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Cooperative Behaviour of Physical Systems

Natural systems exhibiting critical phenomena are driven by fluctuations and have become the focus of attention across many branches of the physical and biological sciences. In the field of neuroscience for example, neurons in the brain appear to sit near a critical point where, on the one side there is stability with neurons ready to respond to stimuli, while on the other side, they fire in a chaotic manner, leading to seizure. Likewise, criticality can be spotted on the macroscale in the flocking of birds, the swarming of insects or the schooling of fish. In the case of bird flocking, for example, correlations have been established using direct measurements of displacements and velocities of particular birds. The statistical analysis of such data [1] has illustrated a diffusive behaviour within flocking with an increasing mean squared displacement of the form $(\delta x)2 = Dt\alpha$ with the exponent, $\alpha \sim 1.7$ and the diffusion coefficient small, resulting in slow rearrangements.

As for such biological systems, in condensed matter physics, critical point behaviour which often accompanies a phase transition, results from interparticle (i.e., interatomic) correlations but unlike the biological systems, it becomes impossible to measure the behaviour of specific "particles." The collective behaviour is observed as an avalanche, or noise, in a particular physical property [2]. Somewhat surprisingly, the statistical analyses of such noise spectra, show results which resemble those for biological systems.

In this paper, a brief review of these ideas will be presented and some of our recent measurements and analysis of noise spectra in shape-memory alloys will be illustrated.

[1] A. Cavagna and I. Giardina, *Ann. Rev. Condens. Matter Phys.* **5**, 183-207 (2014).

[2] J.C. Lashley, K. Gofryk, B. Milhaila, J.L. Smith and E.K.H. Salje, *J. Phys.: Condens. Matter* **26**, 035701 (2014).

Primary author(s) : Dr FINLAYSON, Trevor (University of Melbourne)

Co-author(s) : Dr LASHLEY, Jason (Los Alamos National Laboratory)

Presenter(s) : Dr FINLAYSON, Trevor (University of Melbourne)