

# Dynamics of correlations of many colliding particles

Thursday, 26 September 2024 12:30 (20 minutes)

The talk provides an overview of some advances in the mathematical understanding of the nature of the dynamics of the correlations of many colliding particles. The fundamental equations of modern mathematical physics are studied, in particular the hierarchies of the evolution equations of many hard spheres and their asymptotic behavior described by kinetic nonlinear equations.

First, an approach to describing correlations in a system of colliding particles interacting as hard spheres is discussed, based on a hierarchy of equations for the evolution of a sequence of correlation functions that are cumulants of distribution functions, called the Liouville hierarchy. It is proven that the constructed dynamics of correlations underlie the description of the dynamics of both a finite and an infinite number of hard spheres obeying the BBGKY hierarchies for reduced (marginal) distribution functions or reduced correlation functions.

The structure of expansions representing non-perturbative solutions of the Cauchy problem for these hierarchies of evolution equations is formulated. It has been established that the concept of cumulants of the groups of operators of the Liouville equations underlies non-perturbative expansions of solutions to the hierarchies of fundamental equations describing the evolution of observables and of the state of many hard spheres, as well as forms the basis of the kinetic description of their collective behavior.

In the talk, we also consider a new approach to the problem of a rigorous description of kinetic evolution by means of reduced (marginal) observables governed by the dual BBGKY hierarchy. One of the advantages of the developed approach to the derivation of kinetic equations from the underlying dynamics of many particles is that it provides an opportunity to construct kinetic equations with initial correlations, in particular correlations characterizing the condensed states of a system, and to describe the processes of the propagation of initial correlations within suitable scaling limits.

## References

- [1] Gerasimenko V I and Gapyak I V 2023 Advances in theory of evolution equations of many colliding particles. *Proc. Inst. Math. NASU* **20** 729–804 doi:10.3842/trim.v20n1.528
- [2] Gerasimenko V I and Gapyak I V 2022 Propagation of correlations in a hard sphere system. *J Stat. Phys.* **189** 2 doi:10.1007/s10955-022-02958-8
- [3] Gerasimenko V I and Gapyak I V 2021 Boltzmann–Grad asymptotic behavior of collisional dynamics. *Reviews in Math. Phys.* **33** 2130001 32 doi:10.1142/S0129055X21300016
- [4] Gerasimenko V I and Gapyak I V 2019 Processes of creation and propagation of correlations in large quantum particle system. In: *Panorama of Contemporary Quantum Mechanics – Concepts and Applications*. London: InTech, 2019 doi:10.5772/intechopen.82836

**Primary author:** Prof. GERASIMENKO, Viktor (Institute of Mathematics NAS of Ukraine)

**Presenter:** Prof. GERASIMENKO, Viktor (Institute of Mathematics NAS of Ukraine)

**Session Classification:** Morning Session 3

**Track Classification:** STATISTICAL PHYSICS AND KINETIC THEORY