Frontiers in kinetic theory: connecting microscopic to macroscopic scales - KineCon 2022 Short Report (450 words)

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The thematic semester "Frontiers in kinetic theory: connecting microscopic to macroscopic scales" was organised at the Isaac Newton Institute from the 4th January 2022 to the 24th of June 2022.

Kinetic theory originated from the scientific endeavour launched by Maxwell and Boltzmann at the end of the nineteenth century to explain the macroscopic movement of gases based on the dynamics of many-particle systems. The mathematics of kinetic equations continue flourishing by bridging microscopic and macroscopic descriptions of complex systems using fine analytical tools to uncover these connections and their role. Kinetic approaches have also become ubiquitous in many science and engineering disciplines, due to the indispensable role of kinetic theory in the multi-scale modeling hierarchy. Furthermore, kinetic theory has also been a cross-road of interactions with several areas of mathematical physics such as general relativity, plasma physics, and quantum many-body problems. This program has been a success expanding the knowledge in theoretical analysis, modelling, and numerical analysis of kinetic theory while fostering the interactions between different and new communities.

After two years of pandemic and several periods of lockdown to save lives, this thematic program was for many colleagues in our research community a welcome opportunity to reconnect with in-person lively research discussions and collaborations. In spite of the impact of the omicron variant in the first month of the semester, it was a resounding success.

During the first month, we unfortunately had to move the first one-week workshop and the tutorials online and some participants had to delay their visit until travels became possible again. However, from February on, the semester slowly but surely grew momentum. Let us first give a few quantitative facts.

We had a core of about 10 "very long-term" participants who participated the whole semester, plus another 20 participants that came for at least a month and sometimes two. This provided the basis and manpower for organising two series of weekly seminars (a "junior" and a "senior" one) that each sometimes had double speakers. In total, around 50 talks were organised outside the workshops, often followed by lively discussions over coffee, tea and homemade cakes.

The four workshops all had an impressive attendance, between 50 and 100 each time. The special lectures also proved very attractive. Our Kirk Distinguished Visiting Fellow, Irene Gamba, gave a long series of lectures in response to the interest of the participants. The general audience Rothschild lecture by Pierre-Emmanuel Jabin gathered more than a hundred colleagues with many from outside the institute.

Indeed many interactions occurred with the Centre for Mathematical Sciences nearby, such as joint seminars and colleagues in the department joining punctually some activities at the institute. But interestingly there were also significant interactions with the other semester running at the Isaac Newton Institute at the same time, "Mathematical aspects of turbulence: where do we stand?", with some collaborations in particular.

Overall, as a veteran of our research community and long-time participant of the semester, Claude Bardos,

put it: "the Newton institute is a never-stopping mathematics factory". Beyond the facts and numbers indeed, the semester became a hub for discussions, collaborations, cross-pollination between research areas, and in particular for junior colleagues to train and build new projects and sometimes get advice on their grant applications. Our initial goals were more than fulfilled, and some highlights have been new interactions generated between general relativity and kinetic theory, between stochastic flows and transport turbulence theory, between the quasilinear theory in plasma physics and the analysis of partial differential equations, and between numerical methods for kinetic equations and global optimization to name a few.