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Contents

In Brief

This volume of the LLE Review, covering January–March 2009, features "Applied Plasma Spectroscopy: Laser-Fusion Experiments" by S. P. Regan, B. Yaakobi, T. R. Boehly, R. Epstein, J. A. Delettrez, V. Yu. Glebov, V. N. Goncharov, P. A. Jaanimagi, J. P. Knauer, F. J. Marshall, R. L. McCrory, D. D. Meyerhofer, P. B. Radha, T. C. Sangster, V. A. Smalyuk, J. M. Soures, and C. Stoeckl (LLE); R. C. Mancini (University of Nevada, Reno); D. A. Haynes, Jr. and L. Welser-Sherrill (LANL); J. A. Koch and R. Tommasini (LLNL); and H. Sawada (University of California, San Diego). In this article the authors highlight how high-energy-density plasmas created in laser-fusion experiments are diagnosed with x-ray spectroscopy (p. 55). Hans Griem, considered the father of plasma spectroscopy, provided an excellent foundation for this research. He studied the effect of plasma particles, in particular the fast-moving free electrons, on the Stark-broadening of spectral line shapes in plasmas. Over the last three decades, x-ray spectroscopy has been used to record the remarkable progress made in inertial confinement fusion research. Four areas of x-ray spectroscopy for laser-fusion experiments are highlighted in this article: K_α emission spectroscopy to diagnose target preheat by suprathermal electrons, Stark-broadened K-shell emissions of mid-Z elements to diagnose compressed densities and temperatures of implosion cores, K- and L-shell absorption spectroscopy to diagnose the relatively cold imploding shell (the "piston") that does not emit x rays, and multispectral monochromatic imaging of implosions to diagnose core temperature and density profiles. The seminal research leading to the original x-ray-spectroscopy experiments in these areas is discussed and compared to current state-of-the-art measurements.

Additional highlights of recent research presented in this issue include the following:

- M. Storm, A. A. Solodov, J. F. Myatt, D. D. Meyerhofer, C. Stoeckl, C. Mileham, R. Betti, P. M. Nilson, T. C. Sangster, and W. Theobald (LLE), and C. Guo (The Institute of Optics, University of Rochester) discuss high-resolution coherent transition radiation (CTR) imaging for diagnosing electrons accelerated in laser–solid interactions with intensities of ~10^{19} W/cm^2 (p. 68). The CTR images indicate electron-beam filamentation and annular propagation. The beam temperature and half-angle divergence are inferred to be ~1.4 MeV and ~16°, respectively. Three-dimensional hybrid-particle-in-cell code simulations reproduce the details of the CTR images assuming an initial half-angle divergence of 56°. Self-generated resistive magnetic fields are responsible for the difference between the initial and measured divergence.

- C. K. Li, J. A. Frenje, R. D. Petrasso, and F. H. Séguin (Plasma Science and Fusion Center, MIT); P. A. Amendt, O. L. Landen, and R. P. J. Town (LLNL); R. Betti, J. P. Knauer, D. D. Meyerhofer, and J. M. Soures (LLE) present recent experiments using proton backlighting of laser–foil interactions to provide a unique opportunity for studying magnetized plasma instabilities in laser-produced, high-energy-density plasmas (p. 74). Time-gated proton radiograph images indicate that the outer structure of a magnetic field entrained in a hemispherical plasma bubble becomes distinctly asymmetric after the laser turns off. It is shown that this asymmetry is a consequence of pressure-driven, resistive magnetohydrodynamic (MHD) interchange instabilities. In contrast to the predictions made by ideal MHD theory, the increasing plasma resistivity after laser turn-off allows for greater low-mode destabilization (mode number $m > 1$) from reduced stabilization by field-line bending. For laser-generated plasmas presented herein, a mode-number cutoff for stabilization of perturbations with $m > \sim\left[8\pi\beta\left(1 + D_\mathrm{m}k_\perp^2\,\gamma_\mathrm{max}^{-1}\right)\right]^{1/2}$ is found in the linear growth regime. The growth is measured and is found to be in reasonable agreement with model predictions.

- A. T. Petkoska, T. Z. Kosc, J. C. Lambropoulos, K. L. Marshall, and S. D. Jacobs describe an extension of the theory governing motion of polymer cholesteric liquid crystal flakes in the presence of ac electric fields by introducing the effect of gravity acting on flakes, an important term when the flake density differs from the density of the suspending host fluid (p. 80). Gravity becomes the driving force for flake relaxation when the electric field is removed, and it is now possible to predict relaxation times. Experimental results are compared with predictions from the extended theoretical model.

- G. P. Cox, K. L. Marshall, J. C. Lambropoulos, M. Leitch, C. Fromen, and S. D. Jacobs present a method for modeling the effect of microencapsulation on the electro-optical behavior of polymer cholesteric liquid crystal (PCLC) flakes suspended in a host fluid (p. 86). Several microencapsulation configurations in an applied ac electric field are investigated using Comsol Multiphysics software in combination with an analytical model. The field acting on the flakes is significantly altered as various encapsulant materials and boundary conditions are explored. The modeling predicts that a test cell with multiple materials in the electric-field path can have a wide range of electro-optic responses in ac electric fields. Both theoretical predictions and experimental evidence show that for PCLC flake reorientation to occur as a result of Maxwell–Wagner polarization, a reasonably strong electric field must be present along with at least moderately dissimilar PCLC flake and host fluid material dielectric constants and conductivities. For materials with low dielectric constants, electrophoretic behavior is observed under dc drive conditions at high field strengths for all evaluated microencapsulation configurations. The modeling method is shown to be a useful predictive tool for developing switchable particle devices that use microencapsulated dielectric particles in a host fluid medium.

- T. B. Jones, R. Gram, K. Kentch, and D. R. Harding present a method by which the ponderomotive force, exerted on all dielectric liquids by a nonuniform electric field, can be used for the remote, voltage-controlled manipulation of 10- to 100-μl volumes of cryogenic liquids (p. 101). This liquid dielectrophoretic (DEP) effect, imposed by specially designed electrodes, combines with capillarity to influence the hydrostatic equilibria of liquid deuterium. A simple, 1-D model accurately predicts the measured meniscus rise of D_2 against gravity for sufficiently wide, parallel electrodes. For narrow electrodes, where the sidewalls influence the equilibrium, a finite-element solution using the Surface Evolver software correctly predicts the behavior. A bifurcation phenomenon previously observed for room-temperature dielectrics is also observed in liquid deuterium. This effect could possibly be used in the future to meter cryogenic deuterium when fueling targets for laser fusion.

- A. V. Okishev (LLE); D. Westerfeld (Power Photonic Corporation); and L. Shterengas and G. Belenky (State University of New York at Stony Brook) describe the spectral and output-power stability of a 3-μm-wavelength GaSb-based diode laser operated at room temperature (p. 111). More than 50 mW of output power has been achieved at 14°C with high spectral and output-power stability. This diode laser has a direct application for layering cryogenic targets for inertial confinement fusion implosions on the OMEGA laser.

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Editor