Listening to the ultrafast talk of two excited electrons — and asking them physics questions

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Electrons interact via the long-range Coulomb force, repel each other and feel attracted by a binding nucleus that traps them inside an atom. When both electrons are in excited states, they keep communicating repulsively, where they may agree that one of them drops back down to the ground state, donating its energy to the other one, which feels free to leave the atom (autoionization). In this talk, I will show how this communication and the corresponding dynamics are recorded in time and translated into qualitatively improved physical understanding. The key methods are the combination of ultrafast laser/light fields and multi-dimensional detection techniques accessing time scales of 1 femtosecond (10^{-15} s) and shorter. Moreover, from asking questions encoded/carried at visible frequencies (controlled laser pulses), and listening to the electrons optical response (spectroscopy) we learned to interpret a fundamental quantum interference process—the Fano resonance—in the time domain, with emerging scientific applications ranging from x-ray lasing-without-inversion to frequency combs locked to nuclear resonances in the hard-x-ray region.