Spin glasses, concepts and analysis of susceptibility

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This lecture will be dedicated to the slow dynamics observed in disordered, glassy systems at temperatures below the scale set by the interaction energy. This is now an old subject, indeed the community studying the « ageing » processes I will describe is itself an ageing one! However, over the last 10-15 years there has been considerable renewed interest in this field following remarkable experimental results exposing such ageing phenomena as the breakdown of the fluctuation dissipation theorem, effective non-equilibrium temperature, rejuvenation and memory effects [1,2,3].

My lecture will include four chapters:
I will begin with a review of spin glasses, of their generic behaviour and of the model systems [4] used to describe them. I will review the fluctuation dissipation theorem (FDT) and introduce the notion of slow dynamics. I will discuss some of the physical concepts associated with the physics of spin glasses, such a complex free energy landscape with multiple metastable states. In the second chapter I will review the recent experiments giving rise to breakdown of the FDT, of ageing, rejuvenation and of memory effects. In the third chapter I will illustrate how competing energy and length scales can lead to such complex behaviour through the study of a very simple model system, the low temperature phase of the two-dimensional XY model. This system is characterized by a line of critical points with continuously varying exponents stretching from the Kosterlitz-Thouless transition temperature to T=0. Along this line, the changing nature of the diverging correlation length reproduces much of the phenomenology of the complex glassy systems even in the absence of disorder [5]. Time permitting, in the final chapter I will review the dynamics of a recently studied system, spin ice, where decorrelation occurs via the free propagation of topological defects, carrying topological and even magnetic charge [6,7,8]. I will illustrate the similarities and differences between this, disorder free system and the more complex spin glasses.

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