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"Using Bayesian Computing to Solve a Complex Problem in Astrophysics"

Computer models are becoming increasingly prevalent in a variety of scientific settings; these models pose challenges because the resulting likelihood function cannot be directly evaluated. For example, astrophysicists develop computer models that predict the photometric magnitudes of a star as a function of input parameters such as age and chemical composition. A goal is to use such models to derive the physical properties of globular clusters—gravitationally bound collections of up to millions of stars. Recent observations from the Hubble Space Telescope provide evidence that globular clusters host multiple stellar populations, with stars belonging to the same population sharing certain physical properties. We embed physics-based computer models into a statistical likelihood function that assumes a hierarchical structuring of the parameters in which physical properties are common to (i) the cluster as a whole, or to (ii) individual populations within a cluster, or are unique to (iii) individual stars. A Bayesian approach is adopted for model fitting, and we devise an adaptive MCMC scheme that greatly improves convergence relative to its precursor, non-adaptive MCMC algorithm. Our method constitutes a major advance over standard practice, which involves fitting single computer models by comparing their predictions with one or more two-dimensional projections of the data.