Investigations on the energy resolution of spectrometers

By means of deconvolution procedures it is possible to resolve structures in a spectrum which are finer than the instrument resolution of the spectrometer. A new procedure now allows this property (which is called "super-resolution") to be determined quantitatively for the first time for a scintillation spectrometer which is used for plasma diagnosis. This procedure is also of significance for other applications.

NE213 liquid scintillation spectrometers are used routinely for neutron spectrometry [1]. The spectrum is not measured directly, but it is determined instead from the measured pulse height spectrum. This data analysis procedure is known as "deconvolution". By means of non-linear deconvolution it is possible to resolve structures in the neutron spectrum which are finer than the instrument resolution of the spectrometer. This is known as "super-resolution", and it is quantified by the so-called "super-resolution factor".

In many cases, it is important to know the super-resolution factor. For example, in applications of neutron spectrometry to plasma diagnostics in nuclear fusion [2], the temperature of burning plasma is an important physical parameter which can be determined from the width of the energy spectrum of the neutron emission. The ability to determine this width depends on the super-resolution factor of the spectrometer.

Kosarev [3] derived an absolute limit for the improvement of the resolution using arguments which are based on a well-known theorem of Shannon’s. With the approach of Kosarev it is in principle possible to calculate the super-resolution factor of a detector. His calculations are, however, based on a technical assumption which is not valid for NE213 neutron spectrometers as their response functions do not satisfy his requirements. This is why Kosarev’s approach must be modified and extended. We have developed a procedure for this which overcomes this limitation. With this new method, we have derived the super-resolution factor for an NE213 neutron spectrometer and shown that the factor determined in this way agrees with measurements performed at the PTB accelerator which have been presented in a previous publication [2]. This new procedure is also of significance for other applications.

The results of our analysis were published in the "Proceedings of the 30th International Workshop on Bayesian Inference and Maximum Entropy Methods in Science and Engineering (MaxEnt 2010)", France, 4 to 9 July 2010.

Literature:

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[3] E. L. Kosarev: ***Shannon's superresolution limit for signal recovery***, Inverse Problems 6, 55 (1990).

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