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Title: Classical and Quantum Phase-Space Measures for Information Flow and Non-Markovianity

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Place: Seminar room 915

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In this doctoral thesis we will investigate how one can quantify the information flow in quantum and classical phase space models based on the Breuer-Laine-Piilo measure of quantum non-Markovianity, quantifying memory effects of some open quantum dynamics by the information flow between the open system and its environment. While this measure is defined using the trace distance between density operators on the Hilbert space, in case of continuous variable quantum systems it would be desirable to quantify the information flow by means of the differently ordered quasi-probability distributions over their quantum phase space. We will show how one can approximate the trace distance by the Kolmogorov distance between Glauber P-functions and Husimi Q-functions and we will prove the existence of some optimal ordering such that the Kolmogorov distance between the respectively ordered quasi-distributions equals the trace distance. The Kolmogorov distance represents in this context a classical analogue to the trace distance and can be used in the spirit of the Breuer-Laine-Piilo measure to quantify information flow in classical phase space models. We hence define the limit of classical uncertainty which presents a quantum-to-classical transition in which the approximation of the trace distance by the Kolmogorov distances of the quasi-probability distributions becomes exact. Employing the example of the Caldeira-Leggett model of quantum Brownian motion we present some numerical data which shows that the Kolmogorov distance between the Wigner functions converges especially fast against the trace distance, strongly suggesting that the Wigner function in fact is the optimal ordered quasi-distribution in the limit of classical uncertainty. Additionally, our method can be used to compare the information flow through quantum systems and their classical counterparts. We do so exemplarily for classical and quantum anharmonic chains as used in the Fermi-Pasta-Ulam-Tsingou (FPUT) model. We can show, that the information flow through the quantum and the classical chain is equivalent in case of harmonic coupling between the sites of the chain while significant differences emerge for anharmonic coupling. We can relate these differences to the resolution of the phase space distributions, limited by the Heisenberg uncertainty relation in the quantum case and arbitrary small for the classical chain, and the role of entanglement as genuine quantum correlation type.