Wavelength Scaling in High Harmonic Tomographic Imaging

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Synopsis Increasing the wavelength of the fundamental driving laser at constant intensity in high harmonic generation allows one to significantly increase the upper bound of the harmonic energies produced [1, 2]. This feature of harmonic generation is employed in an effort to improve the spatial resolution achieved in the method of tomographic reconstruction of molecular orbitals from high harmonics [3]. Current experimental measurements and comparison with theoretical work [4] will be presented.

In the harmonic generation process, an electron wavepacket is promoted from a molecule and propagates under the influence of the driving laser, eventually returning to its origin with a maximum cutoff energy, E_{cutoff}, proportional to the field's ponderomotive potential, U_p. The interaction of the returning electron wavepacket with the molecular bound state wavefunction produces harmonics and gives one access to information about the molecular wavefunction. By varying the alignment of the molecular axis of the target gas at known angles to the driving laser's polarization, the returning electron wavepacket interacts with the molecule's wavefunction from differing vantage points. This angular-dependent spectral data can then be used to tomographically reconstruct the molecule's structure. One key point in performing an accurate reconstruction is in producing rescattering electrons with a small deBroglie wavelength capable of resolving molecular features. By extending the harmonic cutoff, the range of the electron deBroglie wavelengths sampling the molecule is also increased, suggesting the abililty to reconstruct a molecular image with finer detail. Because $E_{cutoff} \propto U_p \propto I\lambda_L^2$, the electron deBroglie wavelength for the cutoff scales as $\lambda_e \propto U_p^{-\frac{1}{2}} \propto I^{-\frac{1}{2}}\lambda_L^{-1}$ where I is the laser intensity, λ_L is the fundamental driving laser wavelength and λ_e is the cutoff electron deBroglie wavelength. This suggests increasing the driving laser wavelength as an effective tool for improving the resolution of a molecular tomographic reconstruction, and would be a benefit for imaging experiments with molecules such as N_2 with bond lengths close to 1 $\mathring{A}$. As an example, the shortest deBroglie wavelength for electrons produced at intensities typical for N_2 by a 0.8 μm fundamental laser is ∼1.5 $\mathring{A}$ while a 1.3 μm driving laser at the same intensity produces returning electrons with a wavelength ∼0.9 $\mathring{A}$.

In our work we compare the resolution from experimental results in N_2 using 0.8 micron light to similar conditions with 1.3 micron light. The spectral data is shown in figure 1. We plan to examine the effects of extending the harmonic cutoff on the tomographic recontruction both in N_2 and other simple molecules.

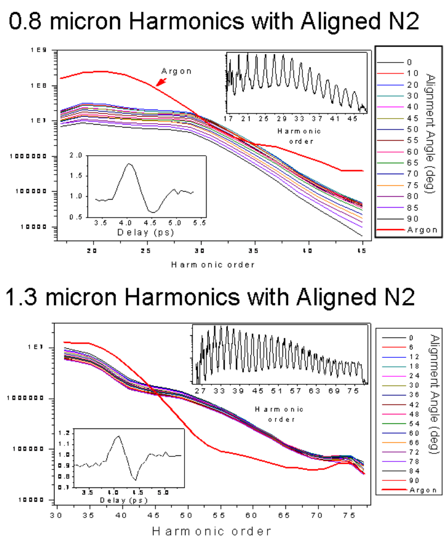

Fig. 1. Harmonic angular dependence in N_2. The insets show typical spectra and harmonic yield around first half revival of alignment for N_2.

References

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