International Journal of Theoretical & Applied Sciences, **5**(2): 60-63(2013)

ISSN No. (Print): 0975-1718
ISSN No. (Online): 2249-3247

Low Energy Electron Scattering Cross Section for Astro-Molecules H_2O, H_2S

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(Received 05 September, 2013, Accepted 15 October, 2013)

ABSTRACT: One of the most exciting aspects of the astrophysics is the continued discovery of the wide range of molecular species. The Astro-molecules like as H_2O, H_2S detected in interstellar matter have been covered in present study. In this paper, we report a theoretical study on electron scattering by Astro-molecules in the low-energy range. The rotational excitation differential scattering cross sections (DCS) are calculated for electron scattering by Astro-molecules like H_2O and H_2S, at the energy 2.14 eV. and 5.0 eV respectively. The Born Eikonal Series (BES) Approximation method is employed for present calculation and using the hard sphere dipole interaction potential model for electron-molecule interaction. The results obtained for present calculation are compared with experiment and theoretical data available in the literature.

Key words: Hard sphere dipole potential, Born Eikonal Series method, Total cross section

I. INTRODUCTION

The space between two stars is known as the interstellar space and matter existing therein is the called the interstellar matter. One of the most exciting aspects of the astrophysics is the continued discovery of the wide range of molecular species. The Astro-molecules detected have been covered in present study. The study of these molecules may show that throw more light on the formation of star and the cooling of interstellar gas. If there are exist free electrons, then their collisions with Astro-molecules might be an important mechanism to cool the gas. Recently, Astro-molecules like H_2O, H_2S have been detected from the interpretation of spectral data. So it is necessary to consider electron collision with Astro-molecules like H_2O, H_2S. In the study of e-HCN collision under interstellar condition, Saha et-al calculated rotational excitation total cross section in low energy range by close coupling method and compared the results with those due to First Born Approximation in the above calculations they used the point dipole potential model [1-4]. In present investigation, the rotational excitation differential scattering cross section (DCS) for electron-H_2O at energy 2.14 eV and e-H_2S at energy 5.0 eV are calculated, employing Born Eikonal Series (BES) Approximation method, using hard sphere dipole interaction potential model. The hard sphere cut-off parameter "a" is considered as "D/2", where "D" is dipole moment of molecule [5-8]. The present results are compared with theoretical the results of Desai *et. al* using FBA finite dipole model [7]. Machado *et. al*, Gianturco *et.al* and Jain Thompson and experiment results of Jung K. *et.al.* [11,9,8]. In general the present DCS results for e-H_2O and H_2S collision at low energy are found in good agreement with those of compared results.

II. FORMULATION

BORN EIKONAL SERIES METHOD (BES)

In order to take into account somewhat higher terms of Born series, one can use Eikonal approximation. Ashihara et. al (1975) employed Glauber formulation in Eikonal approximation for electron dipole collisions [6]. They calculated cross section for strongly polar molecules. Although this approximation is originally a high energy approximation, it has been applied successfully to the low energy electron atom collisions (Gerjuoy; 1971). In the present investigations an attempt is made to employ Born Eikonal Series method for the cross sectional calculations for the low energy electron Astro-molecule collision. The interaction potential V(r) can be expressed in following form [7],

$$V(\underline{r}) = -2eq \sum_{n=odd} \frac{r_<^n}{r_>^{n+1}} P_n(\hat{r},\hat{s})$$ …(1)

Where $r_>$ and $r_<$ are the larger and the smaller of r and P_n $(\hat{r},\hat{s})$ is the Legendre polynomial of the order n. "a" is the parameter which indicates finiteness of the dipole and related to the dipole moment by the relation D = 2aq. Taking n = 1 only one can get the expression for electron finite dipole interaction potential and it is employed in cylindrical polar co-ordinate, one can name a linear dipole model.

$$V(\underline{r},\hat{s}) = V(\underline{b}, z) = o \qquad \text{for } z < a$$ …(2)

$$V(\underline{r},\hat{s}) = V(\underline{b},\hat{z}) = -\frac{D}{b^2+z^2} P_1(\underline{r},\hat{s}) \qquad \text{for } z > a$$ …(3)

Where, "a"- is the hard sphere parameter (cut-off parameter).

The formula for the Eikonal phase shift function $\chi(b)$ is given by,

$$\chi(b) = -\frac{2D\gamma}{ki} \int_a^\alpha \frac{z\,dz}{(b^2+z^2)^{3/2}}$$ …(4)

'γ" is the direction cosine of the dipole axis with respect to the polar axis.

A series expansion of scattering amplitude as give by,

$$f_{E1} = \frac{2D\gamma}{\Delta \exp(a\Delta)}$$ …(5)

$$f_{E2} = \frac{2iD^2\gamma^2}{ki} k_0(a\Delta)$$ …(6)

…(7)

Where $K_0(a\Delta)$ - is a Bessel function, Δ = Iki-kfI is momentum transferred. The differential cross section (DCS) for three terms in Born Eikonal Series Approximation can be expressed as follow,

$$\frac{d\sigma}{d\Omega}(j_0 m_{j_0} \to j m_j;\theta) = \frac{kf}{ki}\left|f_{E1} + f_{E2} + f_{E3}\right|^2$$ …(8)

Summing over m_j and averaging over $m_{j0,}$ one gets the DCS for the rotational transition *j_0 j_o + 1.*

Differential Scattering cross-section (DCS):-

…(9)

Where A = mDe/h^2

III. RESULTS AND DISCUSSION

Aim of the present study is to obtain theoretical differential scattering cross section (DCS) for electron collisions with Astro-molecules like H_2O and H_2S. The Born Eikonal Series (BES) Approximation method and hard sphere dipole interaction potential model is employed for present calculation. The hard sphere cut-off parameter "a" is considered as D/2, D-is the dipole moment of molecule.

Fig.1 show DCS results for e - H_2O collision at energy 2.14 eV. The present DCS results calculated using BES hard sphere dipole potential are compared with the results of Desai et-al using FBA method for finite dipole potential model and Machado *et.al* and experiment results of Jung [8]. The present results are shown in the good agreement with those of Desai *et.al*, Machado *et. al* and experiment results of Jung results at the angles between 0°-70°. Above 70° the present results decreases with increment of scattering angle, it become minimum at about angle 95° and then again increases. Similarly, in the region between 80° to120° the difference between present results and those of Machado results also increase, become maximum and then decrease. However in this region present results are in good agreement with the experimental results of Jung as compared with the results of Machado results. Above angle 120° the present results shown good agreement with the results of Machado [11]. At lower angle (0°- 40°), the present results using BES method employing hard sphere potential model are in better agreement with those of Desai, using FBA finite dipole models, Machado *et. al* and experiment results of Jung [8], but above angle > 40° they differ appreciably.

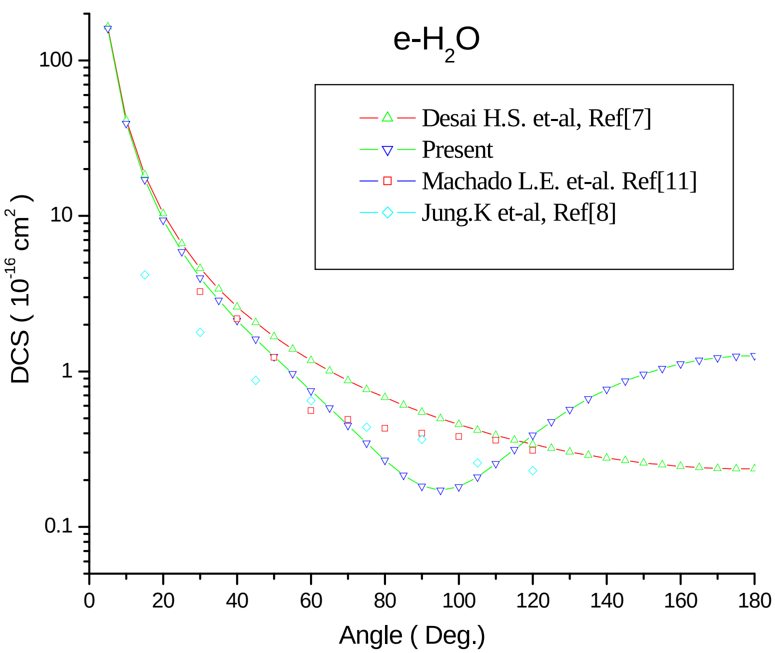

Fig.-1: Differential cross section (DCS) for e-H_2O scattering at 2.14 eV

Fig. 2 show present DCS results calculated for e-H_2S at energy 5.eV. using BES hard sphere dipole potential model. The present results are compared with results of Desai H.S. et-al[7] using FBA finite dipole potential, calculated results of Machado, Gianturco and experimental results of Jain Thompson. It is found that results of FBA finite dipole potential do not show appreciable difference. At lower angle, they are over lapping. At higher angle, the results of FBA finite dipole potential are slightly lower than those of FBA point dipole potential. The present BES hard sphere dipole potential results are found in good agreement with finite dipole potential FBA results at lower angle. The present results are found in a good agreement with the theoretical results of Gainturco, Jain Thompson and Machado at angle from 10°to 80° and above 110° [9,11]. In general the present DCS results for e-H_2S collision at low energy are found in good agreement with those of compared results.

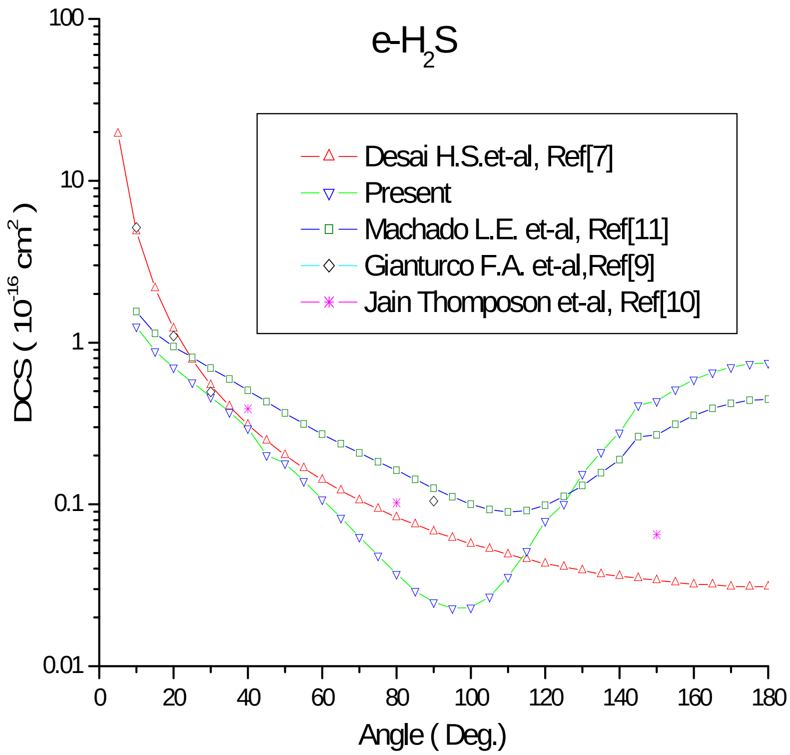

Fig.2: Defferential cross section (DCS) for e-H_2S scattering at energy 5.0 eV.

IV. CONCLUSION

In this work, we have reported a theoretical study of low- energy electron collision with Astro-molecules, using BES hard sphere dipole potential. The rotational excitation DCS results are presented in comparison with some existing experimenta[11] and other theoretical results [9-11]. The results are in general good agreement with the measured data. This good agreement supports the description of the interaction dynamic considered in the present study and methods used for solving the scattering equations. Hence it will be worthwhile to use hard sphere dipole potential model in Born Eikonal Series (BES) for better to study of electron-Astro molecules collision process in low energy region. The present results may be improved to consider higher terms in present method.

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