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ELECTRIC FIELD MEASUREMENTS FROM SATELLITES-TO- FORBIDDEN LINE RATIOS IN AN OMEGA-UPGRADE LASER-PRODUCED PLASMA

Final Report
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Hans R. Griem, Raymond C. Elton and Benjamin L. Welch

University of Maryland
College Park, MD 20742-3511

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Under this FY-96 NLUF program, we primarily carried out an initial search for satellite lines to forbidden transitions for localized laser-induced electric field measurements, using our flat-field grazing incidence spectrograph on the OMEGA-Upgrade facility at the University of Rochester Laboratory for Laser Energetics (LLE). In a second 1996 series of experiments carried out in September we were able to complete 19 shots using all 60 beams and spherical targets consisting of neon-filled microballoons with coatings of aluminum, magnesium and sodium fluoride, sometimes overcoated with a plastic (CH) layer. With cooperation from Dr. Paul Jaanimagi of LLE, we succeeded in adding a LLE streak camera for time resolution. The electric fields that we measured corresponded to laser irradiances comparable to those applied, accounting for some losses in the plasma. The details with figures are included in an attached preprint of a paper recently accepted for publication in the Journal of Quantitative Spectroscopy and Radiative Transfer (JQSRT) as part of the Proceedings of the November 1996 Conference on Radiative Properties of Hot Dense Matter at which the results were presented. They were also presented at the 1996 American Physical Society Division of Plasma Physics Conference in Denver in November 1996.

In addition to the extreme ultraviolet (xuv) laser-induced satellite spectral results, we fortunately were able to study on the same shots the resonance line spectra in the 1 keV range in Mg and Al from layered targets, using an x-ray crystal spectrograph and attached x-ray streak camera on loan to LLE from the Lawrence Livermore National Laboratory (LLNL). These data were supplemented by two-beam data obtained using the Trident laser at Los Alamos National Laboratory in July 1996. The merging of these x-ray resonance-series lines into the continuum led to an estimate of the electron density (Inglis-Teller method) which was found to be surprisingly 30-times higher than that which we deduced from a density-sensitive innershell satellite line to the He-like n=3 to n=1 resonance line. The latter was analyzed numerically through the cooperation of Drs. A. Osterheld of LLNL and R. Mancini of U. Nevada at Reno. This also is described in detail in the JQSRT preprint attached. The large discrepancy remains a challenge for our upcoming FY-97 experiments where we hope to add an independent density measurement, most likely from Stark broadening. A measured shift of ~13 mÅ in these satellites is also targeted for futher investigation in other elements.

Just prior to submission of the JQSRT final manuscript, we are able to obtain some numerical modeling of the October 1996 spherical target experiments on Omega Upgrade, through the cooperation of Drs. J. Delettrez and R. Epstein of LLE. Sample traces are included here as Figs. A and B preceding the JQSRT preprint. This modeling included both hydrodynamics as well as atomic physics. Such modeling was quite useful in understanding the compression observed as well as the laser absorption, and is currently being used to optimize the layered target design for upcoming FY-97 experiments. We were surprised that the time to compressed stagnation as measured from the onset of x-ray lines, as well as the duration of emission for some lines, were approximately 30-50% longer than predicted. After much study, this puzzle has persisted and is currently thought to be associated with the use of targets of smaller than usual diameters (~440 μm) and hence perhaps less uniform irradiation. In any case, it deserves further attention in the forthcoming FY-97 experiments with 900-μm diameter targets at increased neon fill pressure.

Fig. A: Shot No. 96-7906:Hydro

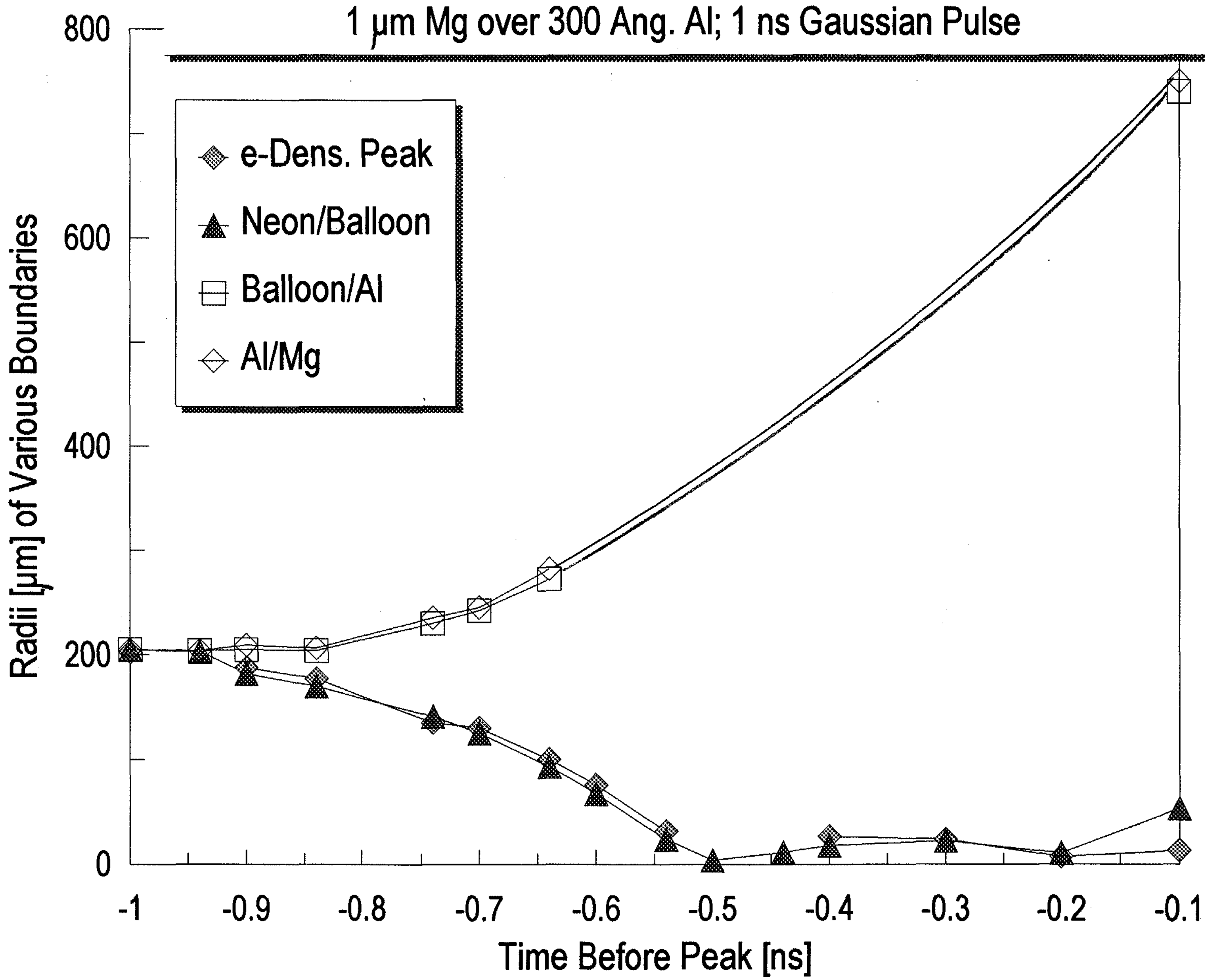
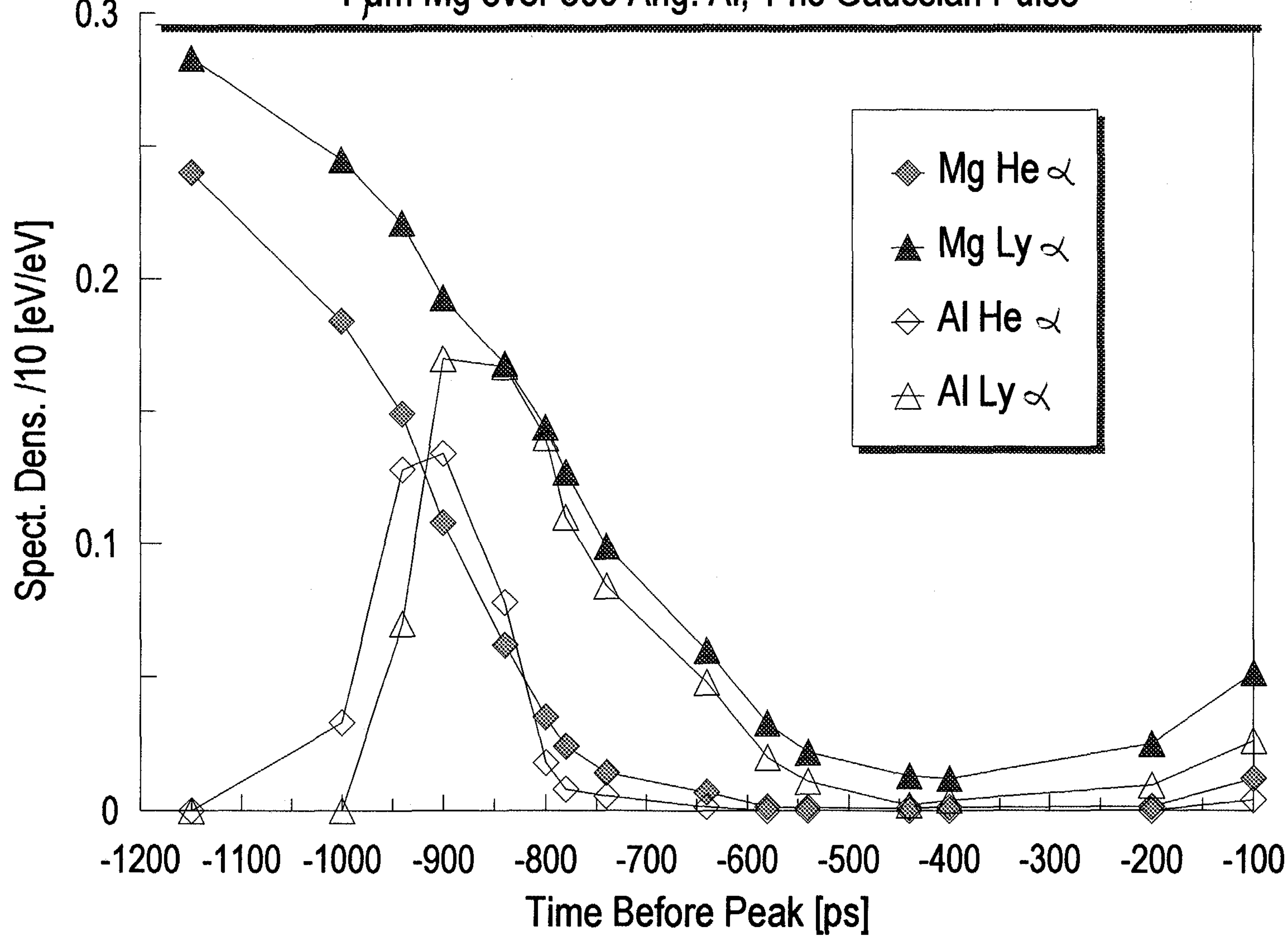


Fig. B: Shot No. 96-7906: Spectra

1 μm Mg over 300 Ang. Al; 1 ns Gaussian Pulse



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