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Penumbral imaging and numerical evaluation of large area source neutron imaging system

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The fusion neutron penumbral imaging system Monte Carlo model was established. The transfer functions of the two discrete units in the neutron source were obtained in two situations: Imaging in geometrical near-optical and real situation. The spatial resolutions of the imaging system in two situations were evaluated and compared. The penumbral images of four units in the source were obtained by means of 2-dimensional (2D) convolution and Monte Carlo simulation. The penumbral images were reconstructed with the same method of filter. The same results were confirmed. The encoding essence of penumbral imaging was revealed. With MCNP(Monte Carlo N-particle) simulation, the neutron penumbral images of the large area source (200 μm×200 μm) on scintillation fiber array were obtained. The improved Wiener filter method was used to reconstruct the penumbral image and the source image was obtained. The results agree with the preset neutron source image. The feasibility of the neutron imaging system was verified.

penumbral imaging, reconstruction, unit source, spatial invariance, spatial resolution, MCNP code

In inertial confinement fusion (ICF) experiment, through detecting the thermonuclear release, such as neutrons, protons and X-rays, a great deal of diagnostic information was obtained. A variety of methods were tried since 1970s and 1980s of the last century, a lot of experiences and results[1−6] accumulated in the last 40 years at the institutes in The United States, Japan, European countries[7−10]. Compared to the X-rays from the target capsule plasma, the fusion neutrons can bring out better information about spatial scale, shape, and uniformity of the implosion compression area of target pill. The detection efficiency is not high enough because the existing detector materials cross section to 14 MeV neutron between fast and ultra-fast neutrons is low. In order to obtain 14 MeV neutron image of thermonuclear fusion, reaction efficiency or neutron yield is improved in efforts, moreover, optimization design is also being made for the imaging aperture. As a result, the aperture diameter is larger than the fusion subject, and so pinhole imaging changes into penumbral imaging, which is the inheritance and development of pinhole image, and has the following advantages: Firstly, the neutron transports efficiency is much improved and appropriate for the diagnosis process at the low-yield neutrons; secondly, the detection limit of dynamic range can be reasonably as low as possible; thirdly, the penumbral image is larger than pinhole image, the resolution of source region can be upgraded moderately; lastly, the aperture is much larger than the fusion source, and so the mechanic requirements were reduced with respect to other encoding pinhole. The penumbral imaging geometric principle is shown in Figure 1. Penumbral image is a complex en-

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