pressure, the spatial mode of the output changes from a diffuse spot into a clean, nearly TEM_{00} mode, as expected. In high-harmonic generation, the nonlinear interaction occurs during the process of ionization of the gas. This creates free electrons that alter the propagation of light in the waveguide and limit the phase matching. To circumvent this difficulty, we use very short (20 fs) driving pulses, so that we can reach the intensities required for high-harmonic generation before very many of the atoms are ionized.

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Two-dimensional Near-field and Far-field Imaging of a Ne-like Ar Capillary Discharge Table-top Soft X-ray Laser

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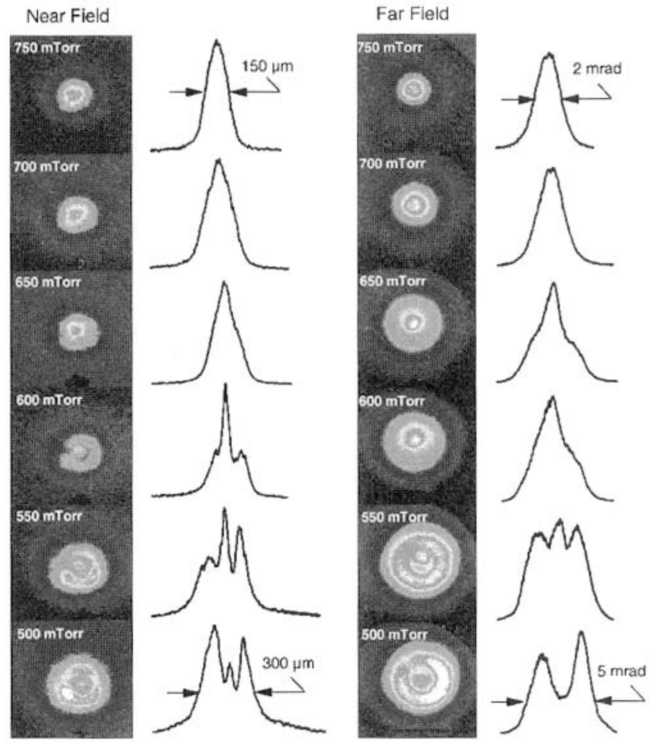
The observation of large soft X-ray amplification in the plasma of a capillary discharge[1] and the subsequent demonstration of a saturated discharge pumped table-top soft X-ray laser in Ne-like Ar at 46.9 nm has established a new approach for the development of compact and practical soft X-ray lasers.[2] In these lasers the gain medium is a hot and dense plasma column with aspect ratios approaching 1000:1, generated in a capillary channel by a fast discharge current pulse where lasing is obtained by collisional electron excitation of Ne-like ions. Knowledge of the near- and far-field spatial distribution of the output of these lasers is of both practical and basic interest.

We obtained the first 2-D near- and far-field imaging of a capillary discharge-pumped soft X-ray laser.[3] The measurements were conducted in an Ne-like Ar capillary discharge laser emitting a single strong laser line at 46.9 nm.[4] The current pulse, having a peak amplitude of ≈37 kA and a first half period of 72 ns generates and compresses an elongated Ar plasma column in which lasing occurs ≈39 ns after the onset of the current. The discharges took place in a polyacetal capillary 16.4 cm long, 4 mm in diameter, filled with pure Ar gas at different selected pressures ranging from 500–750 mTorr. The left side of Figure 1 shows the near-field images. They were obtained imaging the output aperture of the capillary discharge laser using a 150-cm radius of curvature Ir-coated mirror onto a MCP-CCD detector.

It can be seen that at the higher pressures (> 650 mTorr) the laser beam distribution is a single circular peak with maximum intensity at the center and monotonically decreasing intensity toward the periphery. As the pressure decreases, the beam size at the exit of the amplifier gets increasingly larger, and finally develops into a ring structure. The FWHM beam diameter at the exit of the amplifier increases from about 150 μm at 750 mTorr to



Moreno Figure 1. Near-field (left) and far-field (right) patterns of the Ne-like Ar laser beam output as a function of pressure. Diametral cuts with normalized intensities are shown at the left of each image.

about 300 μm at 500 mTorr. The far-field images and model computations show that these effects are caused by larger refraction of the beam in the lower pressure discharges as a result of larger density gradients in the plasma.

Figure 1 (right side) shows the far-field beam patterns corresponding to each of the discharge conditions of the near-field patterns, measured at 148 cm from the capillary exit. As in the case of the near-field images, a transformation is observed in the spatial intensity distribution from a beam profile with a single peak at the center to a ring profile, as the pressure is decreased. This is accompanied by an increase in the beam divergence, from about 2 mrad for discharges at 750 mTorr to about 5 mrad for discharges at 500 mTorr. These results show that refraction increases as the pressure is decreased. The images have the axial symmetry that is expected from a well-behaved capillary discharge. They are a new corroboration of the very high compression, axial symmetry, and plasma uniformity that can be obtained in fast capillary discharges.

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