

# Physical Colloquium

## „A Multivariate Approach to Emergence in Complex Systems“

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Habilitation lecture on

**Monday, 16.12.2024, 2.15 p.m.**  
**Room No. W02 1-148**



The concept of “emergence” is fundamental in modern statistical physics, highlighting how macroscopic dynamics can differ dramatically from the underlying microscopic interactions. This phenomenon is characterized by hierarchical structures within the dynamics of the system. Superstatistics exemplifies this idea by proposing that emergent behavior can often be viewed as a superposition of multiple statistical systems operating across spatiotemporal scales. This framework allows a deeper understanding of complex systems and their emergent properties. The presentation provides an informative introduction to equilibrium statistical physics and then discusses the generalization to superstatistics by proposing a fluctuating intensive parameter (e.g., the reciprocal thermodynamic temperature  $\beta$ ). The concept of superstatistics will be further illustrated by a recent multivariate generalization of the superstatistical approach in a broad range of complex systems (e.g., atmospheric turbulence, urban systems, and anomalous diffusion). Furthermore, we will discuss superstatistics in the context of other approaches from non-equilibrium statistical physics, e.g., Brownian subordination or fractional diffusion processes.

Host: Prof. Dr. Joachim Peinke