BAYESIAN ANALYSIS OF INCONSISTENT MEASUREMENTS OF NEUTRON CROSS SECTIONS

Kenneth M. Hanson, Toshihiko Kawano, and Patrick Talou
Los Alamos National Laboratory
(kmh@lanl.gov, kawano@lanl.gov, talou@lanl.gov)

Abstract

The process of evaluation of neutron cross sections involves combining measurements from numerous experiments to obtain a single cross-section value as a function of energy. The experiments span many decades and are of varying quality. It is not unusual for the evaluator to be confronted with reported cross sections that are in disagreement. The goal is to distill the data into a table of cross section values and provide a full description of their uncertainties. It is important to take into account the independent errors in each datum as well as the systematic effect of uncertainty in the normalization of each experiment. Regrettably, the published data are not always accompanied with detailed assessments of their uncertainties.

The present work focuses on a Bayesian approach to cope with inconsistent measurements. A necessary ingredient in our analysis is the assignment of uncertainty in the data, both in the form of independent errors and normalization error. The latter is treated as a systematic effect common to all the data from a single experiment. We develop a detailed probabilistic model of the measurements, which includes these separate sources of uncertainty. The underlying error distributions are taken to be Gaussian. However, the nominal widths assumed for the error distributions are allowed to vary by assuming that they follow a gamma distribution whose width is adjustable. The resulting likelihood functions for the measurements possesses a long tail, which is known to ameliorate the effect of outliers. The final estimates for the neutron cross sections are obtained by sampling the posterior distribution by means of Markov Chain Monte Carlo. The uncertainties are summarized in terms of covariance matrices. At the end of the analysis, feedback about the details of how the data were combined is provided to the analyst, who must determine whether the final results make sense.

We demonstrate our approach on representative data sets taken from the neutron cross section literature.

Key Words: neutron cross sections, normalization uncertainties, discrepant data, outliers, Markov Chain Monte Carlo