HYPER-FILTER-FLUORESCER SPECTROMETER
FOR FUSION X-RAY DIAGNOSTICS

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HYPER-FILTER-FLUORESCER SPECTROMETER FOR FUSION X-RAY DIAGNOSTICS*

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I. Introduction

The filter-fluorescer spectrometer (FFS) is a powerful tool for measuring x-ray spectrum from high fluence x-ray sources. However, this technique is limited to energies less than 120 keV, because there are no practical absorption edges available above this energy. In this paper, we present a new method of utilizing the filter-fluorescer system for x-ray spectral measurement above 120 keV. The new apparatus is called hyper-filter-fluorescer spectrometer (HFFS).

II. HFFS

The basic idea behind the HFFS is illustrated in Figure 1. In HFFS, the absorption edge (E_p keV) of the prefilter is chosen to be less than that of the fluorescer (E_f keV), i.e., E_p < E_f, contrary to the conventional FFS technique E_p > E_f. In this way the response function is rendered virtually zero between E_p and E_f while a broad peak at higher energy is enhanced for x-ray measurement above 120 keV. For flat incident x-ray spectrum, the x rays under the response function are converted into K-fluorescent lines and are detected by the detector.

Figure 2 shows the response functions of four HFFS channels. The parameters for the 150 and 200 keV channels are:

<table>
<thead>
<tr>
<th>X-Ray (keV)</th>
<th>Prefilter</th>
<th>Fluorescer</th>
<th>Postfilter</th>
<th>Detector</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Material</td>
<td>Thickness (mm)</td>
<td>Material</td>
<td>Thickness (mm)</td>
</tr>
<tr>
<td>150</td>
<td>Dy</td>
<td>1.27</td>
<td>Au</td>
<td>0.0762</td>
</tr>
<tr>
<td>200</td>
<td>Hf</td>
<td>1.37</td>
<td>Pb</td>
<td>0.127</td>
</tr>
</tbody>
</table>

The advantage of the HFFS over the simple filter-detector scheme is that the former has a narrower and cleaner response function. The HFFS can be particularly useful when the x-ray flux is too high for the survival of the detector in the beam line. However if the flux is too low, the HFFS may be too insensitive. In this case the simple filter-detector scheme must be employed.

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III. Suprathermal X-Ray Spectrum From Laser Plasma Interaction

Now, we show how the combination of FFS, HFFS, and filter-detector scheme was used to measure a suprathermal x-ray spectrum from laser-tantalum target interaction. The result is shown in Figure 3. The points below 100 keV were obtained with a conventional FFS. The data at 150 and 200 keV were obtained using HFFS channels. The data at 250 and 350 keV were obtained with simple filter-detector channels. At these energies, the x-ray fluence was too low for the HFFS. Figure 3 clearly demonstrates the existence of two x-ray inferred suprathermal temperatures in the laser-plasma interaction.

IV. References


PHYSICS OF A HYPER-FILTER-FLUORESCER EXPERIMENT

Fluorescer (Au)

Prefilter (Dy)

Post filter (Au) (rejects higher shell fluorescence)

Collimator

Source

Detector

Legend

- Prefiltered spectrum
- K-fluorescent line

Prefilter transmission

Fluorescer cross section

Joint response (a) $\times$ (b) for K-fluorescent line

Linear scale

20-10-0481-0772A Figure 1
RESPONSE FUNCTIONS OF FOUR HYPER-FILTER-FLOURESCER CHANNELS

![Graph showing response functions of different hyper-filter-florescer channels.](image-url)

Figure 2

20-01-1080-3587

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Suprathermal X-ray Spectrum

Laser (1.06 μm)

<table>
<thead>
<tr>
<th>Target</th>
<th>Intensity</th>
<th>Energy</th>
<th>Pulse</th>
<th>Shot No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ta disk</td>
<td>3 × 10^{14} W/cm²</td>
<td>4.1 KJ</td>
<td>2.2 ns</td>
<td>80100209</td>
</tr>
</tbody>
</table>

Figure 3