Physicists study mechanics of 'crackling'

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(PhysOrg.com) -- Everywhere around us, things "crackle" -- from Rice Krispies in a puddle of milk, to crumpled pieces of paper, to the Earth's crust from earthquakes. Physics is helping us understand what this familiar noise is and how it happens.

A study led by postdoctoral associate Stefanos Papanikolaou and Professor of Physics James Sethna provides new insights into the patterns created when things crackle. For the experiments, Sethna's colleagues in Italy and Brazil used magnets, which the researchers call an "excellent playground" for studying such phenomena. The work was published online Jan. 23 in the journal Nature Physics.

Crumple a piece of paper and watch small areas bend and crease abruptly. In the same way, as a magnetic front moves forward, it advances in sharp jumps. As it grows, the magnetized region gets stuck on impurities and imperfections in the material, jumping from one bunch of dirt and getting stuck on another. Physicists call these "crackles" avalanches.

The scientists listened to this magnetic crackling in a one micron-thick metal film -- so thin that they introduced new methods to extract the crackles from the noisy data. As was predicted by theory, they saw that the big avalanches were scaled-up versions of the small ones, as well as mergers of the small ones.

Physicists use this so-called scale invariance to explain the relative number of avalanches with large and small sizes, or short and long durations, and other properties. For example, there are many more small earthquakes than larger ones, which is a "power law" distribution -- that is, the number of earthquakes is given by a power of their size. The Cornell researchers were able to go beyond these power laws to predict the avalanches' average shapes, and also, the shapes of their size and duration distributions.

The researchers' success in describing avalanches in thin magnets gives hope for understanding the larger phenomena that follow these self-similar patterns -- for example, the way the Earth cracks during an earthquake. Earthquakes are avalanches, too -- the Earth's crackling response to moving tectonic plates. The scaling that explains how magnets crackle and how paper crunches may be useful in predicting how earthquakes spread.

"We don't know how to predict when earthquakes will happen -- which is what people want -- but we are gaining real control about what avalanches look like in magnets -- their shapes and sizes and speeds. Magnets are a place to do experiments to understand earthquakes," Sethna said.

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Provided by Cornell University

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