Introduction to Special Issue: Statistical Mechanics on Random Structures

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This Special Issue of *Journal of Mathematical Physics* on **Statistical Mechanics on Random Structures** aims to cover some recent results in the interplay of topics, such as disordered systems and, in particular, spin glasses, random graphs, and their common applications.

The idea of this issue originated from an invitation of the Editor, Bruno Nachtergaele, which we enthusiastically accepted, and followed the organization by the present authors of the 2008 Young European Probabilists (YEP) meeting at EURANDOM (Eindhoven, The Netherlands).

The present issue aims to be an occasion for different scientific communities to have a common collection of new results: probabilists working on random graphs, physicists working on disordered systems, and mathematical physicists working on spin glasses. While the first community has developed along the years a detailed analysis of the topological properties of random graphs, mainly inspired by percolation, physicists first and mathematical physicists later (at different levels of mathematical rigor) developed the statistical mechanics analysis for systems of particles interacting over a random network.

Three decades ago, statistical mechanics witnessed the introduction of disordered interactions in spin glass models. In addition to the description of condensed matter alloys, the proposed statistical mechanics formalism has proven to be an excellent method to study problems well beyond the original motivation and has indeed invaded fields as diverse as combinatorial optimization and neural networks. Interesting applications have been found in the biological, economical, and social sciences. Today, the rich mathematical structure of spin glasses is a leading research topic in probability theory. The introduction of random couplings can be seen as a first attempt to introduce random interactions in particle systems. Diluted spin glasses have moved the theory toward adding a new source of randomness in the connectivity property of the interaction network like those of Erdös-Rényi random graphs. Those are also relevant in computer science, since many random optimization problems are mapped in a natural way into the study of ground states of diluted mean-field spin glass models (for example, the K-sat model has been solved within the framework of "one-step replica symmetry breaking").

Complex networks emerging in real systems (found in biology, social sciences, and internet and power grids) have revealed interesting properties of small world and scale free type, which led to an explosive development of the mathematical theory of random graphs. The modeling of complex networks has given rise to a large number of random graphs models, in which some correlations structure is introduced in the model, for example, the so-called "preferential attachment" type.

To build a theory of interacting particles on random networks is a natural and necessary stop to be pursued in the near future. The present issue collects 20 selected contributions from about 40

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scholars. We hope this collection might be useful for people interested in working at the interface between probability and physics, where the topic of this Special Issue is certainly going to have a rapid increase in the following years.

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