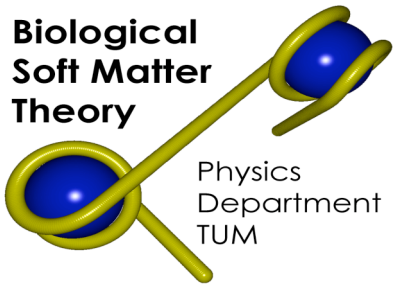

"Soft-Matter Seminar"

Dr. Michael Hinczewski
Feza Gursey Institute

Unusual Phase Transitions in Complex Networks:
Algebraic Order and Griffiths Singularities in Small-world, Fractal Hierarchical Lattices

Recently it has been discovered that a broad class of real-world complex networks shares a remarkable organizational principle: they are structured in nested modules obeying fractal scaling laws. Examples of such fractal networks include the WWW, protein interaction, metabolic pathways, and genetic regulatory networks in a variety of organisms. Despite the widespread occurrence of fractal topologies, little is yet known about the nature of kooperative behavior on these networks, or more generally, on how modular organization affects collective ordering or correlations among interacting objects. In this talk, we introduce a family of hierarchical lattices which mimic the structural features of such fractal networks. By varying the parameters which govern the construction of these deterministic networks, we can control their topological properties, tuning the degree exponent, fractal dimension, clustering coefficient, and the scaling of the diameter with size. When we examine cooperative behavior on the networks, their structural variety translates into highly unusual phase transitions and critical phenomena, even in a simple system like the ferromagnetic Ising model. We look at a specific network, representative of the broader family, and obtain the exact thermodynamic behavior of the Ising model through a renormalization-group approach. The network is composed of tightly-knit communities nested hierarchically with fractal scaling, and we vary the ratio K/J of inter- to intra-community couplings. At high temperatures or small K/J we have a disordered phase with a singularity in the free energy, analogous to the Griffiths singularity in disordered magnets, caused by the presence of rare large clusters. As the temperature is lowered, true long-range order is not seen, but there is a transition to algebraic order. The existence of slowly decaying pair correlations is unexpected in this type of scale-free network, where correlations longer than nearest-neighbor are typically suppressed.

Dienstag, den 5.6.2007
16:00 Uhr
Raum PH 3344

Prof. Dr. Roland Netz
Physik-Department T 37, Technische Universität München, Theoretische Physik
85747 Garching