Patterning the electron wavefunction to achieve control of matter down to the nucleus

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Using optical pulses to coherently control a free electron allows patterning its wavefunction all the way down to the attosecond and possibly even zeptosecond time scale. Furthermore, it enables the generation and dynamical control of vortex beams via the manipulation of the free electrons orbital angular momentum (OAM). Such shaped beams can be used for extreme time resolved experiments, to characterize and modulate plasmonic fields in nanostructures, or even to sense magnetization dynamics. Alternatively, ad hoc prepared electron packets can be used to unveil new phenomena in nuclear reactions and sub-nuclear phenomena. In this presentation, we will review the state of the art in time resolved electron microscopy and show different methods to produce ultrashort electron pulses and controlled OAM state. The potential of such beams for controlling nuclear excitations in electron capture processes will be discussed.