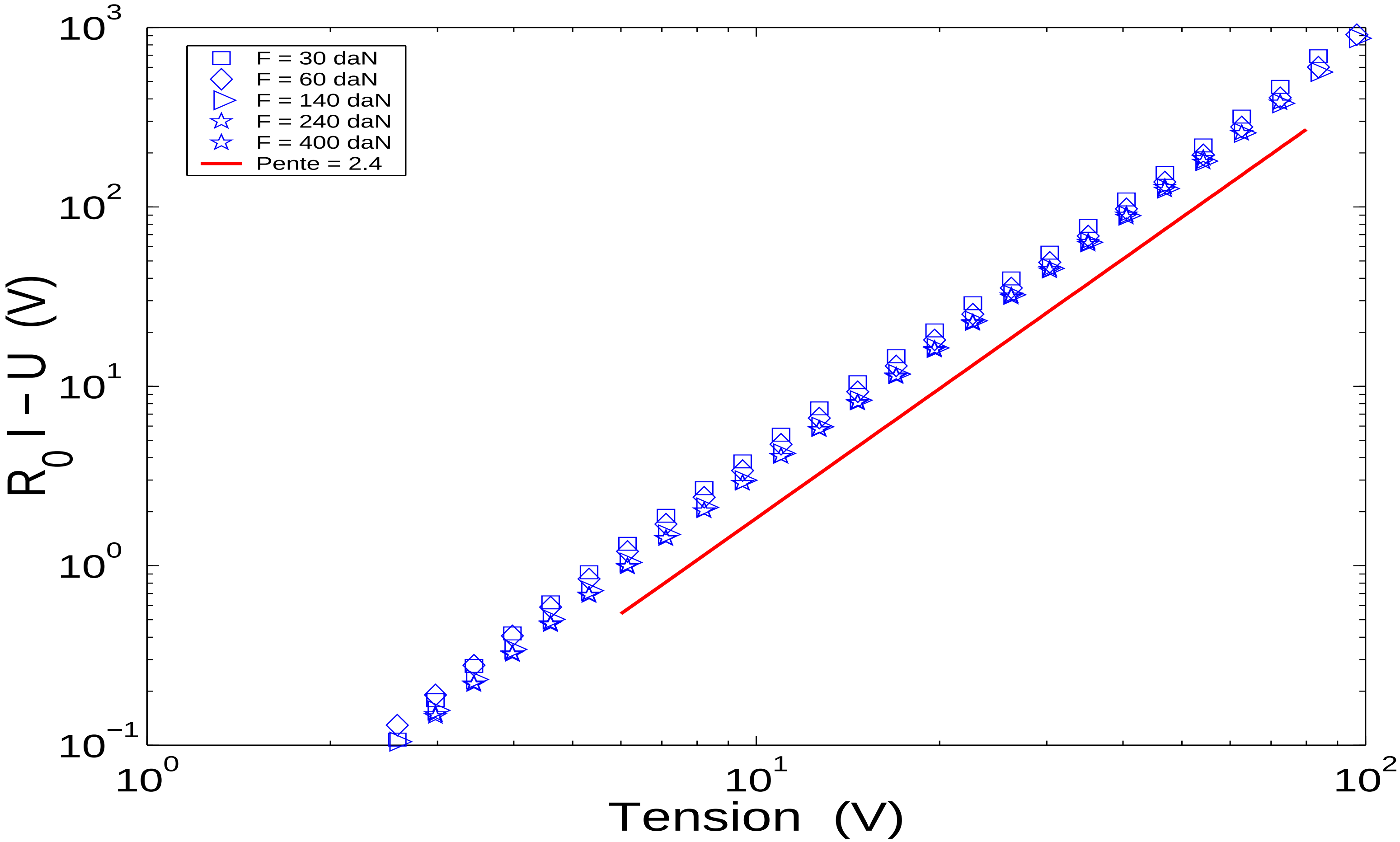
Branly effect



slope=-1.7

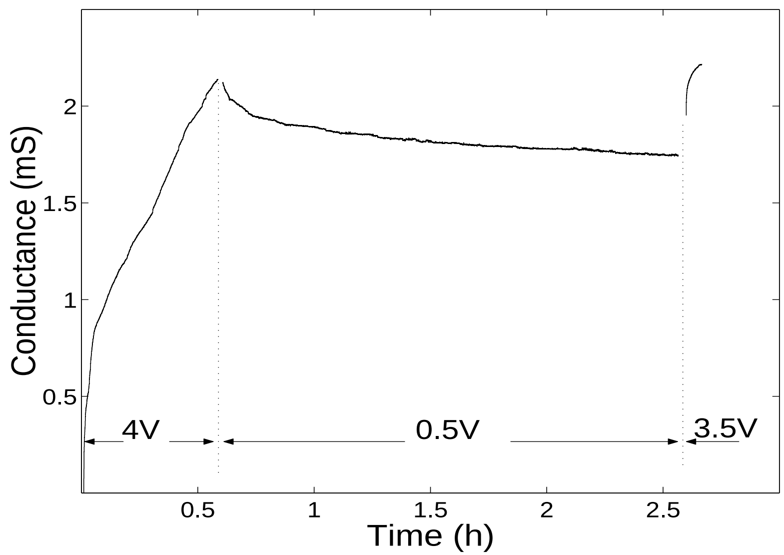
Wide (algebraic) distribution of contact resistances

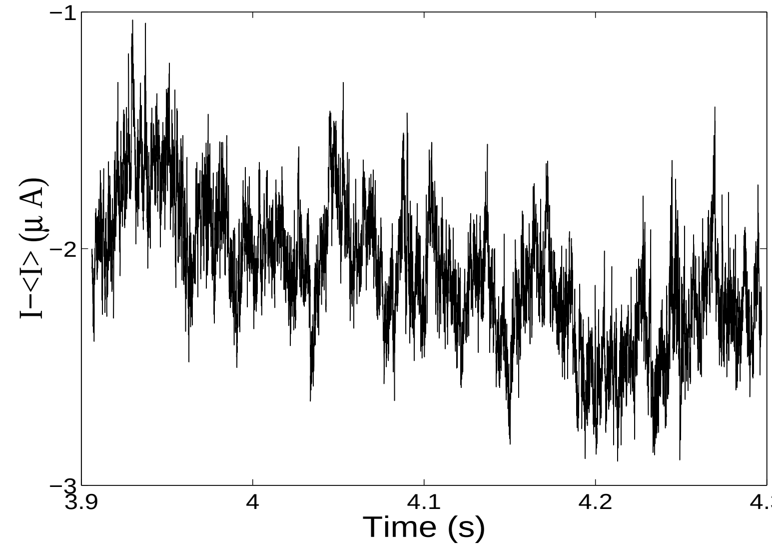
Branly effect



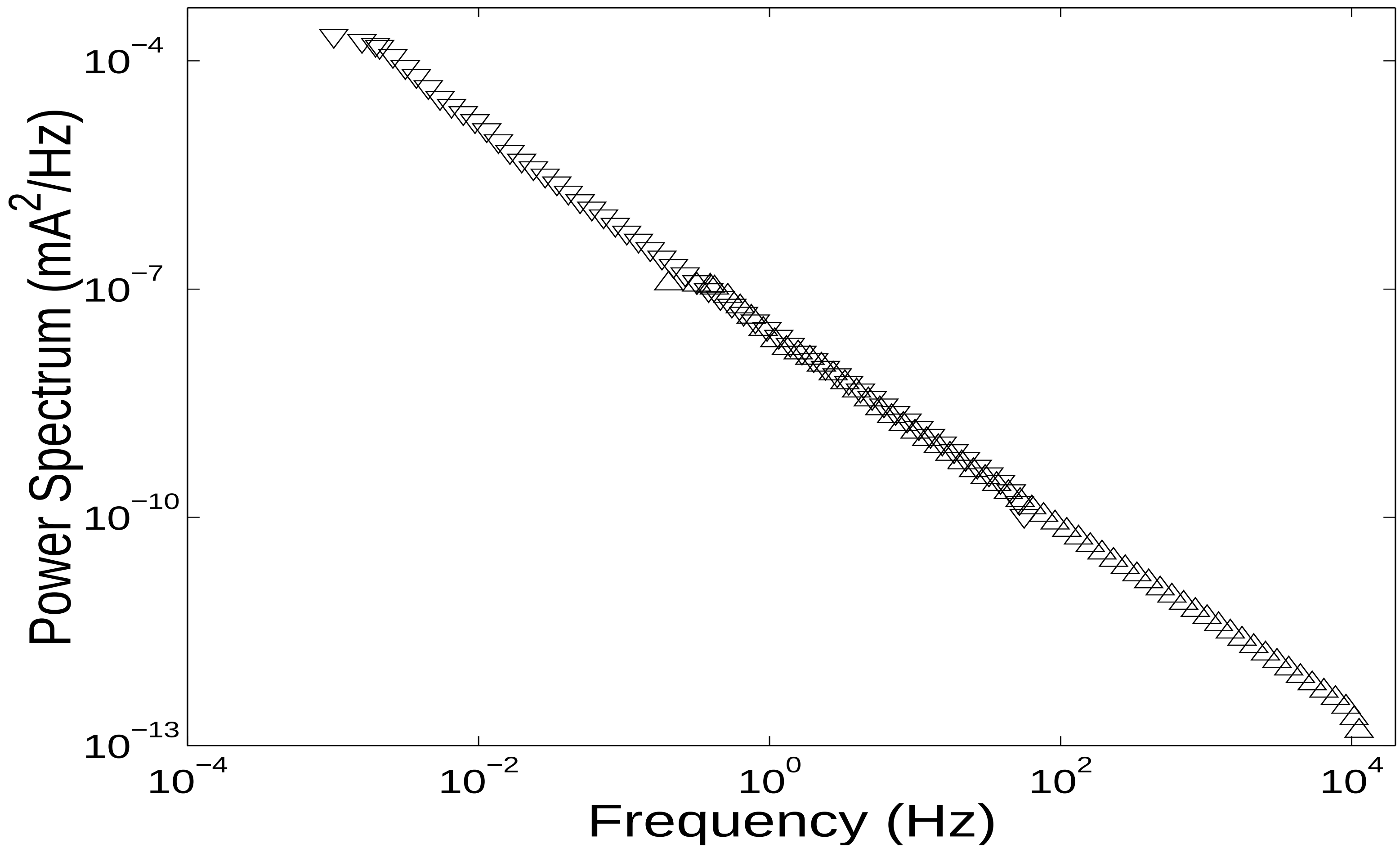
slope=2.3

Branly effect



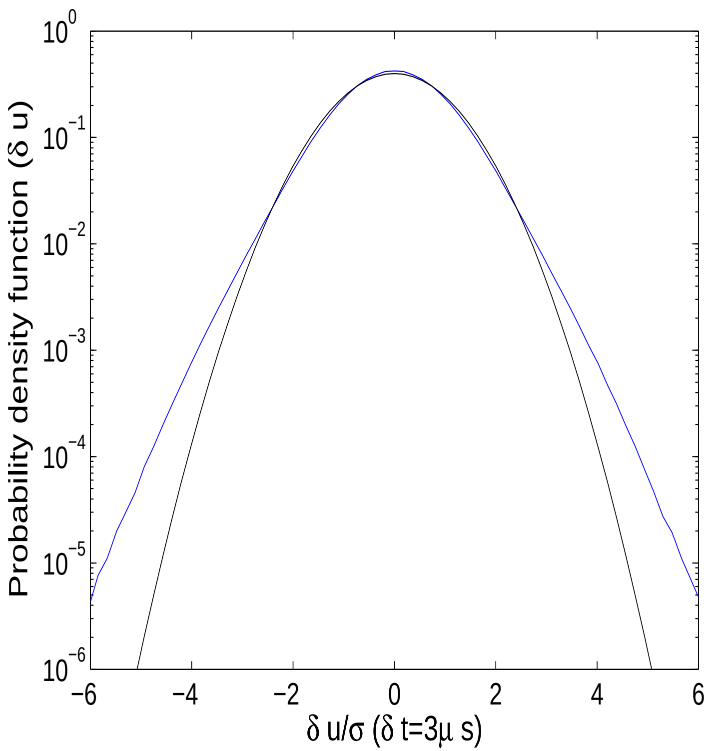


Turbulent velocity

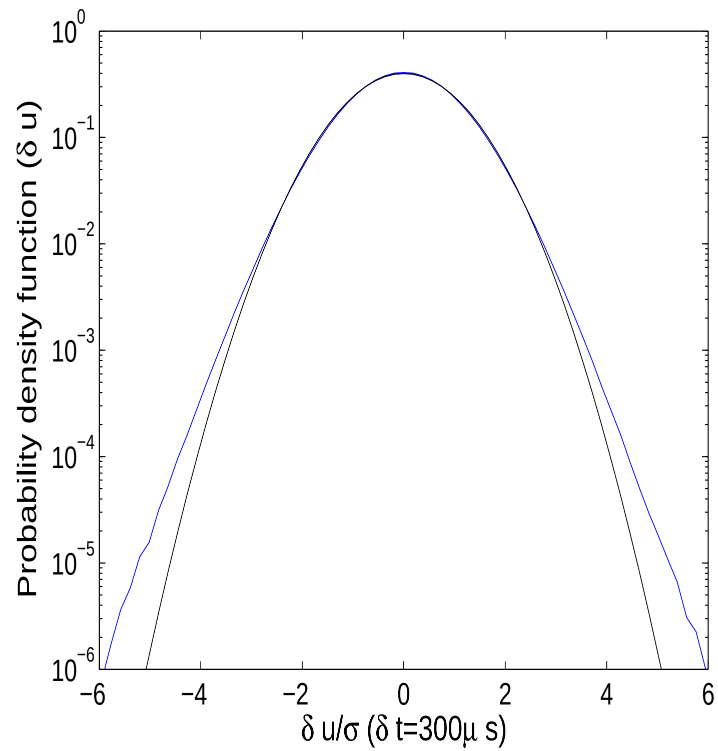


slope=-1.23; P.S. $\propto I^2$ (Resistance noise)

Branly effect



$\tau = 3\mu$s



$\tau = 300\mu$s

Branly effect

- $R \propto F^{-1.7}$ and slope of the spectrum

$\Longrightarrow$ wide distribution of energy barriers

$\Longrightarrow$ Relation between the exponents?

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- Intermittency

$\Longrightarrow$ non linearity (multiplicative noise)

Conclusion

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- Many ways to analyse a noise
- Answers are not always clear
- Lot of work
- Deeper information on complex systems