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Total cross section for low-energy electron scattering from HD

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1 Introduction

The scattering of low-energy electrons by atoms and molecules has been the subject of extensive experimental and theoretical investigations. The cross-section data concerning electron-atom or -molecule scattering are of great importance in understanding fundamental physics of the electron collisions and applications in many fields. Electron scattering from hydrogen molecule has been extensively studied both theoretical and experimentally as a simplest system for electron scattering from a molecule.

A large number of papers have been published to report data for the total cross sections and differential cross sections for electron scattering from H_2 and several recommended cross section data-sets were also published such as Ref. [1]. On the other hand, studies on isotope effect of cross sections for low-energy-electron scattering from H_2 are very few up to now. Early measurements of Golden *et al.* reported identical total electron scattering cross sections for both H_2 and D_2 from 0.25 to 15 eV [2]. Later, Ferch *et al.* measured total electron scattering cross sections for H_2, D_2 and HD down to very low energy of 0.02eV [3]. Although, Ferch et al obtained slightly different cross section values from those reported by Golden *et al.*, no isotope effects were found. However, in our recent measurement of the total electron scattering cross sections for H_2 and D_2, a clear isotope effect has been observed at around 3 eV. Total cross section curve for low-energy electron scattering from H_2 is dominated by a wide structure-less maximum at around 3 eV known as the $^2\Sigma$ shape resonance which is a consequence of the formation of temporary negative ion, i.e., H_2^- with very short lifetime. Since the contribution of the inelastic cross sections including the vibrational excitation of the molecule, which should show isotope effects, is fairly large at around the shape resonance, the observed isotope effect is reasonable.

In the present work, in order to expand our study on the isotope effect for the cross sections of electron scattering from the hydrogen molecule, measurements of total cross sections of electron scattering from HD were carried out.

2 Experiment

The experiment has been carried out at the beamline 20A of the Photon Factory, KEK. Present experiment employs the threshold photoelectron source [4] utilizing the synchrotron radiation (SR) which utilizes the penetrating field technique together with the threshold photoionizaion of noble gas atoms by the SR. The threshold photoelectrons produced by the threshold photoionization of Ar are extracted by a weak electrostatic field formed by the penetrating field technique and formed into a beam. The intensity of the electron beam passing through the collision cell without any collision with the target was detected by the channel electron multiplier. The counting rates of the detected electrons were measured as a function of the number density of the target gas filled in the gas cell in order to obtain the total cross section for electron scattering according to the attenuation law. The use of the threshold-photoelectron source has a great advantage in its extreme stability against the existence of the target gas which leads to the high-precision measurement of the cross sections.

3 Results and Discussion

In the present measurements, the total cross sections for electron scattering from HD showed slight isotope effect to H_2 at around 3 eV, i.e., the total electron scattering cross section curve for HD at around the $^2\Sigma$ shape resonance resembles much more to that of H_2 and differs from that of D_2. This finding shows that the origins of the isotope effect observed in the total cross sections may not be only due to the isotope effect on the vibrational excitation cross section, since the isotope effect for HD due to the vibrational excitation cross sections would be in between H_2 and D_2.

Present study also revealed an interesting cross section feature of HD at electron energy below 0.05 eV. The measured total cross section for HD showed much larger values compared to H_2 and D_2, where the cross sections for H_2 and D_2 were identical. Although, inelastic cross sections may show slight difference, the observed cross section difference is much larger than that expected from the isotope effect on the inelastic cross sections.

References

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