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Crossover Scaling Behavior in Barkhausen Criticality of 2D Ferromagnetic Film

Kwang-Su Ryu[1]*, Hiro Akinaga[2], Hun-Sung Lee[1], and Sung-Chul Shin[1]

[1]Department of Physics and Center for Nanospinics of Spintronic Materials, Korea Advanced Institute of Science and Technology, Daejeon 305-701, Korea

[2]Nanotechnology Research Institute, National Institute of Advanced Industrial Science and Technology, 1-1-1 Higashi, Tsukuba, Ibaraki 305-8562, Japan

A ferromagnetic material displays a sequence of discrete and jerky domain jumps when an external magnetic field is applied, known as the Barkhausen avalanche. Studies of Barkhausen avalanches reveal a power-law scaling behavior suggesting an underlying criticality, as observed in a wide variety of physical systems. The most interesting but unsolved fundamental question is whether the universality in the critical exponent holds independent of materials and their detailed microstructures. All theoretical works so far predict that the universality of the critical exponent depends only on the dimensionality of a system, even though the value of the critical exponent varies according to the theory. However, the measured critical exponents reported in the literature span a relatively wide range of values despite the same dimensionality. Thus, the universality has been questioned, and our understanding is far from complete. To test the validity of the universality of Barkhausen criticality, a desirable approach is to perform systematic measurements of the critical exponent under well-controlled experimental conditions with reliable statistics in a given system while maintaining the same dimensionality. Here we show that the scaling behavior of Barkhausen criticality in a given ferromagnetic film is experimentally tunable by varying an experimental parameter despite the same dimensionality. This is the first finding that the universality in the Barkhausen criticality of a given system breaks down.

Reference

[1] K.-S. Ryu, H. Akinaga, and S.-C. Shin, Nature Phys. 3, 547 (2007).