Minicourse on Atoms and Molecules in Strong Laser Fields, March 18-22

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1st hour (lecture): Introduction to the theory of short pulsed lasers. Topics such as carrier envelope phase, chirped laser and the representation of the fields using time-frequency plots will be covered.

2nd hour (exercise): Different laser fields given in the frequency domain will be discussed. We will Fourier transform the fields into the time-domain.

3rd hour (lecture): Basics of the solution of the time-dependent Schrödinger equation will be discussed. The Dyson series for the time-evolution operator as well as the Magnus expansion in the case of time-dependent potentials are explained.

4th hour (lecture): Basics of semiclassical wavepacket evolution and semiclassical propagators will be explained. The numerical implementation of semiclassical Herman-Kluk propagation will be discussed. To this end we will also highlight symplectic integration and coherent states.

5th hour (exercise): Special cases of thawed Gaussian wavepacket evolution for free particles and harmonic oscillators will be discussed. Furthermore, the short-time evolution operator will be used to rederive the Dyson series.

6th hour (lecture): The minimal coupling of laser fields to charged particles will be discussed both classically as well as quantum mechanically. Different gauges (length and velocity) as well as frames (Kramers-Henneberger) will be introduced.

7th hour (exercise): The transition from the velocity to length gauge as well as the derivation of the Kramers-Henneberger frame from the velocity gauge will be discussed in detail. The ponderomotive potential will be derived.

8th hour (lecture): Different scenarios for driven tow-level dynamcis will be reviewed. We will discuss Rabi oscillations, rotating wave approximation, π pulses and Landau-Zener as well as Rosen-Zener models.

9th hour (lecture): Brief introduction to atomic physics (hydrogen, helium, atomic units) will be followed by the discussion of different ionization phenomena (multi-photon, tunneling, above threshold).

10th hour (lecture): High-order harmonic generation and its implications will be discussed. Topics are the three-step model (and the simpleman's model), the odd harmonics only rule and the plateau and cutoff in the intensity of the harmonics.

11th hour (exercise): Determination of the ground state energy of 3D hydrogen using a variational method, explicit demonstration that only odd harmonics are produced in the limit of cw-laser driving. Determination of ADK ionization rates for a simple model system.

12th hour (lecture): Introduction to the theory of molecules (LCAO approximation) with a special emphasis on the Born-Oppenheimer approximation.

13th hour (lecture): Hydrogen molecular cation under the influence of strong fields: dissociation, ionization, bond softening. Treatment without and with moving nuclei.

14th hour (lecture): Thorough discussion of pump-probe photoelectron spectroscopy of Na_2. The possibility to generate movies of molecular motion will be highlighted.

15th hour (lecture): In-depth review of the theory of coherent destruction of tunneling using the Floquet picture. Recent experimental realizations of the phenomenon will be discussed.