Ultrashort IR-visible- and VUV-pulse generation for attosecond pump-probe experiments using a reaction microscope

K. Simeonidis[1], **R. Gopal, H. Rietz, A. Sperl and J. Ullrich**

Max-Planck-Institut fuer Kernphysik, Saupfercheckweg 1, D - 69117 Heidelberg, Germany

Synopsis The status of the new attosecond beamline at Max-Planck-Institut fuer Kernphysik (MPIK), Heidelberg, and ongoing experiments is reported. The beamline is designed for detailed investigation of the electronic response in atoms and molecules by combining a versatile HHG-source with a compact reaction microscope. Ultrashort laser pulses down to 4 fs generatetd by a novel pulse compression setup utilizing filamentation are applied to produce isolated attosecond pulses.

The attosecond beamline at MPIK is designed for the investigation of the electronic response in atoms and molecules in unprecedented detail. A versatile HHG-source producing either attosecond pulse trains or isolated attosecond pulses is combined with a reaction microscope dedicated for attosecond pump-probe experiments. The optical setup is based on a commercially available femtosecond laser system delivering carrier envelope phase (CEP) stabilized mJ pulses with a pulse duration around 25 fs at a center wavelength of approx. 785 nm. The repetition frequency of the cryogenically cooled Ti:Sapphire amplifier is adjustable to values betweeen 3 kHz and 10 kHz. For experiments using attosecond pulse trains the bare amplifier output is applied to pump the HHG, while for obtaining isolated attosecond pulses further compression is necessary since HHG has to be restricted to only one cycle of the driving CEP-stabilized IR-field. IR-pulse compression is achieved through spectral broadening via self-phase-modulation (SPM) and subsequent dispersion management using a

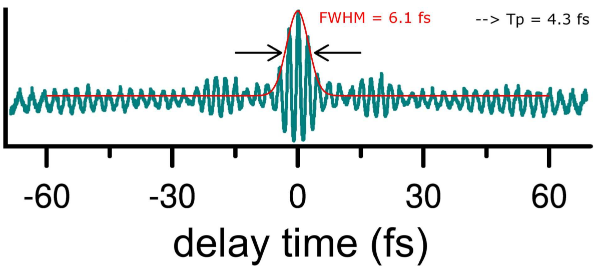

Fig. 1. Autocorrelation measurement after filamentation. From the envelope fit (red line) a pulse duration of the central part of 4.3 fs is derived.

standard chirped mirror pair. A novel double-pass setup loosely focussing the laser twice into a long Argon filled gas cell is used to produce 2 filaments leading to SPM. Pulse durations down to 4 fs while maintaining more than 60 % of the initial pulse energy have been measured (see Fig. 1). Subsequently, the infrared / visible laser pulses are focussed into a gas target, where nonlinear interaction of the intense electromagnetic field with the target atoms leads to the emission of high harmonic radiation. In order to achieve high target pressures up to 400 mbar, the target gas is confined in a cell of some millimeters length. The HHG-setup is housed in a vacuum chamber along with the optics necessary for focussing and delay lines as well as telescopes that adjust the beam diameter. The source is fully optimized for the operation with Argon, where photon fluxes of typically 10^9 photons per second and harmonic order in the plateau region of the UV-spectrum are reached.

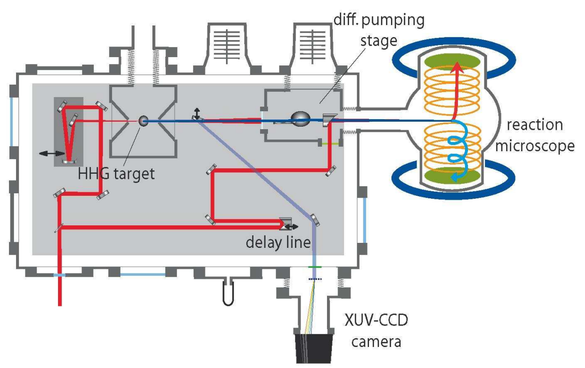

Fig. 2. Schematic of the pump-probe experimental setup. All interferometer components including final focussing optics are mounted on the same breadboard in vacuum.

[1]E-mail: k.simeonidis@mpi-hd.mpg.de