Tutorial Lecture No. 2:

"Tutorial on Attosecond Physics: Near Future Prospects"

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Various experimental groups are aiming to produce isolated, few-cycle attosecond light pulses as well as sub-femtosecond electron pulses. In this tutorial I will survey some of the new physics that will become possible when these goals are achieved. Specifically, I will present the theory of attosecond photoionization by few-cycle, carrier-envelope-phase stable attosecond light pulses and then show and discuss the unique features of the predicted ionization spectra produced by such pulses [1-4]. I will then examine reasons why attosecond electron pulses are advantageous for imaging target electronic motion by means of ultrafast electron diffraction (UED), show proof-of-principle calculations illustrating the ability of such pulses to image electronic motion, and discuss the theoretical requirements underlying the ability of UED to image target electronic motions [5-7].

References:

[1] L.Y. Peng, E.A. Pronin, and A.F.Starace, "Attosecond Pulse Carrier-Envelope Phase Effects on Ionized Electron Momentum and Energy Distributions: Roles of Frequency, Intensity, and an Additional IR Pulse," New J. Phys. **10**, 025030 (2008).

[2] E. A. Pronin, A. F. Starace, M. V. Frolov and N. L. Manakov, "Perturbation Theory Analysis of Attosecond Photoionization," Phys. Rev. A **80**, 063403 (2009).

[3] J.M. Ngoko Djiokap, S.X. Hu, W.-C. Jiang, L.-Y. Peng, and A.F. Starace, "Enhanced Asymmetry in Few-Cycle Attosecond Pulse Ionization of He in the Vicinity of Autoionizing Resonances," New J. Phys. **14**, 095010 (2012). [*Published in the Focus Issue on "Correlation Effects in Radiation Fields."*]

[4] J.M. Ngoko Djiokap, S.X. Hu, W.-C. Jiang, L.-Y. Peng, and A.F. Starace, "Asymmetries in Production of $He^{+}(n=2)$ with an Intense Few-Cycle Attosecond Pulse," Phys. Rev. A **88**, 011401(R) (2013).

[5] H.-C. Shao and A.F. Starace, "Detecting Electron Motion in Atoms and Molecules," Phys. Rev. Lett. **105**, 263201 (2010). *This work has been highlighted in Physical Review Focus: http://focus.aps.org/story/v26/st25 as well as by NSF: http://go.usa.gov/pwn*

[6] H.-C. Shao and A.F. Starace, "Imaging Coherent Electronic Motion in Atoms by Ultrafast Electron Diffraction," Phys. Rev. A **88**, 062711 (2013). *This article has been selected by the editors of Physical Review A as an "Editor's Suggestion."*

[7] H.-C. Shao and A.F. Starace, "Imaging Electronic Motions in Atoms by Energy-Resolved Ultrafast Electron Diffraction," Phys. Rev. A **90**, 032710 (2014).