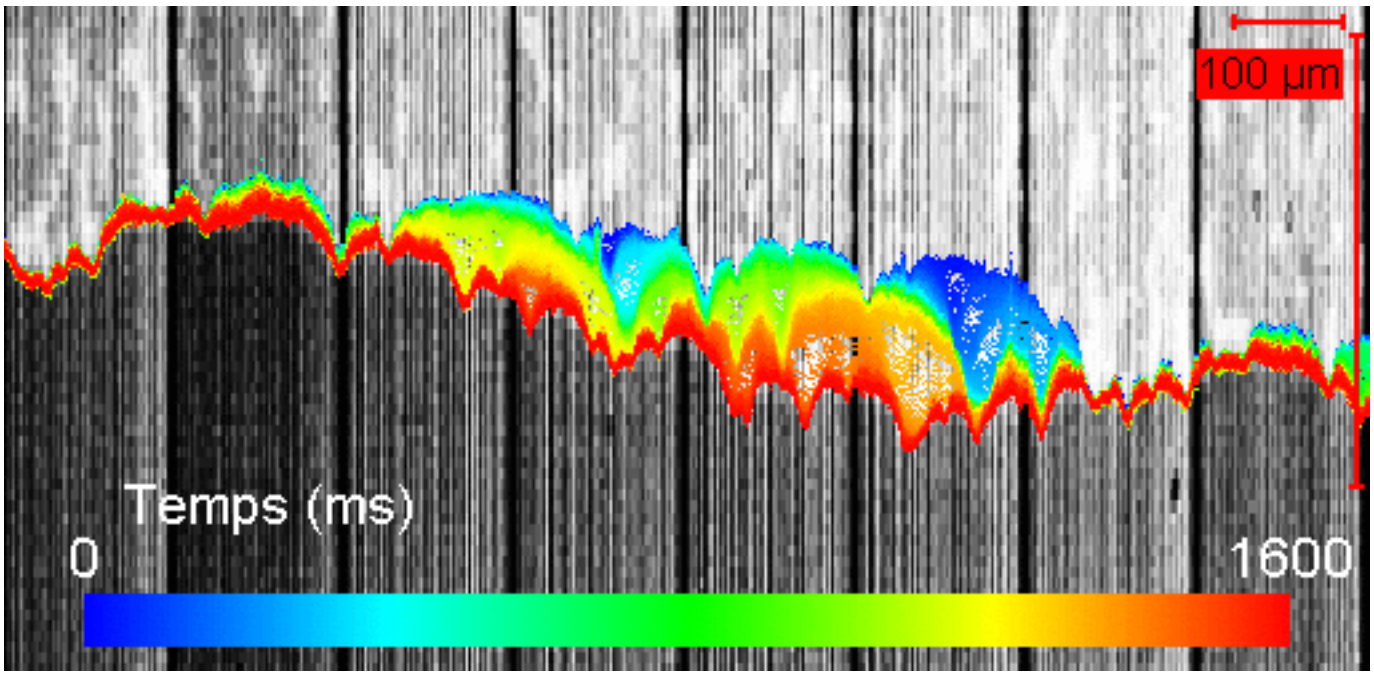
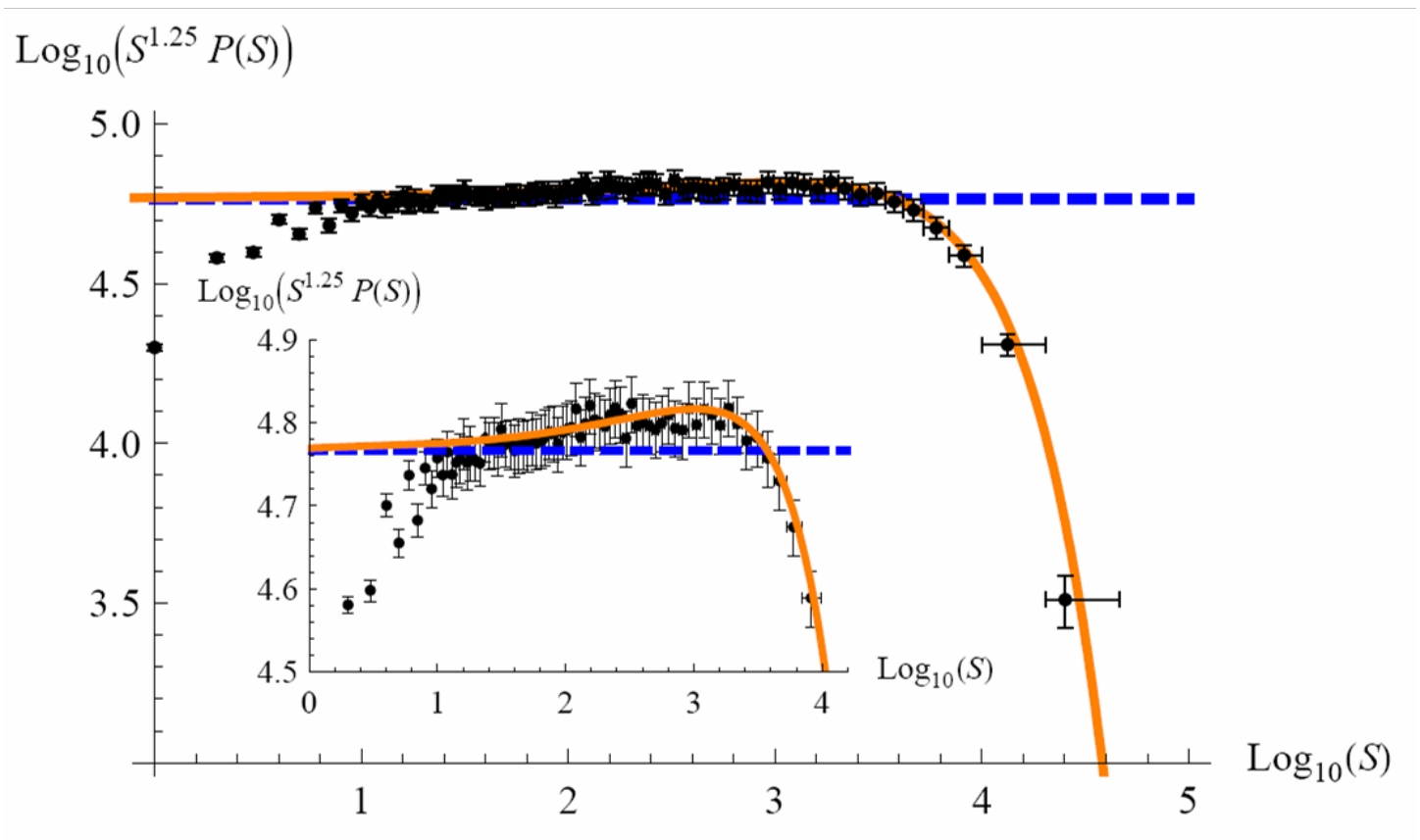
Research Highlight: Avalanches





The motion of a contact-line, appearing in the wetting of a disordered substrate by a liquid as e.g. water, is jerky, as can be inferred from the experimental snapshot above*, color-coding time. This jerky motion is a ubiquitous phenomenon observed in so different situations as the motion of domain walls in magnets, of vortex lattices in superconductors, of charge density waves, of water drops running down a windshield, but also of earthquakes due to the friction of tectonic plates.

How can we describe them? Calling one rapid, jerky motion an avalanche of size S, and knowing that avalanches are chaotic in nature, we strive for a precise statistical description: How many avalanches are there of a given size? Or more mathematically, what is the distribution $P(S)$? A precise theoretical description has eluded for some time, since the systems in question are disordered, and their theoretical modeling demands the use of a *Functional Renormalization Group*. Recently Pierre Le Doussal and Kay Wiese have succeeded in constructing the missing field theoretic description, by resumming all moments of the distribution. In an expansion around 4 dimensions, they obtain that

$$P(S) = \frac{\langle S \rangle}{2\sqrt{\pi}} S_m^{\tau-2} A S^{-\tau} \exp\left(C\sqrt{\frac{S}{S_m}} - \frac{B}{4}\left[\frac{S}{S_m}\right]^{\delta} \right)$$

with calculated parameters A, B, C, τ, and δ. This has been compared to numerical simulations of the Random-Field Ising model in 2 dimensions, in excellent agreement with the analytical prediction, as can be seen from the plot above. The theory also applies to sandpiles and self-organized critical systems, for which many exact results are known, but for which the avalanche distribution remained elusive.

Statistics of static avalanches in a random pinning landscape,
Pierre Le Doussal, A. Alan Middleton, Kay Jörg Wiese
arXiv:0803.1142, LPTENS 08/17 [abs] [pdf]

Size distributions of shocks and static avalanches from the Functional Renormalization Group
Pierre Le Doussal, Kay Jörg Wiese
arXiv:0812.1893, LPTENS 08/63 [abs] [pdf]

* Experimental snapshot courtesy of Sebastien Moulinet and Etienne Rolley, LPS-ENS.