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Bright, Tuneable and Compact Source of Few-Femtosecond Pulses in the Deep Ultraviolet

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Tuneable ultrashort pulses in the vacuum ultraviolet (VUV, 100-200 nm) and deep ultraviolet (DUV, 200-300 nm) are a vital tool for next-generation ultrafast spectroscopy, technology, and medicine. Resonant dispersive wave (RDW) emission in gas-filled hollow-core waveguides is uniquely placed to fulfill this requirement, delivering continuously tuneable VUV and DUV laser pulses with high efficiency, few-femtosecond duration, and near-perfect beam quality [1, 2]. Ultraviolet RDW emission in small-core anti-resonant fibres at low pulse energy and high repetition rate can generate Watt-level average powers [1]. However, this approach requires highly specialised waveguides, suffers from guidance resonances which impede fully continuous tuneability and VUV generation, and is ultimately limited in average power due to plasma build-up effects which cap the pulse repetition rate [3]. At much higher pulse energy, simple large-core hollow capillary fibre (HCF) can be used for RDW emission [2], but this has so far only been demonstrated using large research-grade ultrafast laser amplifiers.

Here we demonstrate a bright source of ultrashort DUV laser pulses based on a reliable industrialised pump laser (Light Conversion Pharos) and simple HCF with a total footprint of only 120 cm × 75 cm including the pump laser. The design, shown in Fig. 1, is based on pre-compression of 220 fs pulses to 13 fs using a first HCF and RDW emission in a short second HCF [4]. Using 14 to 19 bar of helium in the second HCF, we generate between 60 and 230 mW (1.2 to 4.6 µJ) as the RDW is tuned from 220 to 240 nm central wavelength. (Detection below 220 nm central wavelength is currently limited by our measurement apparatus.) Using 0.8 to 3 bar of argon instead allows us to tune from 230 to 365 nm central wavelength, but the generated power drops to around 100 mW, since the stronger nonlinearity requires a reduction in pump energy. By further optimising the pulse compression and upgrading the optics in the system, extension to the VUV will be straightforward [2]. The transform-limited duration of the UV pulses is around 2 fs at all wavelengths; compressed pulses can be delivered by employing a decreasing pressure gradient in the second HCF.

We believe that compact and tuneable few-fs VUV and DUV light sources will broaden access to many new applications in ultrafast photonics and beyond.

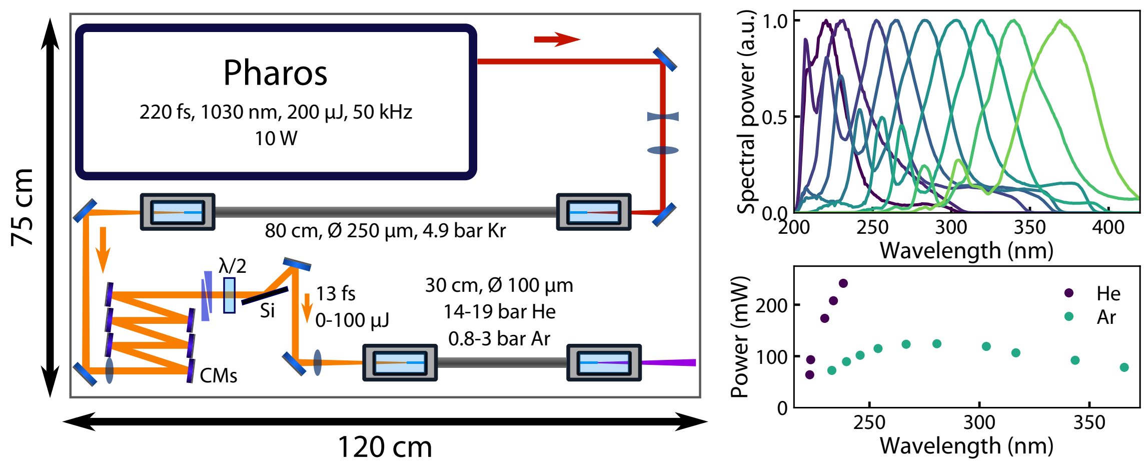

Fig. 1. Left: layout of the light source. A commercial laser emits 200 µJ, 220 fs pulses at 1030 nm at a repetition rate of 50 kHz. These are compressed to 13 fs duration by spectral broadening in a first gas-filled HCF and dispersion compensation by chirped mirrors (CMs) and a wedge pair. A half-wave plate (λ/2) and Brewster-angle silicon plate (Si) form a variable attenuator. DUV pulses are generated in a second HCF filled with helium or argon. Top right: example spectra of DUV pulses generated in the second HCF. Spectra below 250 nm are generated in helium and those above 250 nm in argon. Bottom right: average power of the generated DUV pulses.

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