DOI: 10.34854/ICPAF.52.2025.1.1.251 NEUTRON SPECTROSCOPY USING LACL3-BASED DETECTOR ON EAST TOKAMAK

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The majority of modern and near-future magnetic confinement devices conduct experiments with deuterium plasma. Neutron spectrum and flux rate provide information on plasma parameters such as ion temperature, fusion power, influence of heating. Common neutron detectors include fission chambers, semiconductors, scintillators.

LaCl₃(Ce) is an inorganic crystal distinguished by exceptional light yield (40000 photons/MeV), short decay time (~30 ns), high γ -ray resolution (<4% at 662 keV), light output linearity and a classic shape of the response function. The material is sensitive to neutrons through the ³⁵Cl(n,p)³⁵S reaction. It also possesses an intrinsic background arising from ²²⁷Ac α -decay. It is possible to separate counts by radiation type using pulse-shape discrimination (PSD). A more in-depth study of LaCl₃(Ce) as a neutron spectrometer can be found in [1, 2].

In June 2024 a LaCl₃-based spectrometer was installed at the EAST tokamak, ASIPP Institute, Hefei, PRC [3]. The detector was placed in radiation shielding 8.5 m away from the plasma core. The shielding consisted of 10 cm of lead and 15 cm of boron-doped HDPE on the sides and 50 cm on the plasma-facing side. The detector could observe the plasma through a \emptyset 2 cm collimator in the horizontal plane of the tokamak. 300 shots were recorded, of which ~100 were recorded with working neutral beam injection. The crystal was coupled to a Hamamatsu R6231 PMT, with the signal digitized by a 500 MHz ADC developed in-house at ASIPP. Spectrometer calibration was done using standard sources ¹⁵²Eu, ¹³⁷Cs, ⁶⁰Co, ²²Na and ⁵⁴Mn.

The proton component was singled out using PSD. We compare the resulting spectrum and count rate over time with other neutron diagnostics and plasma parameters; the results from LaCl₃ and from other neutron counters are in good accordance. The detector has successfully measured neutron energies and fluxes. This work marks the first successful application of LaCl₃ to the task of plasma radiation spectroscopy in a long (>10 s) discharge.

References

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