

Scientific report for the ESF-STOCHDYN science workshop

”Stochasticity and non-linearity in material response”

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Abstract

The meeting was held together with Fluctuations and Scaling in Materials -satellite conference at Todi, Italy in early July. Four sessions were held to illustrate various aspects of the science involved. The main emphasis was on magnets and their physics on one hand, and on the irreversible deformation of materials of the other hand. This means plasticity and fracture, where European groups hold currently the leading position in the world.



FIG. 1: A snapshot of the meeting, L. Laurson (HUT, Finland) speaking. In the foreground there is the ESF logo, visible.

I. SCIENTIFIC SUMMARY

The Stochdyn-financed workshop acted as a nice meeting point for scientists interested in the basic physics of fluctuations and noise in materials, and the possible engineering and geophysics applications thereof.

The program (including the ESF financed invited speakers and some contributed talks) was split into four sessions, and with ample time to interact for the participants outside the organized program. We as organizers feel that the meeting fulfilled its role by giving a chance for interested people in various communities to meet, compare their ideas, and in particular to discuss future interactions both in research and in organizing future conferences. It is hoped that the EU FP7 and the European Science Foundation will also play a large role in this.

II. MEETING DESCRIPTION

Next we overview some of the scientific highlights, by the convened speakers. This is done on the basis of a division between various scientific aspects.

In *magnetism*, two main talks are of particular note. Gianfranco Durin did an overview of the physics of the Barkhausen effect, from the viewpoint of an experimentalist. Durin outlined the current understanding of the phenomenon in thin films, which is based on the picture of domains and domain walls in the presence of disorder, or often the Random Field Ising Model. This particular class of systems is now well understood, but many future directions exist. In these experiments, the emphasis is on the stochastic magnetization signals and therefore there are many connections to stochastic processes, and general ways of analyzing timeseries. Eduard Vives spoke about martensitic transitions. These are of particular interest since they are often of first order kind, and can be driven or controlled in many ways. The connection to Durin arises since the modelling approach is very similar.

In *plasticity* we had five talks. Three of the them had an experimental viewpoint: Zaiser, Pantleon and Weiss. They all discussed the stochastic dynamics of plastic deformation but with various tools: surface deformation and its fractal character, neutron scattering, and acoustic emission. All in all the experimental evidence points out towards the intermittent nature of plasticity, and many typical features of crackling noise can be identified and measured. The theoretical understanding of these phenomena is still far from complete. Lemaitre and Miguel discussed recent computer simulations for amorphous materials, simple crystals, and colloidal crystals. In these, similar signatures are seen but any analytical modelling is either nonexistent or far from complete. This is most clear in the case of amorphous systems, where existing attempts as the “Shear Transformation Zone” theory by Langer and Falk may be not completely correct.

Finally, the workshop included two talks by Dalton and Schweitzer on particular experimental systems: granular assemblies and snow physics. In both cases, the most interesting question is not whether the deformation is intermittent and abrupt, but whether one can see precursors or predict sudden events - a granular system changes state from a solid to a liquid like, or an avalanche takes place affecting nearby mountaineers.

The last two invited talks were by Vanel and Zapperi. Both discussed fracture, first experimentally and then theoretically. Vanel explained various experiments on acoustic

emission in fracture, both as regards tensile and creep tests. Interesting similarities exist, but for instance the acoustic emission statistics are not the same in various loading modes. Zapperi outlined theoretical and computational studies of size effects (how the flaw size controls the strength of samples, as a function of sample size). In addition to being an important problem as such it connects to the stochastic nature of the fracture phenomenon, and leads to questions of predictability that should be studied experimentally.

III. MEETING IMPACT

In our opinion, the meeting confirmed that this is a new, exciting area that will keep attracting increasing interest in the future.

This is due to the cross-disciplinary nature of the research area, which couples various branches of physics, materials science, and mathematics and also geosciences to name just the important ones. Moreover, activity is needed from experiment to theory to simulation, and e.g. for the theoretical physicist there are extremely hard problems to tackle, many for which the available mathematical machinery is not sufficient.

We expect that as outgrowth increasing collaborative activity among the interested groups in Europe will develop. Moreover, we expect that followup meeting to be arranged, and we as organizers hope to be able to contribute to this future.

IV. MEETING PROGRAMME

Wednesday 4	
convened (plus contributed)	Durin, Dalton Reblias, Corcoran
Thursday 5	
convened (contributed)	Pantleon, Schweitzer Petaja, Sarkar, Schwerdtfeger, Giordano Pontuale, Clancy
Friday 6	
convened (contributed)	Zaiser, Vives Lemaitre, Weiss Bustingorry, Moretti Kolton, Evans Beato, Laurson
Saturday 7	
convened (contributed)	Zapperi, Vanel Bonamy, Maloney Davidsen, Rosti Ponson

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