§32. Development of Multifunctional Neutron Detector for LHD

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In this study, we are developing a multifunctional neutron detector for DD plasma experiments at LHD, which can measure the absolute flux, rough but wide energy spectrum and direction of incident neutrons.

A schematic view of the present neutron detector is shown in Fig.1, where three position sensitive thermal neutron detectors (^{3}He gas proportional counters) perpendicularly intersecting each other are set up on the x-y-z axes of a spherical polyethylene moderator. Thermal neutron distributions inside the spherical moderator are largely dependent on the energy and direction of incident neutrons onto the sphere because higher energy neutrons need thicker moderator for their slowing down and thermalization. The neutron spectrum and also the direction of neutron incidence, therefore, could be estimated from thermal neutron profiles measured on the x-y-z axes of the sphere.

For fast data processing to convert the thermal neutron profiles into neutron spectra and/or neutron incident direction, we have applied a pattern recognition technique based on a feed forward type neural network (NN), which consists of a set of input neuron units linked to a series of output neuron units through one or more hidden (or intermediate) layers. We adopted a three layer NN for neutron spectrum estimation, where 60 data of thermal neutron profiles were input to the first layer neurons and then a linearly weighted summation of the inputs was in turn transformed into the output neurons of the second and the third layers through sigmoid and/or linear functions with some threshold. The number of neuron units of the second layer was 30, and the outputs of the third layer gave the solution of 24 groups of neutron spectra. It was, however, necessary to obtain the final solution separately from 6 independent NNs with 5 output neurons sharing one neuron each other to overcome the poor learning efficiency of the NNs with a large number of outputs. These NNs were tuned through the back propagation learning process using 10 kinds of the teaching data sets, which were calculated detector responses (or thermal neutron profiles) to monochromatic neutrons.

Fig. 2 shows an example of neutron spectra unfolded with the NN to incident neutrons with an energy of 445 keV, 1.2 MeV and 15MeV, respectively, which demonstrates comparatively good reproducibility. We have also confirmed that, by using the NN, the direction of neutron incidence can be estimated within an accuracy of ±30 degrees over the wide energy range.

It is, therefore, concluded that the present neutron detector combined with the NN data processing would be useful for multifunctional neutron monitoring in the monochromatic and directional neutron fields around fusion devices.

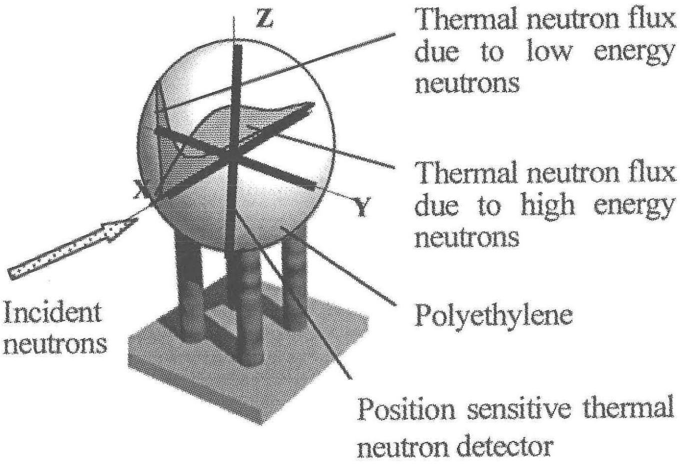

Fig.1 Schematic view of a multifunctional neutron detector consisting of three position sensitive thermal neutron detectors (^{3}He gas proportional counters) perpendicularly intersecting each other set up on the x-y-z axes of a spherical polyethylene moderator.

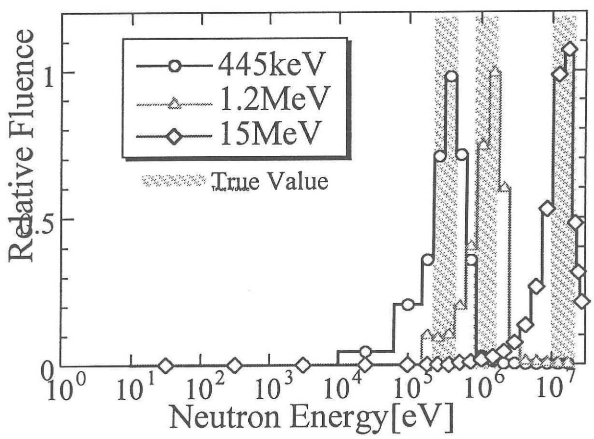

Fig.2. Unfolded neutron spectra with the NN to monochromatic neutrons with an energy of 445 keV, 1.2 MeV and 15MeV.

Reference

1) Makihara, Y., et al., KEK Proc. 2000-14 RADIATION DETECTORS AND THEIR USES (2000) 155.