High harmonics generation using long wavelengths: Scaling and scaled systems

Gilles Doumy*,[1], Anne Marie March*, Erik Power†,[2], Jonathan Wheeler*, Chris Roedig*, Emily Sistrunk*, Fabrice Catoire*, Karl Krushelnick†, Pierre Agostini* and Louis DiMauro*

[*] Department of Physics, The Ohio State University, Columbus, OH, 43210, USA
[†] Center for Ultrafast Optical Science, University of Michigan, Ann Arbor, MI, 48109, USA

Synopsis: Long wavelength lasers have started to become ubiquitous in studies of high harmonics generation, due to their attractive scaling properties (cutoff extension, better synchronization for shorter pulses). They also enable studies where the whole interaction is scaled compared to the usual situation using 800nm light. I will present both results that verified the wavelength scaling and a complete temporal characterization of the emission in a scaled Cesium\3.6mm system using Cross-correlation frequency resolved optical gating (XFROG).

High harmonics generation from gas targets has lead to the advent of attosecond physics, by being able to coherently produce photons across a large bandwidth in the extreme UV [1]. It has accompanied the development of ultrashort, femtosecond lasers, by bringing continuous improvements such as the extension of the generation cutoff or the generation of isolated attosecond pulses.

However, all this tremendous progress has been realized using what had become the workhorse of strong field physics, the Ti:Sapphire systems, operating at a wavelength around 800nm. Experimental progress was accompanied by a very successful theoretical description that indicated how the ponderomotive energy (average quiver energy of an electron in the strong field of the laser pulse) U_p was the main parameter to consider.

Following that reasoning, the attractive qualities of using longer wavelengths were obvious: cutoff extension as λ^2, harmonic synchronization improving as λ^{-1}. And since ultrashort intense sources have started to appear thanks to the development of Optical Parametric Amplifiers (OPA), it has become possible to test those predictions [2]. I will show some of those results, obtained by studying the interaction of noble gases with 50fs pulses up to a wavelength of 2 microns [3]. An example is illustrated in Fig.1.

Another very interesting new angle introduced by those longer wavelengths sources lies in the capability of completing the understanding of the interaction responsible for the generation. Indeed, following Keldysh's treatment [4] of the strong field interaction, noble gases at 800nm should behave very similarly to alkali atoms in the mid-infrared (~4μm). For example, HHG is observed in the interaction of cesium and 3.6 μm light. One remarkable property of those harmonics is that a good number of them lie in the visible\near UV, where it is still possible to use standard pulse characterization techniques, such as Frequency resolved optical gating. I will present results of a cross-correlation FROG measurement, which yielded the full temporal characterization of the pulse train obtained in those conditions. Most of the harmonics in that study had energies below the ionization threshold of cesium, which corresponds to a scantily studied region of the harmonic spectra.

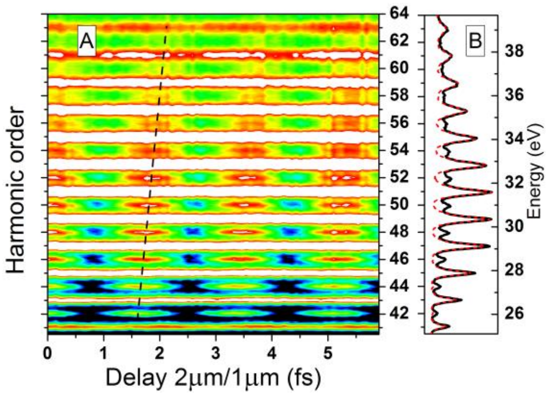

Fig. 1. Measure of the attochirp at 2 micron [3]

References

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[1] E-mail: doumy.1@osu.edu
[2] E-mail: eppower@umich.edu