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On the preservation of invariants by explicit Runge-Kutta methods. (English summary)
SIAM J. Sci. Comput. **28** (2006), no. 3, 868–885.

Classifications

65L06 - Multistep, Runge-Kutta and extrapolation methods for ordinary differential equations
65L05 - Numerical methods for initial value problems involving ordinary differential equations

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Review

While all Runge-Kutta methods preserve linear invariants of ODE systems $y' = f(y)$, it is known that for $n \geq 3$ no such method can preserve all polynomial invariants of degree n [cf. E. Hairer, C. Lubich\ and G. Wanner, *Geometric numerical integration*, Springer, Berlin, 2002; MR1904823]. In this paper the authors derive a class of projected explicit Runge-Kutta methods, by modifying certain standard projection techniques, that preserve general invariants; the aim is to use these methods in numerical integrators based on adaptive RK methods. The theory is illustrated by numerical experiments (ODEs from micro-magnetism (Landau-Lifshitz-Gilbert equation), the three-body problem, Euler equations) in which the adaptive RK code is the (5,4)-pair of J. R. Dormand and P. J. Prince [J. Comput. Appl. Math. **6** (1980), no. 1, 19–26; MR0568599]. The results are compared with those obtained by the standard orthogonal projection technique.

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5. E. Hairer, C. Lubich, and G. Wanner, *Geometric Numerical Integration: Structure Pre- serving Algorithms for Ordinary Differential Equations*, Springer-Verlag, Berlin, 2002. MR1904823