

Ultrafast Electron Dynamics and Attosecond Science

NLS Workshop 13th May 2008

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NLS Project Leader and PSRI

Coordinator for “Ultrafast Electron
Dynamics and Attosecond Science”

Executive Summary

- STFC seeks to examine the case for a New Light Source Facility in the UK with unique and world leading capabilities
- The proposal is jointly supported by STFC and Diamond Light Source Ltd, coupled to strong HEI involvement
- The first phase is broad-based science consultation
 - Workshops and Working Groups coordinated by the leaders of the “Photon Science Research Institute” and the 4GLS project
 - Direct input from anyone in the community

Science Consultation

- The first phase of the NLS project will determine, through wide consultation, the key long term scientific objectives for the UK light source strategy and establish the light source capability we need
 - *“What is the compelling science?”*
- NLS will examine the balance between objectives which can be achieved by exploiting the existing array of international next generation light sources and those which will require a new UK capability
 - *“Do we need a new UK source?”*

What is NLS?

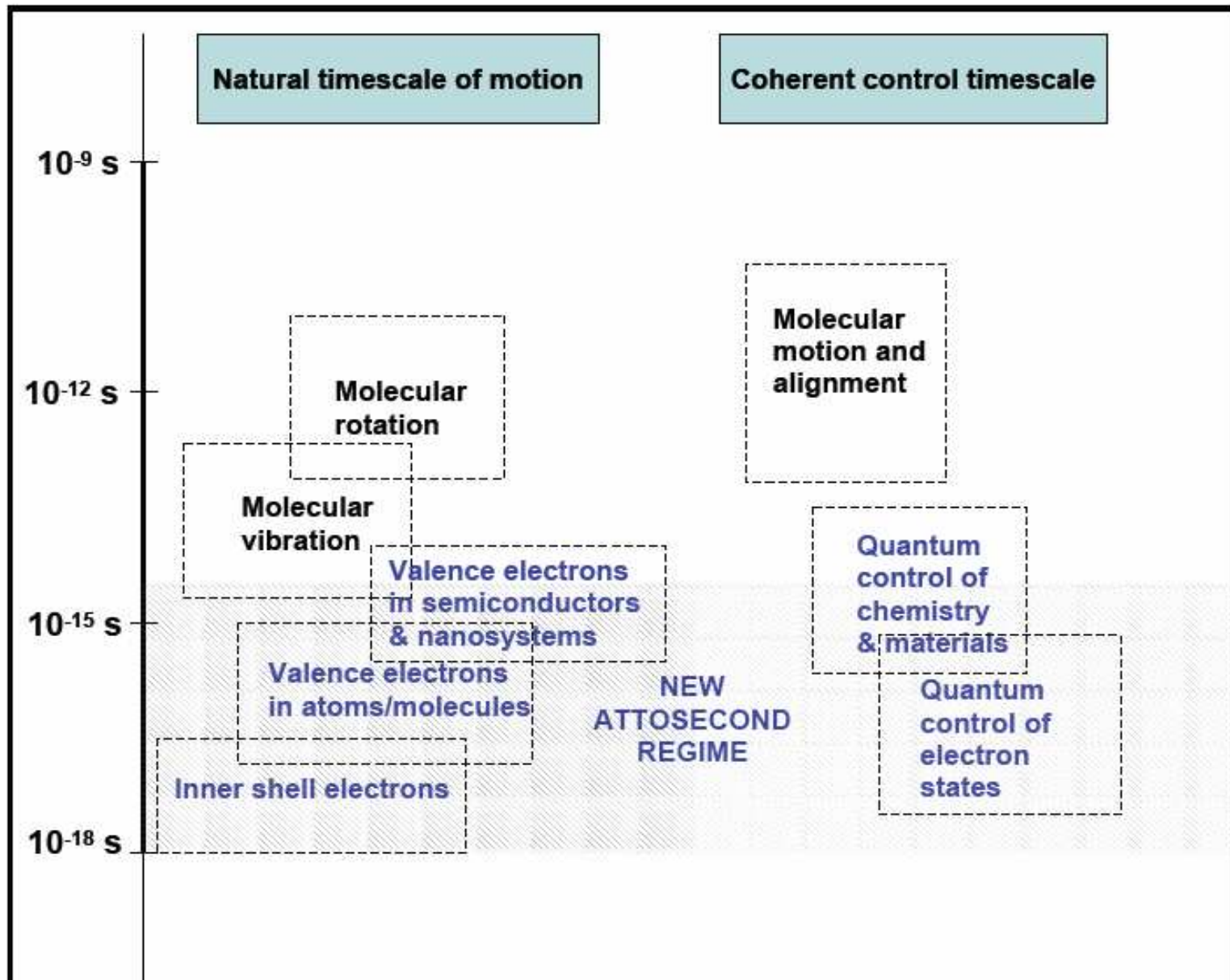
- A science driven project
 - First: define the key science drivers
 - Next: assess the technical solution
 - Then: assess funding and location
- Must take the long view of high level objectives that are likely to be relevant for decades
- The NLS facility, if built, will probably adopt an integrated approach;
 - e.g. incorporating advanced conventional lasers alongside FEL(s) to achieve the science objectives

Establishing Key Science Drivers and Outline Specifications - the Workshops

- **Electron Dynamics / Attosecond Science** [* areas of strong overlap]
 - 13th May 2008, Imperial College London
 - Meeting convenor – Professor Jon Marangos
- High Energy Density Science
 - 20th May 2008, Rutherford Appleton Laboratory
 - Meeting convenor – Professor Justin Wark
- Condensed Matter*
 - 21st May 2008, Rutherford Appleton Laboratory
 - Meeting convenor – Professor Andrea Cavalleri
- Chemical Science*
 - 22-23rd May 2008, Daresbury Laboratory
 - Meeting convenors – Dr. Jonathan Underwood and Professor Wendy Flavell
- Advanced Photon Sources*
 - 3rd June 2008, Daresbury Laboratory
 - Meeting convenor – Professor Richard Walker
- Life Sciences
 - Workshop June 19th , Rutherford Appleton Laboratory/ Diamond Light Source
 - Meeting convenors– Professor Dame Louise Johnson and Professor Peter Weightman

Ultrafast Electron Dynamics and Attosecond Science Objectives

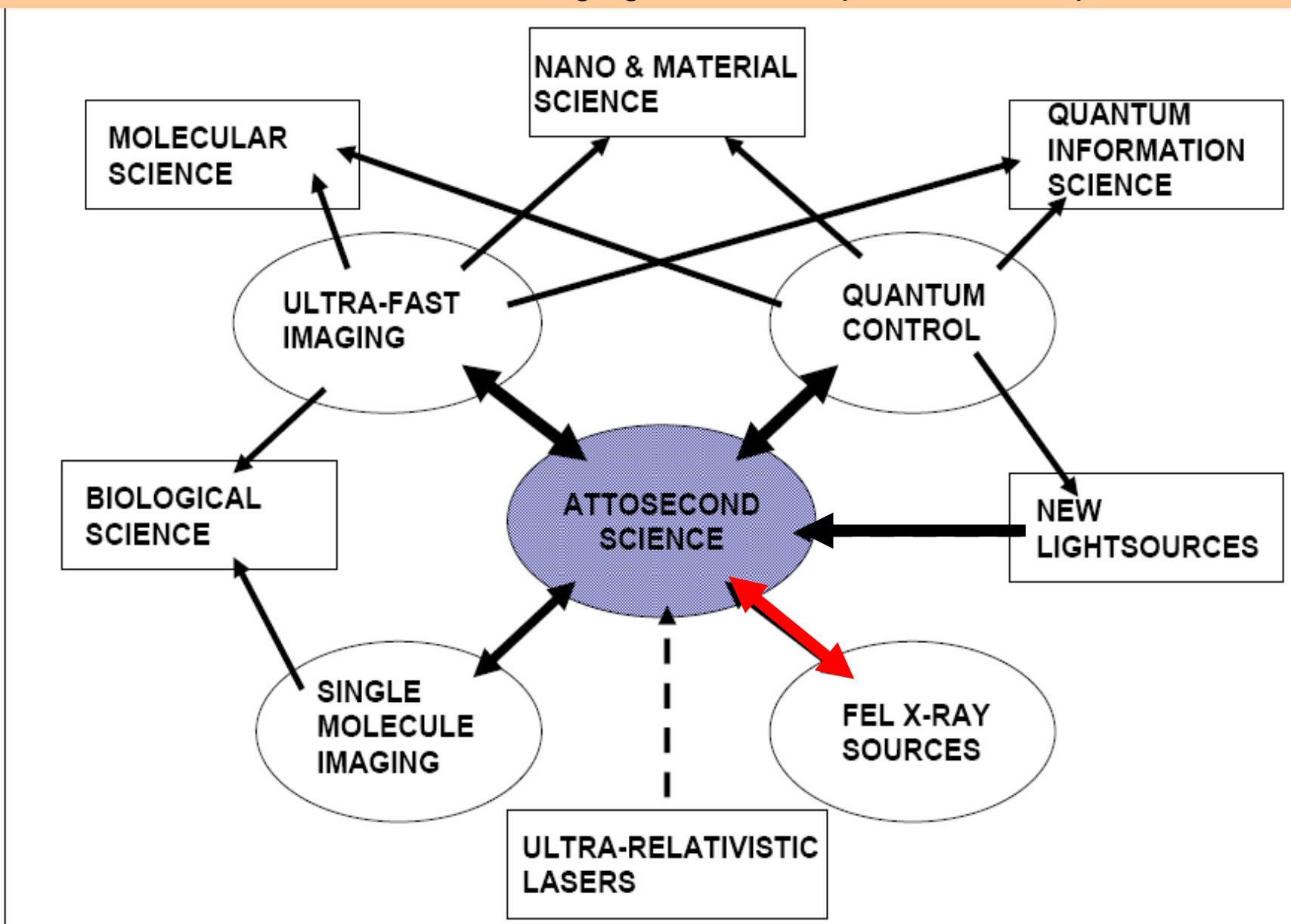
- To probe fast electronic processes within many body quantum systems to find out what makes them “tick” (e.g. if we move one electron how do the others respond?)
- To understand the role of quantum coherence (including coherent superposition, correlation and entanglement) inherent in many body quantum systems
- To seek ways to harness ultrafast coherent phenomena for: coherent control of matter, light sources with new properties, ultra-high speed quantum computing



Technology in the femtosecond regime has revolutionized our ability to measure and control atomic motion in matter

Attosecond technology is allowing us to directly address electronic motion in matter

Attoscience is concerned with the real time evolution of electronic bound states and ultra-fast structural imaging so we anticipate a wide impact



Input to NLS Specification

Science Workshops and Working Groups must address and define the desired source parameters for each science area:

- photon energy range(s)
- pulse energy
- pulse length/bandwidth
- pulse/macropulse repetition rate
- average flux/brightness
- degree of coherence
- polarization
- stability in energy, intensity, timing, position
- contrast against background
- requirement for combinations of sources (e.g. THz, IR, SR, electrons etc.) and degree of synchronisation etc.

+ State of the art “conventional” lasers and NLO

Need to establish the extent to which Attosecond science would benefit from a centralised facility

Workshop Programme

- **10:30 “Attosecond technology and measurement” John Tisch (Imperial)**
- **10:55 “Connecting attosecond science and XUV FEL research ” Marc Vrakking (AMOLF, Netherlands)**
- **11:20 “Ultrafast two-colour experiments with laser- and accelator-based XUV sources” Markus Drescher (Hamburg/DESY)**
- **11:45 “Harmonics from solid targets – towards an ultrabright source of attosecond pulses” Matt Zepf (QUB)**
- **12:10 Discussion of technological opportunities with lasers and FELs (Lunch)**
- **13:30 “Attosecond high harmonic generation spectroscopy of holes in polyatomic molecules” Misha Ivanov (NRC Ottawa)**
- **13:55 “Electron correlations probed by coherent VUV-IR fields” Leszek Frasinski (Imperial)**
- **14:20 “Photoionization in Intense XUV and NIR Laser Fields with the FLASH Pump-Probe Facility” John Costello (Dublin)**
- **14:45 “Electron correlation in intense-laser atomic processes” Ken Taylor (QUB)**
- **15:30 Discussion of scientific objectives and NLS capabilities (Tea)**

Discussion essential to this process

– we need to hear your views

- Please e-mail directly to me (j.marangos@imperial.ac.uk) or up-load to website (links to be available shortly) your views and ideas
- If you do raise any points during today's discussions we will note them – but it would help us if you would also e-mail these later to ensure they are accurately captured