



International prize

“Tullio Levi-Civita” for the Mathematical and Mechanical Sciences

We are pleased to announce that the *2024 Levi-Civita Prize for the Mathematical and Mechanical Sciences* will be presented to

Zaher Hani

for his remarkable contributions to the extension of foundational results in kinetic theory.

L. Boltzmann, following previous ideas due to Maxwell, proposed in 1872 an equation (the Boltzmann equation) to describe the time evolution of a rarefied gas. His justification from the Newtonian mechanics was subtle and long debated. A remarkable novelty is the emergence of macroscopic irreversibility and approach to equilibrium from the time-reversible particle dynamics.

Much later (1949), H. Grad predicted the validity of the BE in the limit $N \rightarrow \infty$, $\varepsilon \rightarrow 0$, $\varepsilon^{2N} = 1$, for a gas of N hard spheres of diameter ε . This is called low-density or Boltzmann-Grad limit. The unknown is $f(x,v)$, the one-particle probability density. All particles are identical, so that they have the same distribution. Strictly speaking, $f(x,v)dx dv$ is a probability, distinct from the empirical fraction of particles in a phase-space cell, but the two coincide asymptotically via a law of large numbers as $N \rightarrow \infty$.

O. Lanford proved in 1975 the validity of the BG limit, thus giving a rigorous derivation of the Boltzmann equation, but only for a suitable short time.

Recently, Hani (in collaboration with Deng and Ma) proved a significant extension, namely the validity of the BE for arbitrary times, provided that a sufficiently smooth solution exists up to that time. This reduces the validity to the existence problem. The result is deep and the proof introduces new remarkable ideas.

Before of these results D. Hanani worked in wave kinetic theory, namely in the use of Boltzmann like equation for problems of turbulence, as suggested by Peierls, Hasselman, Zakharov and other physicists.

In the present context the main problem was to derive suitable kinetic equations from nonlinear wave-type equations, under suitable scaling limits, actually different from the BG limit. Also in the present situation Z. Hanani (often in collaboration with Y. Deng) was able to extend his previous results holding for short times only, to arbitrary times. This research was also important in inspiring right strategies for the particle problem.

Z. Hanani is the Lois and Frederick Gehring Professor of Mathematics at the University of Michigan. He received his PhD in 2011 from UCLA working under Terence Tao, and did his postdoctoral studies at the Courant Institute, NYU. After that, he held a position at Georgia Tech before moving to Michigan in 2018. He is a recipient of a Sloan Fellowship, the Leonard Eisenbud Prize for Mathematics and Physics, and the Clay Research Award.