

**Speaker: Prof. John Costello from DCU.**

**Title: Photoionization of Rare Gases in Intense X-ray and Optical Laser Fields**

The photoelectric effect is one of the most fundamental physical processes in nature. It impacts many domains from biophysics to astrophysics. For X-ray irradiation of many-electron atoms a plethora of processes including inner shell ionization, multielectron ionization, resonant excitation followed by ionization, secondary (Auger) electron emission (normal and resonant) and so called 'shake processes' are all possible. On the other hand, for atoms in intense laser fields, valence electrons are liberated and usually more than one photon needs to be absorbed. Photons can be absorbed either simultaneously or sequentially, termed direct or sequential multiphoton ionization respectively. The advent of free electron lasers (FELs) operating at vacuum ultraviolet (VUV) and X-ray photon energies has permitted the study of multiphoton processes involving not just valence electrons but also inner shell electrons. In the latter case the hole states formed have lifetimes on the femtosecond timescale. Two recent results from the FLASH FEL at DESY-Hamburg [1] and the LCLS FEL at SLAC-Stanford [2] will be used to illustrate both cases. In the first case the angular distribution of valence photoelectrons emitted by Kr atoms irradiated by two photon double ionization (TPDI) will be presented [3]. In the second case a measurement of the time delay between the emission of an inner-shell electron and a secondary (Auger) electron in Ne will be briefly discussed [4].

### **References**

1. Operation of the Free Electron Laser FLASH in the Water Window  
W. Ackermann et al, Nature Photonics 1, pp336-342 (2007)
2. First Lasing and Operation of an Ångstrom-Wavelength Free Electron Laser  
P. Emma et al. Nature Photonics 4, pp641–647 (2010)
3. Near-Threshold Two-Photon Double Ionization of Kr in the Vacuum Ultraviolet  
L. Varvarezos et al., Phys. Rev A 103 (Accepted 7th February, 2021)
4. Clocking Auger Electrons  
D. C. Haynes et al., Nature Physics 17 (Published online 10th January, 2021)