Ultrafast Science and Development at the Astra-Artemis Facility

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Astra-Artemis is a unique, new, ultrafast science facility under development in the UK. The paper will report on the: (a) ultrafast science experimental results obtained with Artemis on: HHG mapping of electronic structure; ultrafast molecular process; HHG with 2-colour laser fields, energy transfer in photosynthesis and (b) Artemis facility development of new ultrafast XUV and laser beamlines and time-resolved science end-stations.

Astra-Artemis is a unique, new, ultrafast science facility open to UK and EU university groups as well as to world-wide collaborations. The paper will report on the:

- New ultrafast science experimental results and
- Artemis facility capabilities and development. The facility development proceeds in parallel with the ultrafast-science experimental schedule.

The ultrafast science programme bringing together the expertise of a large number of university groups produced new results in the:

Investigation of HHG mapping of electronic structure of polyatomic molecules (ICL, UCL, CSIC, Napoli, CLF);

- Investigation of HHG with 2-colour laser fields (ICL, UCL, CLF);
- Measurement and control of ultrafast molecular process: vibrational and rotational states in simple molecules (UCL, QUB, SU, CLF); dissociation of vibrationally cold simple molecules held in an ion trap (QUB, DCU, SU, Denison, CLF);
- Energy transfers and coherences in a photosynthetic protein (UCD, ICL, Glasgow, CLF).

The Astra-Artemis facility provides three ultrafast laser beams, two ultrafast XUV beamlines, and two end-stations for ultrafast science. All the femtosecond laser and XUV beams are synchronized to sub-femtosecond resolution. Either beam combination can be temporally and spatially overlapped (delayed and focused) on targets into either of the two end stations.

The two end-stations are dedicated to ultrafast time-resolved:

- materials science (solid target)
- atomic and molecular physics (gas-phase target)

The laser and XUV beamlines consist of the:

- Red Dragon (KML) Ti: sapphire laser driver generating 14Watt with 1kHz repetition, sub-30fs pulse duration and carrier-envelope-phase (CEP) lock.
- Hollow fibre sub-10fs laser compressor (ICL, CLF)
- TOPAS (Light Conversion) opto-parametric-amplifier (OPA) laser tuneable from UV into the mid-IR.
- The XUV beams are produced by focusing either of the laser beams in the high-harmonic-generator (HHG) chamber. The XUV photon energy range is 10eV – 100eV. The two beamlines provide:
  - Monochromatic and tuneable XUV photon pulses spectrally selected from the HHG beam with a novel time-preserving XUV monochromator (CNR, DEI, CLF, DL). This beamline is optimized for the materials science end-station
  - Broad-band XUV beamline optimized for the atomic and molecular physics end station.

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