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Absolute measurements of high field generation of plasmas in gases with femtosecond time- and micron space-resolution[1]

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Laser-driven ionization of gases and gaseous density plasmas is a fundamental aspect of light-matter interactions affecting everything from propagation of high power laser pulses to coherent and incoherent laser-driven light sources. Using ultra-broadband 2D spectral interferometry we have performed absolute time- resolved and 2D in space-resolved measurements of the ionization of the noble gases He through Xe and several diatomic molecules, including O_2 and N_2. The refractive index is measured with a time resolution of 5 femtoseconds and spatial resolution of 3 microns, with absolute results ranging from the multiphoton through tunneling ionization regimes. With these results, combined with our previous measurements at nonionizing intensities [1,2], we have characterized the nonlinear response of the noble gases from the weak field limit up to full ionization of the first electron. For the molecular gases, we use prepulses to prepare an ensemble of partially aligned molecules and examine alignment-dependent ionization. Finally, we assess whether the nonequilibrium electron gas generated immediately after ionization has birefringent optical properties. Our measurements will lead to more accurate models of the propagation of intense optical pulses in gases and may serve as an experimental benchmark of calculations of strong field ionization.

[1] J. K. Wahlstrand, Y.-H. Cheng, and H. M. Milchberg, Phys. Rev. A 85, 043820 (2012).
[2] J. K. Wahlstrand, Y.-H. Cheng, and H. M. Milchberg, Phys. Rev. Lett 109, 113904 (2012).

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