Bayesian analysis of spectrometric measurements in high-energy neutron fields

The uncertainty of measurements made with an extended-range Bonner sphere spectrometer in high-energy neutron fields has been analysed by means of Bayesian methods. It was shown that the spectrum below approx. 1 MeV is well determined whereas the information from the measurements is not sufficient to determine the high-energy end of the spectrum with low uncertainty.

Spectrometric measurements in high-energy neutron fields (i.e. with neutron energies of up to several hundreds of MeV, such as those found behind the shielding at high-energy particle accelerators or in cosmic-ray induced neutrons) are particularly challenging. These spectra usually consist of a thermal peak, an evaporation peak at approx. 1 MeV, and a high-energy peak at approx. 100 MeV. Extended-range Bonner sphere spectrometers (ERBSS), i.e. with modified moderating spheres with metallic inserts, are well-suited for such measurements. The spectrum, however, is not measured directly with an ERBSS but has to be inferred from the number of counts in the set of spheres. The analysis of the data requires some care, because the response functions of the modified spheres increase dramatically above approx. 100 MeV and the responses of different spheres overlap substantially. Special methods are, therefore, necessary in order to find out how well the main structures of the spectrum, represented by a parametrisation, are determined by the data, and in order to quantify the uncertainties of the spectrum and of the derived quantities (e.g. fluence or dose).

Bayesian parameter estimation was used to determine spectra and to quantify uncertainties. Both simulated data and real measurements of neutron fields behind the shielding of a high-energy particle accelerator were used. It was shown that most parameters which describe the spectrum below approx. 1 MeV can be well determined. The information concerning the high-energy peak is, however, incomplete. This observation is important for the purpose of dosimetry: Since the fluence to dose equivalent conversion coefficient varies by a factor of two in the range of the high-energy peak, the uncertainty in the parameters of the high-energy peak contributes significantly to the uncertainty of the dose determined by means of an ERBSS. Using Bayesian parameter estimation, this contribution to the uncertainty can be easily incorporated into the analysis. In addition, with a careful choice of prior probabilities, it is possible to complement the information from the measurements with other information based on the physics of the experiment, and this leads to a good determination of integral quantities.

Literature

[1] M. Reginatto, E. Hohmann, B. Wiegel: *How Accurately Can We Determine Spectra in High-energy Neutron Fields with Bonner Spheres?*, Submitted for publication in "Nuclear Technology"

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