QuantumCumulants.jl: A Julia framework for generalized mean-field equations in open quantum systems

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A full quantum mechanical treatment of open quantum systems via a Master equation is often limited by the size of the underlying Hilbert space. As an alternative, the dynamics can also be formulated in terms of systems of coupled differential equations for operators in the Heisenberg picture. This typically leads to an infinite hierarchy of equations for products of operators. A well-established approach to truncate this infinite set at the level of expectation values is to neglect quantum correlations of high order. This is systematically realized with a so called cumulant expansion, which decomposes expectation values of operator products into products of a given lower order, leading to a closed set of equations, see e.g. [1–3]. Here we present an open-source framework [4] that fully automazes this approach: first, the equations of motion of operators up to a desired order are derived symbolically using predefined canonical commutation relations. Next, the resulting equations for the expectation values are expanded employing the cumulant expansion approach, where moments below a chosen order specified by the user are included. Finally, fast numerical code is automatically generated from the symbolic equations which then can be directly solved.

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