4902

Spatio-spectral technique to verify pump-pulse propagation model in an Ar-filled capillary in the presence of high harmonic generation

T J Butcher,[1] R T Chapman,[2] P Horak,[1*] F Poletti,[1] J G Frey,[2] and W S Brocklesby[1]

[1] Optoelectronics Research Centre, University of Southampton, Southampton, UK
[2]School of Chemistry, University of Southampton, Southampton, UK

High-power ultrashort laser pulses propagating in gas-filled capillaries can form a compact source of extreme ultraviolet (XUV) and soft X-ray radiation by high-harmonic generation (HHG) [1]. Maximisation of the frequency conversion requires a detailed understanding of the atom-light interaction mechanism as well as the propagation properties of both the near-infrared pump in the presence of a partially ionized gas, and of the generated XUV. Previous theoretical studies of capillary based HHG by Christov et al. [2] have used numerical solutions of the 3-dimensional version of the scalar wave equation.

Here we present a theoretical model for pump propagation based on a multimode generalized nonlinear Schrödinger equation [3], which we verify by detailed experimental testing. We have developed a method of spatially resolving the output spectrum of the capillary, which allows detailed comparison with the spatial and spectral structure of the theoretically-modelled pump, Figure 1. In addition to this we have measured the output XUV spectrum for this pump pulse, which we can compare with a theoretical spectrum derived from a quantum mechanical model of the atom-light interaction along the capillary. This work will lead to improved HHG capillary-based sources for use in high resolution XUV imaging.

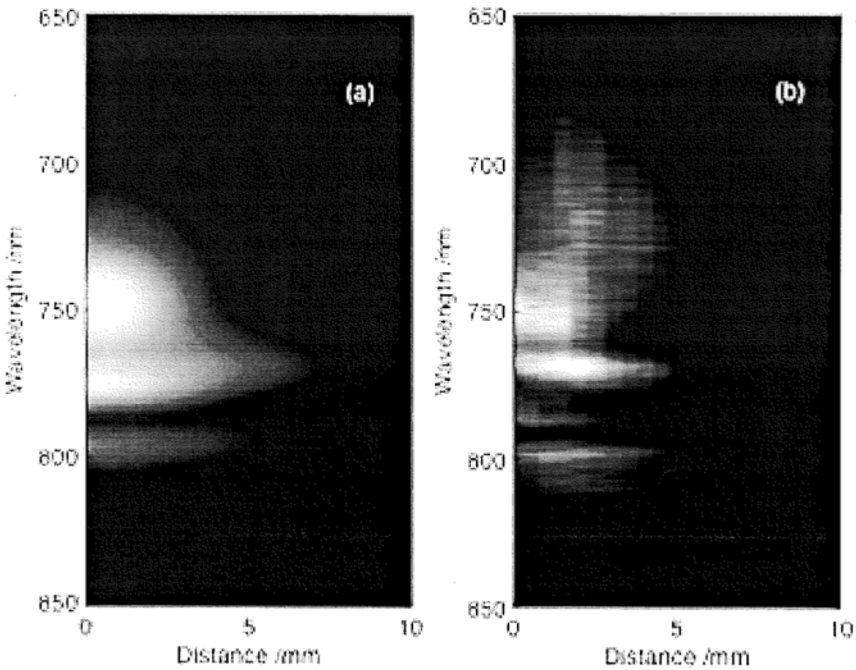

Fig 1: Predicted (a) and experimental (b) spectral intensity plots in the λ-r-plane. The measurement was taken using a 125µm fibre-coupled spectrometer placed in the far field, 60cm from the capillary exit. The fibre end was translated radially from the beam axis in 0.5mm increments to a distance of 10mm.

1. L'huillier, A. and P. Balcou, *High-Order Harmonic Generation in Rare Gases with a 1-ps 1053-nm Laser.* Phys. Rev Lett., 1993. **70**: p. 774-777.
2. Christov, I., H. Kapteyn, and M. Murnane, *Quasi-phase matching of high-harmonics and attosecond pulses in modulated waveguides.* Optics express, 2000. **7**: p. 362-7.
3. Poletti, F. and P. Horak, *Description of ultrashort pulse propagation in multimode optical fibers.* Journal of the Optical Society of America B, 2008. **25**: p. 1645.