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Numerical instability and dynamical systems

In philosophical studies regarding mathematical models of dynamical systems, instability due to sensitive dependence on initial conditions, on the one side, and instability due to sensitive dependence on model structure, on the other, have by now been extensively discussed. Yet there is a third kind of instability, which by contrast has thus far been rather overlooked, that is also a challenge for model predictions about dynamical systems. This is the numerical instability due to the employment of numerical methods involving a discretization process, where discretization is required to solve the differential equations of dynamical systems on a computer. We argue that the criteria for numerical stability, as usually provided by numerical analysis textbooks, are insufficient, and, after mentioning the promising development of backward analysis, we discuss to what extent, in practice, numerical instability can be controlled or avoided.