Recovery of soft x-ray flux and spectrum in inertial confinement fusion experiments using filtered x-ray diodes

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In indirectly driven inertial confinement fusion (ICF) experiments, hohlraums with high-Z inner wall are widely used to convert high power laser energy into intensive soft x-ray radiation, and it is of great importance to measure the amplitude and time history of the soft x-ray radiation generated in those laser driven radiation sources. Multi-channel spectrometers composed of filtered x-ray diodes are routinely used in ICF experiments to measure the radiation flux and unfold the soft-x-ray spectrum. This kind of spectrometers includes Dante on Omega and NIF in U.S.[1-3], DMX on LMJ in France[4], and soft-x-ray spectrometer(SXS) on Shenguang laser facilities in China[5], etc. Recently, a novel design of flat response XRDs (FXRD)[6, 7] are intensely used in our experiments and replaced our traditional Dante-like multi-channel spectrometer(SXS) because of the compact design, the capability of multi-angle installation, and easier and cheaper maintenance. In addition to FXRDs that cover full soft x-ray photon energy range which is from about 80eV to 6keV, single channel band pass XRDs (MXRD) are also invented whose response functions cover only the higher energy part of the soft x-ray radiation (from 1.6keV to 4.4keV), which are used in the measurement of M-band radiation in gold hohlraum experiments[8].

The methods used in the recovery of the radiation flux and spectrum in experiments carried out on Shenguang series laser facilities are reviewed. Due to the imperfection in design and manufacture, the response functions of the FXRDs are not perfectly flat or with a clear band pass response, which introduce errors in the recovery of radiation flux. An iterative method is introduced to reduce this error using weight function. The unfolding method used for multi-channel SXS is an iterative method using a group of specially selected B-splines as base functions. Monte Carlo sampling method is applied to analyze the uncertainty caused by various sources such as calibration errors and cross-timing between channels, etc. The combination of a FXRD and a MXRD can also be used to unfold the radiation spectrum which can be composed with a blackbody and a Gaussian bump for the M-band radiation. The recovery results of radiation information using traditional multi-channel SXS and a dual-channel FXRD/MXRD pair are compared in an experiment using laser driven halfraum as radiation source.

Future optimizations for our multi-channel SXS and flat response XRDs are discussed.

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