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A-stable and high order nonlinear time integration methods based on deferred correction schemes

The starting point of our methods is the A-stable BDF (Backward Differentiation Formulae) schemes of order 1 and 2. Our methods consist in gradually increasing the order of these schemes from deferred corrections, while keeping the unconditional stability. The dominant terms of the local truncation error are substituted from the initial expression of the BDF1 and BDF2 methods. The substituted term is then the correction, interpolated by a Newton polynomial from the solution of the lower order method, supposed to be the most accurate. For example, the DC2/BDF1 method substitutes the term $-\ddot{u}(t^n)\frac{k_n}{2!}$ (first dominant term of the truncation error of the BDF1 scheme) in the expression of the BDF1 scheme. Concerning $\ddot{u}(t^n)$, it is interpolated from the numerical solution u_1^n, resulting from the BDF1 solution at time t^n, in order to make it discrete. By construction of the correction, the DC2/BDF1 method is then of order 2.

By applying the same strategy, we gradually increase the order of the methods and can expect to reach very high orders (DC6/BDF, DC7/BDF, etc.).

But, because of the interdependence of the methods, the restriction of the order allows limiting the complexity of implementation as well as the computational cost. Thus, in order to limit this one, we aim to build an algorithm with adaptive time steps in order to minimize the number of time steps. Before that, it is necessary to verify the numerical behaviour of the methods in different time step configurations.