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Two-Point Correlation in Dyson Gases Out-of-Equilibrium

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We study the dynamics of a Log-Coulomb gas consisting of N charged particles confined to a unitary circle and coupled to a thermal bath characterized by a dimensionless effective parameter $\beta = q_0^2/(k_B T)$ with q_0 the charge per particle, T the bath temperature, and k_B the Boltzmann's constant. The use of a circular domain eliminates boundary effects and ensures exact rotational invariance, leading to a uniform equilibrium density without external confinement. This geometry isolates universal collective properties and greatly simplifies both static and dynamical analyses of logarithmic Coulomb gases particularly, for $\beta = 2$, the system can be treated as a free-fermion model, for which we can obtain an analytical expression for the two-point correlation function in the simplest case $N = 2$, and then extend our analysis to $N > 2$ both numerically and analytically. By varying β , we show that a logarithmic time-law scaling governs the time evolution of this process, and we verify the validity of the probability distribution of spacings between consecutive particles (levels), called Wigner's surmise, for $\beta \geq 1$ by comparison with the corresponding Gaussian ensembles for times larger than the relaxation time, $\tau \geq \tau_{\text{Eq}}$, i.e., once the system has reached thermal equilibrium.

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