Above-threshold ionization caustics and their parameter dependence

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Ultrafast photoelectron holography has revealed a myriad of interference patterns, which can be associated with different quantum pathways. In particular, path-integral methods link these pathways with interfering electron orbits. Thereby, important questions are the relevant orbits and the interplay of the external driving field with the residual binding potentials [1]. Important breakthroughs in this direction have been achieved with the Coulomb Quantum-Orbit Strong field approximation (CQSFA). This approach avoids a large number of orbits by solving a boundary problem relying on physical intuition and/or symmetries to classify specific types of orbits. This makes it straightforward to disentangle specific holographic structures [2], but compromises its versatility if different driving fields are used.

Recent developments to the CQSFA have increased versatility in comparison with previous iterations of the theory [3, 4]. Instead of solving the boundary value problem for a very specific selection of trajectory types, initial forward propagation is utilised to generate an abundance of additional valid semiclassical trajectories. These additional trajectories lead to new interference structures in the resulting photoelectron momentum distributions (PMDs) as well as introducing different caustic structures. This comes at the cost of the simplicity of trajectory classification which can no longer be straightforwardly utilised to disentangle the interference patterns observed in the PMDs as in [2]. This difficulty arises due to the increased complexity of the initial to final momentum mapping, defined by the endpoints of the semiclassical trajectories. In two dimensions, the mapping consists of regular points and singular points where fold and cusp catastrophes occur. Additionally, caustics which take the form of two-dimensional slices of the catastrophe surface of higher codimension catastrophes can occur such as those found in [5]. We study how these caustics vary with parameters of the field and the potential, such as how the rescattering ridge recedes tangentially as a Coulomb softening parameter is introduced. Also, we use trajectory classifications derived from the focal character of these trajectories, to regain some of the power of the original CQSFA to disentangle and understand the new interference patterns.

References

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