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A limitation placed on the split operator method by the algebraic form of the Hamiltonian

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The Split Operator (SO) method is an efficient and a popular numerical scheme used to solve the time dependent Schrödinger equation (TDSE). In this paper we discuss an intrinsic limitation imposed on the SO method which is inferred from the algebraic form of the Hamiltonian. This finding renders, the recent modification to the SO method, the third order splitting (SO3), baseless, though, at first glance, they seem to improve the numerical accuracy of solutions to the TDSE. In order to keep the mathematical analysis simple in this paper we have rigorously analyzed the most general form of a Hamiltonian of a one dimensional system. However, extension our analysis to higher dimensional quantum mechanical systems is straightforward and the limitation mentioned here exists in such systems too.