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► **To cite this version:**

R. London, N. Ceglio, D. Eder, A. Hazi, C. Keane, et al.. THE SOFT X-RAY LASER PROGRAM AT LI VERMORE. Journal de Physique Colloques, 1988, 49 (C1), pp.C1-221-C1-221. 10.1051/jphyscol:1988144 . jpa-00227464

HAL Id: jpa-00227464

<https://hal.science/jpa-00227464>

Submitted on 4 Feb 2008

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THE SOFT X-RAY LASER PROGRAM AT LIVERMORE⁽¹⁾

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Abstract

We describe the experiments and supporting theoretical modelling to develop and characterize soft x-ray lasers. The x-ray lasers are created in dense plasmas produced by optical laser irradiation of solid targets with line focussed beams. We use mainly thin foil targets, which upon appropriate illumination, produce rather uniform plasmas. We consider laser schemes pumped by electron collisional excitation and dielectronic recombination in Ne-like and Ni-like ions, and schemes pumped by collisional and radiative recombination following rapid cooling for H-like and Li-like ions.

Experimental measurements of the time and space resolved spectra taken both along the lasing axis and at other viewing angles, in addition to data on the angular pattern of x-ray laser radiation and on the absorption and scattering of the optical laser light are presented. These data allow us to determine the characteristics of the plasmas which have been created, as well as the properties of the x-ray lasers, such as the gain coefficients for the inverted transitions, and their spatial and temporal distributions. The modelling includes calculations of the absorption of the optical laser light, the heating and hydrodynamics of the targets and the evolution of the atomic level populations within the plasma. Transfer of the emitted radiation is calculated, including resonance line trapping, amplification for inverted transitions, and refraction of the x-ray laser beam due to electron density gradients. Results are used to optimize x-ray laser designs before the experiments and to interpret the measured spectra.

The latest experimental results from the NOVA laser facility on the performance of several laser schemes and on the use of multilayer mirrors to produce x-ray laser cavities are reported. These results are compared to the models to test and improve our understanding of the complex physics involved in making x-ray lasers. Based on current experiments, we show how the modelling can be used to design shorter wavelength and more efficient schemes for use in applications such as x-ray holography.

⁽¹⁾Work performed under the auspices of the US Department of Energy by the Lawrence Livermore National Laboratory under contract number W-7405-ENG-48