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Opportunities and challenges in statistical mechanics: The fluctuationdissipation theorem and its limitations

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The fluctuation-dissipation theorem is the main tool for obtaining the response of a physical system. However, FDT fails in many situations (see [1] for review), such as phase transitions, spin glass, anomalous diffusion, and growth phenomena. We develop the hypothesis that the dynamics of a given system may lead to a fractal dimension d_f different from the original spatial dimension d. This phenomenon is more easy to observe near a phase transition. We also speculate how the response function might be sensitive to this change in dimensionality. We discuss how this phenomenon appears in phase transition and growth phenomena [2-7]. We show that the Fisher exponent η
$\eta = d - df$ is the deviation from the integer dimension. Thus we determine exactly the fractal dimension df for the Ising model in two dimensions as $d_f = 7/4$ and we validate it via computer simulations.

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