Universität Basel

Research Project

From Newton and Schrödinger many-body dynamics to the Boltzmann equation

Third-party funded project

Project title From Newton and Schrödinger many-body dynamics to the Boltzmann equation
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This proposal aims at investigating the rigorous derivation of effective macroscopic equations starting from the microscopic laws of classical and quantum dynamics. Albeit considerable progress has been done in last years, several problems still claim for solutions. Among them, questions concerning the validity of the Boltzmann Eq.n, as well as its quantum version, are certainly of primary interest both from a physical and mathematical viewpoint. Major open questions deal with the long time derivation of the Boltzmann Eq.n; its validity for long range interactions; the role of boundary conditions; the derivation of the quantum Boltzmann Eq.n from a system of quantum particles. In light of recent mathematical developments, we propose a research agenda to contribute in the aforementioned items:a) Derivation of the Boltzmann Eq.n for long range potentials. Our goal is to deeply understand the onset of instability due to the long tail effects, first of all looking at the linear Boltzmann Eq.n. We believe techniques developed in a work in preparation joint with L. Desvillettes and S. Simonella will be successful ingredients and draw the lines for a long term investigation in the nonlinear case.b) Derivation of the Boltzmann Eq.n with inelastic collisions. When collisions occurring at microscopic scale are inelastic, a loss of energy in the scattering process appears. It can be seen as a boundary effect. We plan to rigorously derive the Boltzmann Eq.n for granular gases, by adapting techniques developed by Gallagher, Saint-Raymond, Texier and Pulvirenti, Saffirio, Simonella. The result would be relevant for applications and provide the first step to understand the role of boundaries in the validity of the Boltzmann Eq.n.c) Derivation of the Landau Eq.n. When the long-range interaction is the Coulomb potential, the Boltzmann collision operator is no longer well defined and has to be replaced by the Landau operator. We are interested in the rigorous derivation of the Landau Eq.n from a Hamiltonian system of interacting particles in the weak-coupling limit. We plan to combine the result obtained by Bobylev, Pulvirenti, Saffirio with the mathematical methods recently developed by Velázquez and Winter, thus providing an equivalent of Lanford's result in the weak-coupling context.d) Evolution of fermionic systems with Coulomb interaction. In light of recent developments obtained by Benedikter, Porta, Saffirio, Schelin, we plan to provide an explicit rate for the semiclassical limit of the Hartree-Fock dynamics towards the Vlasov-Poisson Eq.n. We expect techniques developed here to be useful for point e).e) Derivation of the quantum Boltzmann Eq.n. We plan to perform a weak-coupling scaling in the many-body Schr odinger Eq.n and to obtain the quantum Boltzmann Eq.n in the limit. We believe that the choice of the initial data will play a crucial role. In particular, we will construct two-particle reduced density matrices that take into account correlations between two particles in the spirit of Benedikter, De Oliveira, Schlein.

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