Quantitative scaling of avalanches in soft magnetic materials

G. Durin,[1,2] F. Bohn,[3] M. A. Corrêa,[3] R. L. Sommer,[4] P. Le Doussal,[5] and K. J. Wiese[5]

[1] *Istituto Nazionale di Ricerca Metrologica, Strada delle Cacce 91, 10135 Torino, Italy*
[2] *ISI Foundation, Via Alassio 11/c, 10126 Torino, Italy*
[3] *Departamento de Física Teórica e Experimental, Universidade Federal do Rio Grande do Norte, 59078-900 Natal, RN, Brazil*
[4] *Centro Brasileiro de Pesquisas Físicas, Rua Dr. Xavier Sigaud 150, Urca, 22290-180 Rio de Janeiro, RJ, Brazil*
[5] *CNRS-Laboratoire de Physique Théorique de l'Ecole Normale Supérieure, 24 rue Lhomond, 75005 Paris, France*

The motion of a domain wall (DW) in a soft magnetic material has been recognized as a truly critical phenomena, as its jerky motion, giving rise to avalanches, is understood in terms of a depinning transition driven by fields and controlled by magnetostatic fields. The scaling laws of avalanche size and duration, for instance, show exponents which are in agreement with phenomenological models, such as the ABBM, where a single DW moves in a random media with spatial Brownian properties. One of the most striking prediction of this mean-field (MF) model is the average shape of temporal avalanches as a universal scaling function in form of an inverted parabola, as experimental verified[1]. Other materials have shown properties that go beyond MF, showing a different set of exponents and shapes. None of these models, by the way, is able to predict the analytic universal scaling functions. Recent advances in the theory of interface depinning provide a new predictive universal framework for the avalanche statistics both in and beyond MF[2]. Analytical distributions, such as the joint distribution of size and duration, or the temporal avalanche shape at fixed size has been calculated. Here we show a one-to-one quantitative comparison of these predictions for avalanches measured in materials showing both MF and non-MF properties[3]. This comparison is not only a significant test for the theory, but offers a deeper comprehension of the dynamics of DWs in soft magnetic materials.

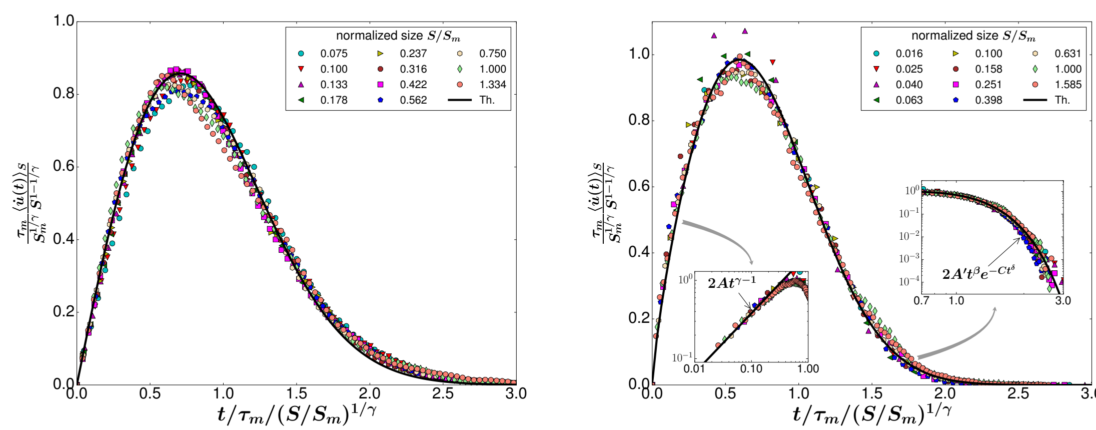

FIG. 1. Universal scaling functions of the temporal avalanche shape at fixed size for MF (left, $\gamma = 2$) and beyond MF (right, $\gamma = 1.77$). The continuous lines are the analytical theoretical predictions where no fitting parameters are involved.

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[2] P. Le Doussal and K.J. Wiese, *Avalanche dynamics of elastic interfaces*, Phys. Rev. E **88** (2013) 022106.

[3] G. Durin, F. Bohn, M.A. Correa, R.L. Sommer, P. Le Doussal and K.J. Wiese, *Quantitative scaling of magnetic avalanches*, Phys. Rev. Lett. **117** (2016) 087201.