Embedded Zassenhaus Expansion to Operator Splitting Schemes: Theory and Application in Fluid Dynamics

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In this paper, we contribute operator-splitting methods improved by the Zassenhaus product for the numerical solution of linear partial differential equations. We address iterative splitting methods, that can be improved by means of the Zassenhaus product formula, which is a sequential splitting scheme. The coupling of iterative and sequential splitting techniques are discussed and can be combined with respect to their compuational time. While the iterative splitting schemes are cheap to compute, the Zassenhaus product formula is more expensive, based on the commutators but achieves higher order accuracy. Iterative splitting schemes and also Zassenhaus products are applied in physics and physical chemistry are important and are predestinated to their combinations of each benefits. Here we consider phase models in CFD (computational fluid dynamics). We present an underlying analysis for obtaining higher order operator-splitting methods based on the Zassenhaus product.
Computational benefits are given with sparse matrices, which arose of spatial discretization of the underlying partial differential equations. While Zassenhaus formula allows higher accuracy, due to the fact that we obtain higher order commutators, we combine such an improved initialization process to cheap computable to linear convergent iterative splitting schemes.
Theoretical discussion about convergence and application examples are discussed with CFD problems.

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