Neutron spectral fluence measurements of BNCT beams using Bonner sphere spectrometer

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Neutron energy distribution of accelerator-based neutron source for BNCT varies from facility to facility and should be evaluated by calculations and experiments to realize the effective treatments. Neutron spectral fluence of an accelerator-based BNCT facility of the Ibaraki Neutron Medical Research Center (iNMRC) headed by University of Tsukuba [1] was measured by a conventional He-3-proportional-counter-based Bonner sphere spectrometer (BSS) with weak beams available only in the developing facility [2]. Derived neutron spectra of the two locations on the neutron beam axis, 1 m and 2 m from the beam port, were derived by the unfolding method and applicability of the Bonner unfolding method for the BNCT neutron beam was demonstrated. The two measurement locations were selected to reduce interactions between the Bonner sphere detectors and a collimator wall around the beam port or a behind shielding wall. Neutron spectral fluence at the beam port, where patients will be set in the actual treatment, was estimated based on the measurement results for the two locations and Monte-Carlo calculations. However, the therapy-level intense neutron beam cannot be measured using the He-3-proportional-counter-based BSS due to the high event rate. Thereafter, new BSS using lithium-glass scintillation detectors have been developed. Gamma-ray correction method using a pair of the Li-6- and Li-7-glass scintillators and the current integration measurement of PMTs' output were employed to directly measure the therapy-level intense neutron beams of ~10^9 $cm^{-2}s^{-1}$ neutron flux. Effects of individual difference of size of scintillator, optical coupling condition between the scintillators and the PMTs, and contamination of the isotopes were carefully investigated and considered in the data analysis. Their response characteristics and linearity to neutron intensity were experimentally evaluated at National Metrology Institute of Japan of the National Institute of Advanced Industrial Science and Technology and the Institute for Integrated Radiation and Nuclear Science of Kyoto University. Measurements for the intense neutron beam of about 5×10^8 $cm^{-2}s^{-1}$ neutron flux were successfully performed at the BNCT facility of iNMRC. Further characteristic evaluation of the scintillator-based Bonner sphere detectors to improve the neutron spectrometry is ongoing. Details of the intense-neutron measurements using the new BSS and their analysis will be reported in this presentation.

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References

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