Relativistic treatment of hole alignment due to autoionization processes and Cooper minima in noble gas atoms

R Tahouri, A Papoulia, F Zapata, S Carlström and J M Dahlström
Department of Physics, Lund University, Lund, 22100, Sweden
marcus.dahlstrom@matfys.lth.se

The recent developments in attosecond physics allow us to study the temporal dynamics of photoelectrons and corresponding ions in photoionization experiments. In noble gases, the ion consists of several "holes" characterized by the properties of the missing electron. The alignment of a hole refers to the population ratio of different magnetic quantum numbers, m_j, with the same j [1]. In this work, we tune the field frequency to make use of particular spectral properties of absorption cross section, like Fano profiles of autoionizing states and Cooper minima, to control this alignment. Since holes are coupled to the total angular momentum, j, a consistent treatment of relativistic effects should be employed. Here, we use the Relativistic Time-Dependent Configuration-Interaction Singles (RTDCIS) method [2].

The RTDCIS method can be used to study partial cross sections and photoelectron fluxes in noble gas atoms when interacting with ultra-fast pulses. This method, which is based on the Dirac-Fock spin-orbitals, accounts for electron correlation effects at the level of single excitations. In this way, photoelectron and hole pairs can be simulated in a relativistic framework. Here, we focus on reduced ion channels, which correspond to unresolved photoelectrons, by summing incoherently the population of the outgoing electrons corresponding to a given hole state.

In previous studies, the photon energy was tuned to autoionizing states [1]. As Fano resonances are spectrally narrow, they demand long XUV pulses (hundreds of fs) to achieve a high degree of alignment. Here, we consider the Cooper minimum of argon and xenon, which gives the possibility of employing shorter pulses (hundreds of as) to obtain a high degree of alignment, as seen in Figure 1 where an alignment ratio of 23.6 is achieved for argon. Thus, Fano resonances and Cooper minima present promising avenues to hole alignment studies for a wide range of pulses.

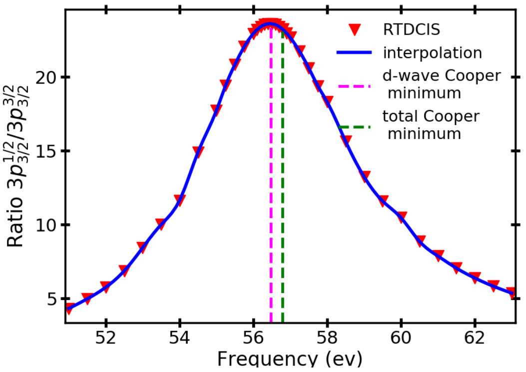

Figure 1: The ratio of ion populations in argon after interaction with a 300 as pulse.

References

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