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Consistency & Numerical Smoothing -> Long-time Error Estimation.

We all know Lax-Richtmyer Theorem: Assuming consistency, convergence is equivalent to numerical stability. However, it is in practice very difficult to verify the numerical stability of a scheme while solving an evolution equation, especially if the equation is nonlinear and/or the scheme is complex. Consequently, a large gap exists between error analysis theory and numerical computation practice. We prove that one can use numerical smoothing to replace numerical stability in error estimation. As a property of the computed numerical solution, the numerical smoothing property can be monitored by a "smoothing indicator". This approach has several advantages, including (1) it works for nonlinear equations and systems; (2) it works for any time stepping scheme, as long as the smoothing indicator remains bounded; (3) it allows error propagation to be analyzed with differential equations independently of numerical schemes, which makes long time error estimation possible. Hence, we can narrow the gap between theory and practice significantly. In this talk, we focus on the concept of numerical smoothing. (Received January 07, 2008)