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A rigorous theory of chaos in disordered systems

Disordered systems are an important class of models in statistical mechanics, having the defining characteristic that the energy landscape is a fixed realization of a random field. Examples include various models of glasses and polymers. They also arise in other subjects, like fitness models in evolutionary biology. The ground state of a disordered system is the state with minimum energy. The system is said to be chaotic if a small perturbation of the energy landscape causes a drastic shift of the ground state. In this talk I will present a rigorous theory of chaos in disordered systems that confirms long-standing physics intuition about connections between chaos, anomalous fluctuations of the ground state energy, and the existence of multiple valleys in the energy landscape. Combining these results with mathematical tools like hypercontractivity, I will present a proof of the existence of chaos in directed polymers. This is the first rigorous proof of chaos in any nontrivial disordered system. Applications to other models like spin glasses, fitness models, and general Gaussian fields will also be discussed.