



Graduate School Event

Thesis Defense: On the large-scale behavior of interacting particle systems, composite magnetic materials, and interface motions through random obstacle fields

Jonas Ingmanns (Fischer Group)

Fischer Group

Host: Monika Henzinger

Precise microscopic models of physical processes are often too complex to be useful for understanding or simulating phenomena on a macroscopic scale. The complexity can be drastically reduced if there is a suitable approximation which still accurately captures the effective large-scale behavior of the underlying model. This thesis contains contributions to the rigorous justification of such large-scale approximations or three different models. Chapter 2 presents joint work with Federico Cornalba, Julian Fischer, and Claudia Raithel. We consider a large system of weakly interacting particles, driven by independent Brownian motions. The physicists Dean and Kawasaki proposed a strongly singular SPDE to describe fluctuations of the particle density. However, without a suitable regularization, the Dean–Kawasaki equation has been shown to be ill-posed in the sense that it does not admit martingale solutions for any continuous initial data. We show that a structure-preserving discretization of the Dean–Kawasaki equation – acting as a suitable regularization – captures the density fluctuations of the particle system up to arbitrary order in the inverse number of particles and a discretization error. Chapter 3 presents joint work with Elisa Davoli and Lorenza D’Elia. We consider a magnetic body consisting of a composite material with a random microstructure. The oscillating magnetic properties are encoded in the micromagnetic energy functional which is restricted to functions taking values on the sphere, governing the observable states of magnetization. We obtain a qualitative stochastic homogenization result in the form of Γ -convergence. The Γ -limit is a micromagnetic energy functional with constant, deterministic coefficients, meaning that the magnetic body can be treated as if consisting of a single material when the microstructure is small enough. On a technical level, we obtain an analogous result replacing the sphere with other sufficiently regular manifolds. Chapter 4 and Chapter 5 present joint work with Julian Fischer. We consider interface motions driven by curvature and a uniform forcing through a stationary field of possibly impenetrable random obstacles satisfying a finite range of dependence assumption. This process models, e.g., the motion of dislocation lines or magnetic domain boundaries in materials with inhibiting impurities. In Chapter 5, for dimension $d = 2$, we introduce an easy-to-check criterion for general

obstacle fields which implies ballistic behavior. More precisely, this criterion yields an almost guaranteed effective minimum speed on large scales for the interface motion , with 'effective' meaning that enclosures left behind a main front can be ignored. In Chapter 4, for any dimension ≥ 2 , assuming such an almost guaranteed effective minimum speed, we obtain a quantitative stochastic homogenization result in any dimension, proving that the main front can be approximated with a constant-speed motion on large scales.

Tuesday, September 1, 2026 03:00pm - 04:00pm

Office Bldg West / Ground floor / Heinzl Seminar Room (I21.EG.101) and Zoom



This invitation is valid as a ticket for the ISTA Shuttle from and to Heiligenstadt Station.

Please find a schedule of the ISTA Shuttle on our webpage:

<https://ista.ac.at/en/campus/how-to-get-here/> The ISTA Shuttle bus is marked ISTA Shuttle (#142) and has the Institute Logo printed on the side.

www.ista.ac.at | Institute of Science and Technology Austria | Am Campus 1 | 3400 Klosterneuburg