XXIX International Conference on Photonic, Electronic, and Atomic Collisions (ICPEAC2015) IOP Publishing
Journal of Physics: Conference Series **635** (2015) 032094 doi:10.1088/1742-6596/635/3/032094

Electron interferences in the ionization of the dimers by swift ion impact: Origin of high-order frequency

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Synopsis We report evidence for interference phenomena beyond Young-type in electron emission spectrum from the dimers by fast ions. Prior measurements for H_2 have led to a wide discussion for which no definitive conclusions have been settled, whereas theoretical-side have failed to reproduce the phenomenon. The process under investigations is treated by using a nonperturbative semi-classical approach to solve the time-dependent Schrödinger equation. Our results are supported by an analytic model based on second- and third-order Born series.

Double-scattering effects were claimed to be observed and evoked to explain additional oscillatory structures in the measured spectra in fast ion-H_2 collisions. The first experimental observations of such additional structures were sparked off further experimental and theoretical efforts to enhance the understanding of the complete nature of the phenomenon [1]. In spite of the number of experiences performed in that context, no clear demonstration has been reached [2, 3, 4, 6]. In contrast, theoretical investigations have been unable to reproduce the phenomenon [7, 8]. This makes the numerical demonstration of the existence of such effects a real challenge.

During the conference we shall present our results stemming from a nonperturbative approach to solve the time-dependent Schrödinger equation in which all high-order mechanisms are taken into account in the dynamical stage. The purpose is to resolve this controversy and explain why calculations on H_2 do not get to any additional features related to high-order interference. This is achieved by investigating completely different energetic ion-molecule collisions, in which a clear footprint of high-order frequency in electron emission spectra is found. As is shown in Fig. 1 the spectrum shows up to four distinct harmonics from the full molecular treatment. In contrast, the corresponding results "2Rb" stemming from a pseudo-molecular model exhibit only first order frequency characteristic of Young-type interference. Our nonperturbative calculations are supported by a model derived from second- and third-order Born series. The latter reproduces the spectrum almost perfectly. We will also report an extension to a triatomic linear molecule which reveals additional and strong harmonics.

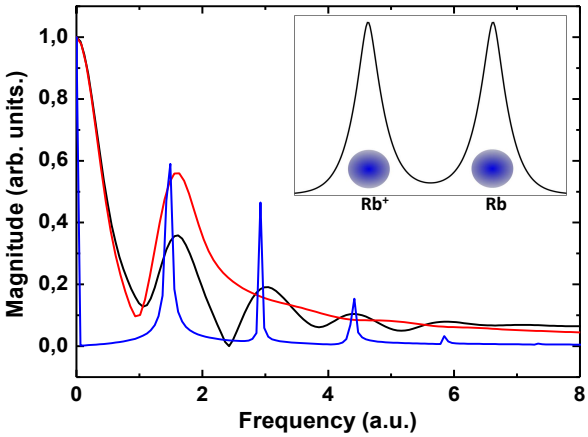

Figure 1. Frequency distributions from calculations for 63 Mev/u collisions of $H^+ - Rb_2^+$ (black curve) and $H^+ - 2Rb$ (red curve) compared with the Fourier spectrum from the third Born model (blue curve). The model $2Rb$ is resulting from a coherent sum of the ionization wave-function from two-independent monomers separated by a distance R_{ab}=9.2 a.u.. Inset: Initial Electronic probability density vs. spatial coordinate x ($\mid x \mid$<10 a.u.).

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