

## Multi-scale model of HHG in gases

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The High-order harmonic generation (HHG) is a workhorse tool of the whole attosecond science. Our intention is to have a comprehensive computational picture of HHG in a gas phase. Such a picture requires to couple two scales: 1) The macroscopic model of the driving pulse strongly affected by a non-linear propagation. 2) A single microscopic system – an atom or a molecule interacting with the pulse – described naturally by quantum physics.

The primary goal is to provide an ab-initio fully-numerical solver of the process. The microscopic aspect is covered by solving the Time-dependent Schrödinger equation (TDSE) and the resulting harmonic field is computed by the means of the diffraction integral based on the Hankel transform. Finally, the non-linear propagation of the driving pulse is computed by the unidirectional solver [1].

Coupling these solvers already provided a detailed insight in generating mechanisms. We used the multi-scale approach to model the control of the focusing properties of the generated field in thin targets [2] without a need of an XUV optics. Next, we modelled the optimisation of HHG in long media controlling the initial degree of the ionisation of the generating medium [3]. Both these schemes were investigated in close collaboration of experimentalists and theorists. The numerical model proved its indispensable role to extract key mechanisms and to sort complex interplays of microscopic and macroscopic effects within the process. The multi-scale approach reached a good quantitative agreement with experiments.

Finally, the fully numerical model is computationally expensive. Our palette is then enriched by simpler tools (modelling both IR- and harmonic beams by Gaussian optics, using simplified models of the microscopic response, etc.). A large parametric space may be searched by these simple models and promising configuration pivot refinements and detailed studies by the full model.

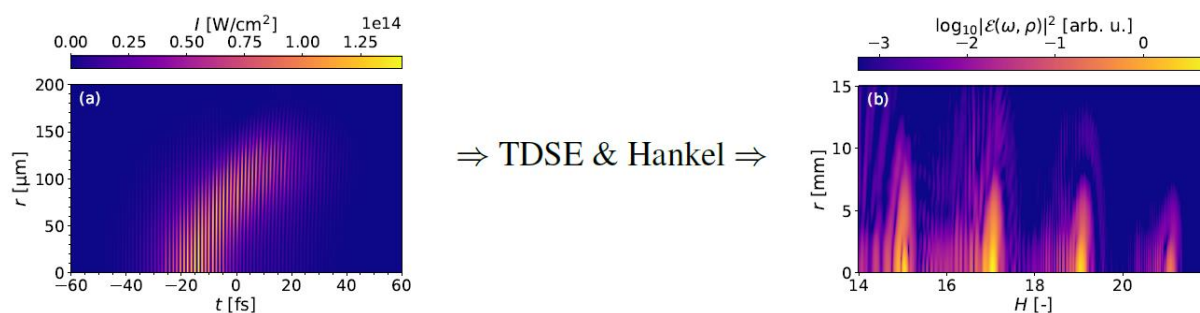


Figure 1: (a): An example of the distortion of a Gaussian pulse (both in space and time) at 800 nm after the passage through a 15mm-long gas-cell filled by Krypton. (b): The harmonic spectrum from the whole interaction volume in the far-field (5 m). The conditions correspond to the generating scheme used in [3].

### References

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