Scaling limits for particle systems

The *Scaling limits for particle systems* group participated in the first half of the Junior Trimester Program at the Hausdorff Institute for Mathematics in Bonn, during the summer of 2019. The members of the group were Roberta Bianchini (IAC CNR, LJLL Paris at the time), Lingbing He (Tsinghua University), Chiara Saffirio (University of Basel, University of Zurich at the time) and Sergio Simonella (ENS Lyon). One of the intended group members, Serena Cenatiempo (GSSI), was not able to attend. She however had a key role in the workshop organised by the group, both from the practical (such as dealing with emails to speakers and participants) and scientific viewpoint (such as by contributing in the choice of speakers).

All the members of the group share the opinion that their stay at HIM was very fruitful and pleasant. They enjoyed the scientific interactions among them, with members of other groups and with visitors who were attending the several workshops that have been organised. Some of the ideas arisen and discussed, and the collaborations started during the stay at HIM will lead the research of the group for the next years. The members of the group are therefore thankful to the HIM for giving them such an opportunity.

1 Overview on topics and goals

A major question in kinetic theory concerns the rigorous derivation of effective macroscopic equations from the microscopic laws of classical and quantum mechanics. The prototype of kinetic equations has been introduced by Maxwell and Boltzmann at the end of the XIX century while attempting at a realistic description of the time evolution of a rarefied gas at a kinetic level, namely on quantities which averages are susceptible of measurement. In recent years, the problem of rigorously deriving effective evolution equations from many-particle classical or quantum systems has seen an increasing interest from the mathematic community and several progresses have been done. However, some central questions are still open. The group *Scaling limits for particle systems* focused on some of those during the stay at HIM.

More precisely: the effect of long range interactions in the Boltzmann description and the related Landau equation (Cf. 1, 2 and 4, and **a**, **b**, **d**, **f** in Section 3); the role and characterisation of pathological configurations in the derivation of the Boltzmann equation (Cf. 2, 3 and **e** in Section 3); the hydrodynamics of the Boltzmann equation (Cf. **c** in Section 3).

2 Activities

Organisation of the workshop "Effective equations: frontiers in classical and quantum systems" (June 24-28, 2019).
The workshop was a great opportunity to enhance interactions with the most prominent experts in the field of derivation of effective equations. The members of the group very much profited from the talks and the discussions during the breaks. Some collaborations started thanks to these discussions (Cf. items **d** and **e** in Section 3). Moreover, the workshop was largely attended and the feedbacks of the participants were extremely positive.

Invitation of Prof. Bobylev and Prof. Pulvirenti.
The group benefited from interesting and fruitful discussions with Prof. Bobylev (Keldysh Institute of Applied Mathematics in Moscow) and Prof. Pulvirenti (University of Rome La Sapienza). The two invited professors also contributed two informal lectures, two official talks and one mini-course during their stay at HIM.

Informal seminars and discussions.
The group planned several discussion sessions and informal seminars among the members of the group and in collaboration with other groups (in particular with A. Nota and R. Winter at the University of Bonn). Among them, the seminar by one of the member of the group (S. Simonella) on the derivation of the Boltzmann equation with short range interaction potentials and several blackboard discussions leaded by L. He on the quantum Boltzmann equation and its relation to the Landau equation.

Active participation to workshops.
The group actively participated in the summer school *Trails in Kinetic Theory: fundamental aspects and numerical methods* (May 20-24,2019) and the workshops *Qualitative behaviour of Kinetic Equations: numerical and theoretical aspects* (June 3-7, 2019), *Analytical and computational problems for mixtures and plasma dynamics* (June 17-21, 2019) organised by other participants in the Junior Trimester Program.

3 Scientific outputs

The outcomes of the stay at HIM are summarised in this section.

SCIENTIFIC PUBLICATIONS AND PREPRINTS

1. L. He, Y. Zhou. *Boltzmann equation with cutoff Rutherford scattering cross section near Maxwellian.* arXiv:2009.07598

2. M. Pulvirenti, S. Simonella. *A brief introduction to the scaling limits and effective equations in kinetic theory.* In: Trails in Kinetic Theory, SEMA SIMAI Springer Series 25, ed. Albi Merino-Aceituno Nota Zanella (2021)

3. M. Pulvirenti and S. Simonella. On the cardinality of collisional clusters for hard spheres at low density. Disc.&Cont.Dyn.Syst. (in press)

4. A. Nota, C. Saffirio, S. Simonella. *Two-dimensional Lorentz process for magnetotransport: Boltzmann-Grad limit.* arXiv:1910.12983

NEW PROJECTS AND COLLABORATIONS

a. Extension of the Landau's derivation to the potentials with inverse power law: work in progress (L. He, J.C. Jiang and Y. Zhou).

b. Grazing collision limit towards the Landau equation (L. He, M. Pulvirenti, S. Simonella, R. Winter).

c. A priori estimate on the Boltzmann equations, which should provide interesting informations at the hydrodynamic scale (R. Bianchini, C. Saffirio).

d. A Kac model for the Landau equation (C. Saffirio, R. Strain, R. Winter).

e. Triple collisions in the Boltzmann picture (I. Gamba, N. Pavlovic, C. Saffirio).

f. The Boltzmann-Vlasov equation: work in progress (L. Desvillettes, C. Saffirio, S. Simonella).

The members of the group very much profited from constant discussions with Prof. Spohn (TU Munich) and Prof. Velázquez (University of Bonn).