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A problem in particle physics

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There is a class of statistical problems that arises in several contexts, the Lattice QCD problem of particle physics being one that has attracted the most attention. In essence, the problem boils down to the estimation of an infinite number of parameters from a finite number of equations, each equation being an infinite sum of exponential functions. By introducing a latent parameter into the QCD system, we are able to identify a pattern which tantamounts to reducing the system to a telescopic series. A statistical model is then endowed on the series, and inference about the unknown parameters done via a Bayesian approach. A computationally intensive Markov Chain Monte Carlo (MCMC) algorithm is invoked to implement the approach. The algorithm shares some parallels with that used in the particle Kalman filter. The approach is validated against simulated as well as data generated by a physics code pertaining to the quark masses of protons. The value of our approach is that we are now able to answer questions that could not be readily answered using some standard approaches in particle physics. The structure of the Lattice QCD equations is not unique to physics. Such architectures also appear in mathematical biology, nuclear magnetic imaging, network analysis, ultracentrifuge, and a host of other relaxation and time decay phenomena. Thus, the methodology of this paper should have an appeal that transcends the Lattice QCD scenario which motivated us. The purpose of this paper is twofold. One is to draw attention to a class of problems in statistical estimation that has a broad appeal in science and engineering. The second is to outline some essentials of particle physics that give birth to the kind of problems considered here. It is because of the latter that the first few sections of this paper are devoted to an overview of particle physics, with the hope that more statisticians will be inspired to work in one of the most fundamental areas of scientific inquiry.

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