

## Invisible oscillations in the photodetachment cross section of $H^-$ near a surface

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**Abstract.** The photodetachment of  $H^-$  near a surface is investigated. A laser polarized parallel to the surface is used for the detachment of the electron. Analytical expressions for the detached-electron flux and total photodetachment cross section are derived. The detached electron flux displays strong interference pattern on the screen. Unlike the detached electron flux no visible oscillations are found in the photodetachment cross section. The photodetachment cross section in low energy limits is double of the cross section of  $H^-$  in free space.

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## 1 Introduction

Interference phenomenon of quantum particles, like electrons and photons, has played vital role in the development of quantum mechanics [1]. Interest in the photodetachment process and photodetachment spectroscopy is shown in the recent years [2]. The photodetachment cross section for hydrogen negative ion ( $H^-$ ) has been investigated experimentally [3,4] and theoretically [5–11].

External fields and surfaces significantly manipulate the photodetachment process of negative ions [12–14]. The induced effects of external fields and walls in the photodetached electron spectra is an interesting topic of investigation in quantum interference.

Effects of laser polarizations relative to the static electric field direction have been studied by closed orbit theory [15,16]. Yang *et al.* applied closed orbit theory to study the

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photodetachment of  $H^-$  near a wall. The derived formula has two parts, one for smooth background term and second for oscillatory term. Their result shows some deviation from the one in static electric field. In another study Yang *et al.* [17] applied closed orbit theory and quantum approach to study the photodetachment of  $H^-$  in a static electric field near a wall. They found that the cross section displays irregular staircases. Theoretical imaging method [18] and the closed orbit theory [7, 19] have provided a useful theoretical frame-work to understand the oscillations in the absorption spectra of  $H^-$  near a reflecting surface. In the present work we use theoretical imaging method and study the photodetachment of electron from  $H^-$  near a surface in a laser field polarized parallel to the surface. We report that unlike the case in Ref. [18], when the laser is polarized parallel to the surface, it induces invisible oscillations in the photodetachment cross section of  $H^-$ . Atomic units are used throughout the article or mentioned otherwise.

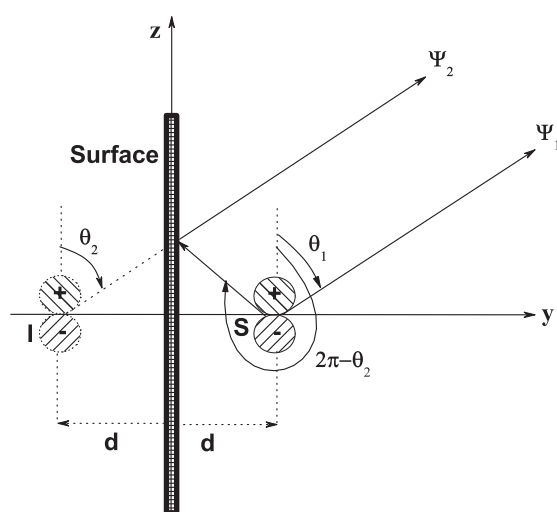


Figure 1: Schematic diagram of the photodetachment of hydrogen negative ion ( $H^-$ ) near a hard reflecting surface. The surface is orientated parallel to  $z$ -axis. The  $H^-$  which acts as a source (S) of the detached electron waves is placed at a distance ( $d$ ) in front of the surface. The surface like a plane mirror forms image of the  $H^-$  behind the surface. A  $z$ -polarized laser is used to shine the system. The two component waves are indicated by  $\Psi_1$  and  $\Psi_2$ . The component wave  $\Psi_1$  is the direct outgoing wave and the component wave  $\Psi_2$  appears as originated from the image (I) of  $H^-$  behind the surface. The two adjacent circles in front of the surface represent the  $p$ -symmetry of the outgoing detached electron wave. The observing screen is assumed to be placed at a large distance from our system.

## 2 Theory

The schematic diagram for the photodetachment of  $H^-$  near a reflecting surface is shown in Fig. 1. The surface is placed at origin perpendicular to the  $y$ -axis. The hydrogen