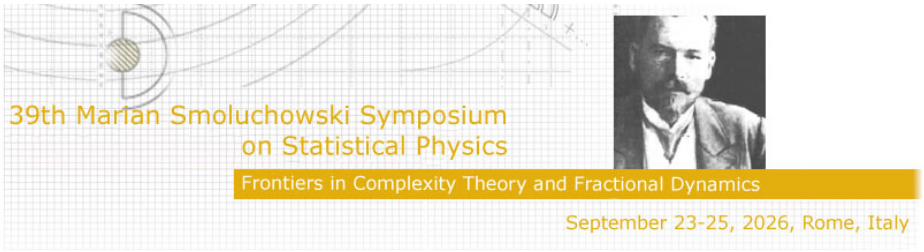

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Probabilities of rare events in product kernel aggregation: An exact formula and phase diagram

Thursday, 24 September 2026 15:30 (1h 30m)

We present an exact method for calculating the large deviation function (LDF) describing rare fluctuations in the number of particles for product-kernel aggregation. Starting from the master equation, we derive an exact integral representation for the probability $P(M, N, t)$ of observing N particles at time t starting from M monomers for any finite M, N, t. From this, we obtain an exact expression for the exponential moment $\langle p^N \rangle$ for integer p. Employing a replica conjecture—numerically validated by finite-M scaling—we extend this result to real $p \geq 0$. The convex envelope of the large deviation function, obtained via a Legendre-Fenchel transform of the exponential moment, shows singular behavior. The singular structure allows us to construct the full phase diagram of product-kernel aggregation, which contains a tricritical point, separating continuous and discontinuous transitions. We also compute the asymptotic form of the LDF for small N/M. We obtain the full asymptotic structure of the distribution $P(M, N, t)$, including its non-convex regime. By casting the problem in a path integral framework, we solve the associated Euler–Lagrange equations and determine the instanton trajectories leading to rare events. Along these optimal paths, we compute exactly both the particle mass distribution and the gel fraction. Our results provide the exact LDF and the corresponding phase diagram derived from its singular structure, revealing features that go beyond previous analyses based on exponential moments.

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