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EXPERIMENTAL STUDY OF LAYER MIXING, RELATIVE IONIC
ESCAPE VELOCITY, AND ELECTRON TEMPERATURE GRADIENTS IN
SPHERICAL MULTILAYERED TARGETS BY XUV SPECTROSCOPY

Final Report

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Final Report

Experimental Study of Layer Mixing, Relative Ionic Escape Velocity, and Electron Temperature Gradients in Spherical Multilayered Targets by XUV Spectroscopy

This past year we have undertaken experiments at the University of Rochester's Laboratory for Laser Energetics investigating layer mixing and expansion velocities of spherical targets uniformly irradiated by high intensity laser light. Due to delays in scheduling we only recently obtained data and have a preliminary analysis to present at the moment. We performed high resolution spectroscopic measurements of spherical plasmas, produced using the Omega laser, and have observed enhanced broadening of XUV emission lines due to the expansion velocities. A 3-meter XUV grazing incidence spectrograph, covering the spectral range 20 Å to 300 Å, was utilized for these measurements. The targets consisted of glass spheres ($\sim 250 \mu\text{m}$ diameter) coated with a layer of aluminum and then overcoated with parylene (CH). Laser intensity on target was typically $8 \times 10^{14} \text{ W/cm}^2$. Both the thickness of the Al layer and the thickness of the parylene layer was varied from shot to shot. H-like to Li-like charge states of C, O, Al, and Si were observed. Widths of emission lines were measured and found to be larger than could be expected from instrumental broadening and thermal Doppler broadening. Theory and modeling (e.g. LILAC hydrocode) predict expansion velocities greater than 10^7 cm/s for the outer layers of the ionizing target. These velocities are much larger than thermal velocities but are consistent with our line width measurements. A further analysis of the data using more detailed modeling is presently being pursued. Possible relative shifts of spectral lines emitted from plasma regions expanding at different velocities are also being investigated.

During this same experimental run we obtained for the first time time-gated XUV spectra using a 1-meter grazing incidence spectrograph equipped with a microchannel plate detector. The microchannel plate contained three separate striplines to allow multiple time-gated spectra. A very fast high voltage gate pulse of width ~ 1 ns was used to measure spectra at different times during the plasma lifetime. From changes in line intensities and intensity ratios we expect to get information on the time evolution of the temperature and density.

We are completing construction and will begin testing soon an XUV spectrograph with a varied space grating which produces a flat focal plane nearly perpendicular to the light emission. Wavelength coverage will extend from 50 Å to over 300 Å. This spectrograph when coupled to an XUV streak camera will give good spectral resolution and excellent temporal resolution.

From previous research on line focus plasmas we have published papers on line identifications of highly ionized Al and Mg, of which the reprints are enclosed. Also enclosed is a preprint of a paper from an invited talk at the 10th ICSLS conference which will be published in the 6th volume of the series *Spectral Line Shapes*.

Appendix A: "Identification of new helium-like Al XII transitions emitted by laser-produced plasmas"

Appendix B: "Identification of hydrogenlike and heliumlike transitions in the spectrum of laser-produced magnesium plasmas"

Appendix C: "Influence of line broadening in x-ray lasers"

Reprints removed

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