ELLiptical spectrometer for the study of x-PinCh physics through absorption spectroscopy

Adam D. Cahill, Cad L. Hoyt, Tania A. Shelkovenko, Sergei A. Pikuz, and David A. Hammer
Cornell University
Ithaca, NY 14853 USA

We discuss here the use of the x-pinch x-ray source together with an elliptical crystal spectrometer for determining plasma conditions in high energy density plasmas. The use of absorption spectroscopic techniques for the study of plasma conditions is often restricted to diagnosing non-radiating plasma samples. This is done to avoid radiation emitted by the samples being recorded along with the probing radiation. This can easily obscure or conceal the features of the absorption spectrum and introduce substantial error in inferred conditions.

We propose that this limitation may be overcome by adopting an experimental geometry differing from the traditional arrangement of the source, sample, crystal, and film. A typical experimental setup disperses the source radiation after it has passed through the sample. This leads to the problem described above. We move the dispersive element and place it between the source and the sample so as to separate the probing radiation into its individual wavelengths before interacting with the sample. Radiation from the sample now reaches the film unaltered and exposes it with a uniform background signal. This eliminates sample spectral features in the data at the expense of decreased signal-to-noise ratio (SNR). The loss of SNR is mitigated by placing a band-pass filter in front of the film so that it is only exposed by the raw intensity of the sample in the absorption band under study. The current design uses an aluminum filter to pass magnesium absorption lines to the film.

The proposed arrangement is realized by placing both the source and sample at an ellipse’s foci while the dispersive crystal forms the surface of the ellipse. The wavelength band to be used for the study of the sample is selected by adjusting the eccentricity of the ellipse. The probing radiation in such a setup converges onto the sample in a radial fashion with each wavelength entering at a different azimuth. Thus we require that the sample, an x-pinch in this case, possesses azimuthal symmetry to facilitate analysis of the data. With the crystal as the surface of the ellipse, it is also possible to use the point radiation source to capture simultaneously an areal density measurement of the sample. This density map is used to constrain the analysis of the absorption spectrum.

We present the concept for this new spectrometer along with a finalized design for the study of magnesium doped aluminum x-pinches using continuum radiation. Preliminary data for characterization and validation of the design is also shown.

* This work was supported by the SSAA program of the NNSA under DOE Cooperative Agreement No. DE-FC03-02NA00057 and the Stewardship Science Graduate Fellowship.