High-Precision Computation and Reproducibility

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The advent of large-scale, highly parallel computing has greatly exacerbated difficulties with numerical reliability and reproducibility. Indeed, as large computations are scaled up in size by factors of thousands or millions, numerical sensitivities are similarly scaled up, and may produce results that have no numerical significance whatsoever. At best, users are often plagued with numerical non-reproducibility, even when codes are run on different numbers of processors of the same system.

One straightforward solution to these difficulties is to employ double-double or higher precision arithmetic, at least in key operations such as global summations. This solution is often much easier to implement than converting the underlying algorithms. And there are an increasing number of applications that fundamentally require higher-precision, include planetary orbit calculations, supernova simulations, certain types of climate models, Coulomb n-body simulations, Shrodinger solutions for light atoms, computations of scattering amplitudes of nuclear particles, discrete dynamical systems, nonlinear oscillators, strange attractors, Taylor's algorithm for ODEs, Ising integrals from mathematical physics, and numerous examples in computational mathematics. This talk will give an overview of these numerical difficulties, solutions and applications.