Reduced Density Matrix Theory for Coupled Fermion-Boson Systems

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Reduced density matrix (RDM) theory proved in the last decades to be successful in describing a wide range of many-body problems that are not easily accessible by the more common many-body perturbation theories or density functional theory. Especially as RDM theories are typically non-perturbative, there are advantages in strong coupling scenarios.

However, RDM theory was to our knowledge never applied to systems with more than one active particle type. The focus of the present work is to analyze the possibilities and problems of an extension to coupled Fermion-Boson theories. Comparing a typical bilinear interaction term of the form $c_i^+ c_j (a_k^+ + a_k)$, where c^+/c and a^+/a indicate Fermion and Boson creation/annihilation operators, respectively and the Fermionic 2-body interaction term $c_i^+ c_j^+ c_k c_l$, the former should have a considerably reduced definition space, which we hope to be exploitable somehow. On the other hand, the bilinear interaction has a very different structure and it is not clear at all, how to define a RDM that carries all information to compute the expectation value $\langle c_i^+ c_j (a_k^+ + a_k) \rangle$.

In the present talk, I will illustrate some of the peculiarities of the Fermion-Boson interaction for simple model systems and present some ideas to deal with those.