

A Bayesian approach to uncertainties

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Abstract

Bayesian methods provide a unified framework for combining information in the presence of uncertainty. All uncertainties that enter into the description of the measurement process are modeled in terms of probability distributions, and these are handled according to the rules of probability theory, ensuring that the approach is free of inconsistencies. The result of the analysis is the full probability distribution for the parameter of interest, and from this distribution an appropriate uncertainty interval can be obtained. Some of the advantages of a Bayesian analysis include a straightforward approach to the problem of dealing with nuisance parameters (i.e., quantities which necessarily enter the analysis but are of no intrinsic interest), the ability to incorporate prior information in a natural way, and the flexibility that is necessary for a realistic modeling of the measurement process. As an example of the usefulness of the Bayesian approach in dosimetry, I discuss the problem of deriving neutron dose estimates and their uncertainties based on measurements made with a Bonner sphere neutron spectrometer. In the standard approach, the data collected with the spectrometer is first unfolded and the dose quantities are then derived from the unfolded spectrum. However, the unfolding process is not simple, and uncertainties associated with the analysis are often difficult to quantify. An approach based on Bayesian parameter estimation methods can overcome many of the difficulties that are encountered in the standard approach. These types of problems can be easily solved using readily available software packages such as WinBUGS.