Optical Analogy in Ion-Atom Collision

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Interference patterns observed in the collisions between ions and diatomic molecules have been extensively investigated as analogous to the Young's double slit experiment [1-2]. It turns out, however, that a similar pattern can also be observed in the scattering from an atom by the impact of ion, the interaction region of which behaves like a single slit, instead of a diatomic molecule. This is well known by Fraunhofer-type diffraction in classical optics. Every particle has a wave nature according to deBroglie's hypothesis. So, when an atomic matter wave instead of light is projected on aperture, a similar diffraction pattern should appear. The difficulty in realizing this kind of experimentlies in the fact that the radius of the aperture has to be of the order of atomic scale size owing to the short wavelength of an atom.

For deeper understanding of charge transfer dynamics in ion atom collision, the differential scattering cross-sections (DCS) are required and they provide more detailed information about the dynamical stage between the collision patterns. Such DCS results show the oscillatory pattern. The first experimental observations of oscillatory DCS were made by Van der Poel et al [3] for slow $Li^{+}-Na$ single electron-capture collisions. We use the four-body formalism of boundary corrected continuum intermediate state approximation (BCCIS-4B) [4]. In the center of mass frame, the DCS for electron capture is given by

$$\sigma(\theta_P, E) = \frac{d\sigma}{d\Omega_P} = \frac{\mu_i \mu_f}{4\pi^2}\frac{k_f}{k_i}\left|T_{if}^{(-)}\right|^2,$$

where $$T_{if}^{(-)} = < \psi_f^- \mid V_i \mid \psi_i^+ >.$$

Here ψ_i^+ is the initial state which is distorted by incoming projectile and ψ_f^- is a Coulomb distribution in the final channel.

References:

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