CHAPTER - III

MODIFIED DAS METHOD

3.1 INTRODUCTION

As mentioned in the first chapter eventhough the exact wave function is known the evaluation of the schrodinger equation for a scattering process is a formidable task. Hence various approximations are used for the evaluation of the coupled integro differential equation. The simplest problem in scattering theory is the $\bar{e}$ - H atom scattering. Hence the validity of a new approximation is checked by applying it on $\bar{e}$ - H atom system . If it gives desirable results then it is appreciable to check the validity of that method for other atoms and molecules. The next simplest atom is helium atom. For helium also highly accurate and simple wave functions are known. Experimental results are also available for it. After that comes Li atom . But for Li experimental results are not available for intermediate energy region. Thus in the present chapter we have applied the new method for the elastic scattering of electrons by hydrogen, helium and Li atoms.

The Born series can be applied to find out the scattering amplitude for $\bar{e}$ - atoms. Even for $\bar{e}$ - hydrogen atom problem the exact evaluation is difficult since it contains an infinite number of terms. Hence various truncated forms of the series are taken. The first Born approximation account only the static part. Hence to account for other interactions namely polarisation, absorption and distortion of the incident particle effects one has to include the higher order Born terms. In recent years various approximations containing higher order terms are employed with varying degrees of success (Byron and Joachain 1973, 77a, 77b, 75 ; Holt and Moiseiwitch 1968 ; Gien 1977a, 77b, 79 ; Rao and Desai 1981, 83a, 83b). A new method was suggested by Das (1978) to account for the missing higher order Born terms. He had started with Fredholm integral equation. He used a trial function for the scattering amplitude (f_{in}) as the input function to obtain a better output scattering amplitude(f_{out}) as the solution of the integral equation. f_{in} is a complex multiple of the first Born scattering amplitude. The complex parameter a + ib is independent of the scattering angle but depends upon the electron energy. The values of the parameters 'a' and 'b' are determined by minimising $|f_{out} - f_{in}|^2$

integrated over the whole angular region. This method was found highly successful for potential scattering (Das 1978). Das and his associates have applied this method for various scattering phenomena in the intermediate energy region (Das 1979 ; Das and Biswas 1980 ; Das et al 1981 ; Das and Saha 1981, 1982). However Jhanwar et al (1982) had shown that the real part of the forward scattering amplitudes for $\bar{e}$ - H and He atoms using the Das method are not in agreement with the dispersion results of de Heer et al (1977). The real part of the forward scattering amplitudes for $\bar{e}$ - H atom decreases continuously with the increase of the energy in the case of dispersion relation. But in Das method it increases with energy upto 400 eV and then starts decreasing. Further, it is observed that the total cross sections in Das method overestimate the experiment. Hence, the Das technique which is not difficult than a second Born computation, requires modification. A possible way to improve the Das method is to choose a better trial input scattering amplitude. This was done by Kusum Lata (1984). She had included the second amplitude, obtained by the use of the modified trial input scattering amplitude contains the third order Born term also and the higher order Born terms are included through the parameter 'a' and 'b'. They have retained the term of the order of K_i^{-2} in the expression for out put scattering amplitude. In this modified Das method only one parameter 'a' is required. This 'a' is calculated by two methods. In the first method (PI) 'a' is calculated following the same method described by Das. Hence it depends only on energy and independent of the scattering angle. But it has shown that if the expression for the scattering amplitude in modified Glauber approximation should equal to the scattering amplitude in Das method then 'a' and 'b' should be functions of scattering angle also. (Jhanwar et al 1982c) Hence in the second method (PI) they have calculated 'a' as a function of scattering angle also. This was done by making the difference $f_{out} - f_{in}$ equal to zero. Thus in PII, a is angle and energy dependent whereas in PI, it is only energy dependent.

As mentioned in first chapter, the second Born terms can be replaced by the second Born terms of HHOB approximation (Yates - 1979). The advantage is that the computation is much more simpler and the values will not differ from 2nd Born terms. The problem of diverging integrals are also not there. Hence we have applied the modified Das method (PI) with yates terms to find out the DCS for hydrogen helium and lithium atoms. Total cross sections are also found out for energies 100 to 700 eV for hydrogen atom. We have used PII also to find out the DCS for hydrogen and Helium.

Another modification we have done is the replacement of $\frac{1}{k_i^2}$ term of the real part of Yates by $\frac{1}{k_i^2}$ term of the real part of wallace (The calculations for that will be shown in next chapter). The DCS is calculated for the elastic scattering of electrons by H, He and Li.

Das method was also used to find out the total elastic cross sections for H, He and Li. Here also we have replaced the second Born terms by the corresponding terms in yates and wallace terms. The potential used here is the static potential given by Cox and Bonham (1976).

3.2 THEORY :

The input trial function using HHOB second Born term is taken as

$$f_{in}(\hat{\underline{q}}, \hat{\underline{k}}_i) = (a^H + i\, b^H)\,[f_{B1}(\hat{\underline{q}},\hat{\underline{k}}_i) + f_{B2}(\hat{\underline{q}},\hat{\underline{k}}_i)] \qquad (3.1)$$

Substituting this in (1.51) and proceeding the same way as described by Das, the expression for output scattering amplitude in PI method using HHOB terms is obtained as

$$f^{HI}_{out} = f_{B1} + (a^{HI} + i\, b^{HI})\,[f^{(2)}_{HEA} + f_{G3}]$$

$$= f_{B1} + a^{HI}(\mathrm{Re}\, f^{(2)}_{HEA} + f_{B3R}) - b^{HI}(I_m f^{(2)}_{HEA}$$

$$+ f_{B3I}) + i[a^{HI}(I_m f^{(2)}_{HEA} + f_{B3I})$$

$$+ b^{HI} \left(Re\ f^{(2)}_{HEA} + f_{B3R} \right)] \qquad (3.2)$$

Here $I_m f^{(2)}_{HEA}$ and $Re\ f^{(2)}_{HEA}$ are the imaginary and real terms of HHOB (Yates 1979) terms. $Re\ f^{(2)}_{HEA}$ contains two terms. Hence we will write $Re\ f^{(2)}_{HEA} = Re\ 1\ f_{HEA} + Re2f_{HEA}$

The parameters a^{HI} and b^{HI} are obtained as

$$a^{HI} = \frac{\int d\Theta\ Sin\Theta\ f_{B1} \left(f_{B1} - f_{B3R} \right)}{\int d\Theta\ Sin\Theta \left[(f_{B1} - f_{B3R})^2 + f^2_{B3I} \right]}$$

$$(3.3)$$

$$b^{HI} = \frac{\int d\Theta\ Sin\Theta\ f_{B1}\ f_{B3I}}{\int d\Theta\ Sin\Theta \left[(f_{B1} - f_{B3R})^2 + f^2_{B3I} \right]}$$

where f_{B3R} and f_{B3I} are real and imaginary parts of 3^{rd} order Born term. f_{B3I} is of the order k_i^{-3}. Hence it is neglected. f_{B3R} is replaced by f_{G3} since it is equivalent to f_{B3R} practically all angles.

Thus the output scattering amplitude becomes

$$f^{HI}_{out} = f_{B1} + a^{HI} \left(Re\ f_{HEA} + f_{G3} \right) + i\ a^{HI}\ I_m f^{(2)}_{HEA}$$

$$(3.4)$$

Replacing Re 2 f_{HEA} by the corresponding wallace term we will get the output as

$$f_{out}^{WI} = f_{B1} + a^{HI}(\mathrm{Re}\ 1\ f_{HEA} + f_{w2} + f_{G3}) + i\ a^{HI}\ I_m\ f_{HEA}^{(2)} \qquad (3.5)$$

The output scattering amplitude for the second method can be obtained as

$$f_{out}^{HII} = f_{B1} + a^{HII} + i\ b\ H^{II}\ (\mathrm{Re}\ f_{HEA}^{(2)} + f_{B3})$$

$$= f_{B1} + a^{HII}(\mathrm{Re}\ f_{HEA}^{(2)} + f_{B3R}) - b^{HII} (I_m\ f_{HEA}^{(2)} + f_{B3I}) + i[\ a^{HII}(I_m f_{HEA}^{(2)} + f_{B3I}) + b^{HII}(\mathrm{Re}\ f_{HEA}^{(2)} + f_{B3R})\ ] \qquad (3.6)$$

The parameters a^{HII} and b^{HII} are calculated by putting $f_{out}^{HII} - f_{in} = 0$.

$$a^{HII} = \frac{f_{B1}}{(f_{B1} - f_{B3R}) + \dfrac{f_{B3I}^{2}}{(f_{B1} - f_{B3R})}} \qquad (3.7)$$

and

$$b^{HII} = \frac{f_{B1}\, f_{B3I}}{(f_{B1}-f_{B3R})\,[(f_{B1}-f_{B3R}) + \frac{f^2_{B3I}}{(f_{B1} - f_{B3R})}\,]} \qquad (3.8)$$

Replacing f_{B3R} by f_{G3} and keeping the terms up to k_1^{-2} f^{HII}_{out} becomes

$$f^{HII}_{out} = f_{B1} + a^{HII}\,(\mathrm{Re}\, f^{(2)}_{HEA} + f_{G3}) + i a^{HII}\, I_m\, f^{(2)}_{HEA} \qquad (3.9)$$

f^{WII}_{out} can be obtained by replacing $\mathrm{Re}\,2f_{HEA}$ by the corresponding wallace terms.

$$f^{WII}_{out} = f_{B1} + a^{HII}\,(\mathrm{Re}\; 1\; f_{HEA} + f_{w2} + f_{G3}) + i\, a^{HII}\, I_m\, f^{(2)}_{HEA} \qquad (3.10)$$

where

$$a^{HII} = \frac{f_{B1}}{f_{B1} - f_{G3}} \qquad (3.11)$$

The exchange scattering amplitude is obtained using the ochkur approximation.

The total elastic scattering cross sections are calculated using HHOB terms in place of second Born terms in Das method for hydrogen helium and lithium atoms. The state potential used here is those of Cox and Bonham. The present results are compared with those of Das and simple HHOB approximation.

3.3 CALCULATIONS

The interaction potential taken here is

$$V_d = - r_o + \sum_{j=1}^{z} \frac{1}{|\underline{r}_o - \underline{r}_j|} \qquad (3.12)$$

The ground state wave function for the hydrogen atom can be written as

$$\psi_{1s}^{H} = \left(\frac{y^3}{8\pi} \right)^{1/2} \exp \left(- yr/2 \right) \qquad (3.13)$$

where $y = 2$

Hartree - Fock orbital for the atom is taken (Byron and Joachain 1973) as

$$\psi_{1s}^{He} = \phi_{1s}^{He}(\underline{r}_1) \; \phi_{1s}^{He}(\underline{r}_2)$$

$$= \frac{(P + Q)}{\sqrt{4\pi}} \; \frac{(R + S)}{\sqrt{4\pi}} \qquad (3.14)$$

where $P = A \exp(-y' r_1)$, $Q = B \exp(-y'' r_1)$,

and $R = A \exp(-y' r_2)$, $S = B \exp(-y'' r_2)$.

with $A = 2.60505$, $B = 2.08144$, $y' = 1.41$ and $y'' = 2.61$.

The first Born scattering amplitude can be obtained by substituting (3.13) in (1.16) with $z = 1$ in (3.12).

$$f^{H}_{B1} = 2 \frac{(q^2 + 2 y^2)}{(q^2 + y^2)^2} \qquad (3.15)$$

with $q = 2 k \sin \theta/2$.

For the atom represented by (3.14) we will get

$$| \psi^{He}_{1s} | = \frac{1}{16\pi^2} [P^2 R^2 + Q^2 s^2 + 4PQRs) + 2 P^2 s^2 + 2(2 PQs^2 + 2 PR^2Q)] \qquad (3.16)$$

Substituting (3.15) in (1.16) with $Z = 2$ in (3.12) we will get

$$f^{He}_{B1} = \sum_{k=1}^{3} C_k \left[\frac{(8 y_k^2 + q^2)}{(4y_k^2 + q^2)} \right] \qquad (3.17)$$

where C_k's and y_k's are constants given as

$C_1 = 2.420884$; $C_2 = 0.2336732$; $C_3 = 1.33543$

$Y_1 = 1.141$; $Y_2 = 2.61$; $Y_3 = 2.01$

The expression for $I_m f^{(2)}_{HEA}$ can be obtained from eqn. (2.12). Substituting $\bar{V}$ from (1.44) and $\psi\,\psi^*$ from (3.13) we will get for hydrogen atom

$$I_m^H f^{(2)}_{HEA} = -\frac{4}{\pi k_i} \left(\frac{\partial}{\partial y}\right) \int \frac{dp}{(|q-p|^2 + \beta_i^2)\, y^2} \left[\frac{2}{(p^2 + \beta_i^2 + y^2)} - \frac{q^2}{(q^2+y^2)\,(p^2+\beta_i^2)} \right] \tag{3.18}$$

After the evaluation of the two dimensional dp integral (given in appendix) the closed form of the imaginary contribution can be given as

$$I_m^H f^{(2)}_{HEA} = -\frac{4}{\pi k_i} \left(\frac{\partial}{\partial y} \right) \frac{1}{y^2} \left[2\, I_1(\beta_i^2, y^2) - \frac{q^2}{(q^2+y^2)}\, I_1(\beta_i^2, 0) \right] \tag{3.19}$$

The I_1 integral is given in the appendix.

The dr_1 evaluation of the real part, $Relf_{HEA}$, of order k_i (2.19) is exactly same as imaginary part. Hence using the above results of imaginary part, the

$\mathrm{Re}\,1f_{HEA}$ can be written as

$$\mathrm{Re}^{H}\,1f_{HEA} = \frac{4}{\pi^{2}k_{i}} \frac{\partial}{\partial y} \mathcal{P}\!\int d\mathrm{p} \int_{-\infty}^{\infty} \frac{dp_{z}}{(p_{z}-\beta_{i})}$$

$$\frac{1}{y^{2}} \frac{1}{(|q-p|^{2}+p_{z}^{2})} \left[\frac{2}{p^{2}+p_{z}^{2}+y^{2}} \right.$$

$$\left. - \frac{q^{2}}{(p^{2}+p_{z}^{2})(q^{2}+y^{2})} \right] \qquad (3.20)$$

After, performing the dp and dp_z integrals, the closed form of this scattering amplitude can be obtained as

$$\mathrm{Re}^{H}\,1f_{HEA} = \frac{4}{\pi^{2}k_{i}} \left(\frac{\partial}{\partial y}\right) \frac{1}{y^{2}} \left[2\, I_{2}\,(\beta_{i}^{2},\, y^{2}) \right.$$

$$\left. - \frac{q^{2}}{(q^{2}+y^{2})}\, I_{2}\,(\beta_{i}^{2},\, 0) \right] \qquad (3.21)$$

The evaluation of the integral I_2 is given in the appendix.

Now the integrals in $\mathrm{Re}\ 2\ f_{HEA}$ in (2.20) are same as $\mathrm{Re}\ 1f_{HEA}$. Here the integrand is simpler than $\mathrm{Re}\ 1f_{HEA}$. After performing $d\underline{r}_1$ integration, we will get

$$\mathrm{Re}^{H}\,2\,f_{HEA} = \frac{2}{\pi^{2}k_{i}^{2}} \left(\frac{\partial}{\partial\beta_{i}}\right) \left(\frac{\partial}{\partial y}\right) \mathcal{P}\!\int d\mathrm{p} \int_{-\infty}^{\infty} \frac{dp_{z}}{p_{z}-\beta_{i}}$$

$$\frac{1}{(|\underline{q} - \underline{p}|^2 + p_z^2)} \left[\frac{q^2 + 2y^2}{y^2 (q^2 + y^2)} - \right.$$

$$\left. (|\underline{q} - \underline{p}|^2 + p_z^2 + y^2)^{-1} - (p^2 + p_z^2 + y^2)^{-1} \right] \qquad (3.22)$$

Following the same proceedure for $d\underline{p}$ and dp_z integrals as discussed above, the closed form of this real part can be obtained as

$$\mathrm{Re}^{H}\, 2\, f_{HEA} = \frac{2}{\pi^2 k_i^2} \left(\frac{\partial}{\partial y} \right) \left(\frac{\partial}{\partial \beta_i} \right) \left[\frac{I_3\,(\beta_i, 0)}{q^2 + y^2} + \right.$$

$$\left. \frac{I_3\,(\beta_i,\, y)}{y^2} - I_2\,(\beta_i^2,\, y^2) \right] \qquad (3.23)$$

The integral I_3 is given in appendix.

For He following the same procedure for H the corresponding terms will be obtained by using (3.12), (3.15), (2.12), (2.19), and (2.20).

$$I_m^{He}\, f_{HEA} = \frac{1}{\pi k_i} \sum_{J,k=1}^{3} \left[- A_k \left(\frac{\partial}{\partial y_k} \right) \frac{H\,(y_k)}{y_k^2} + \right.$$

$$B_{kk} \left(\frac{\partial}{\partial y_k} \right) \frac{I_4'\,(y_k^2,\, y_k^2)}{y_k^2 \;\; y_k^2} + B_{kj} \left(\frac{\partial}{\partial y_k} \right)$$

$$\left(\frac{\partial}{\partial y_j} \right) \quad \frac{I_4'\,(y_k^2,\, y_j^2)}{y_k^2\;\; y_j^2} \qquad (3.24)$$

A_k' s and B_{kk}' s and Y_k' s , B_{kj}'s are constants given as

$y_1 = 2.82$, $Al = 13.573$, $B_{11} = 92.1074$,

$B_{12} = 117.604$, $y_2 = 5.22$, $A_2 = 8.665$,

$B_{22} = 37.5392$, $B_{23} = 187.931$, $A_3 = 21.689$

$B_{33} = 235.208$ $B_{31} = 294.376$, $y_3 = 4.02$ and

$$H(Y_k) = 2\, I_1\, (\beta_i^2,\, y_k^2\,) - \frac{q^2}{(q^2 + y_k^2)} \quad I_1(\beta_i, 0)$$

$$\mathrm{Re}\ 1\ f_{HEA}^{He} = \frac{1}{\pi^2 k_i} \sum_{j,k=1}^{3} A_k \left(\frac{\partial}{\partial y_k} \right) \frac{H'(y_k)}{y_k^2}$$

$$- B_{kk} \left(\frac{\partial}{\partial y_k} \right) \left(\frac{\partial}{\partial y_k} \right) \frac{I_4(y_k^2,\, y_k^2)}{y_k^2\ ,\ y_k^2}$$

$$- B_{kj} \left(\frac{\partial}{\partial y_k} \right) \left(\frac{\partial}{\partial y_j} \right) \frac{I_4(y_k^2,\, y_j^2)}{y_k^2\;\; y_j^2} \qquad (3.25)$$

Here $H'(y_k) = 2\, I_2\, (\beta_i^2,\, y_k^2) - \dfrac{q^2}{(q^2 + y_k^2)}\, I_2(\beta_i^2, 0)$

$$\mathrm{Re}\ 2\ f_{HEA}^{He} = \frac{1}{2\pi^2 k_i^2} \sum_{j,k=1}^{3} \left(\frac{\partial}{\partial \beta_i} \right) \left[\ A_k \left(\frac{\partial}{\partial y_k} \right) H^{11}(y_k) \right.$$

$$- \frac{B_{kk}}{2} \left(\frac{\partial}{\partial y_k} \right) \left(\frac{\partial}{\partial y_k} \right) \frac{I_5(y_k^2 , y_k^2)}{y_k^4}$$

$$- \frac{B_{kj}}{2} \left(\frac{\partial}{\partial y_k} \right) \left(\frac{\partial}{\partial y_j} \right) \frac{I_5(y_k^2 , y_j^2)}{y_k^2 \; y_j^2} \;] \tag{3.26}$$

where

$$H''(y_k) = \frac{I_3(\beta_i , 0)}{q^2 + y_k^2} + \frac{I_3(\beta_i , y_k^2)}{y_k^2} - I_2 (\beta_i^2 \quad y_k^2) \tag{3.27}$$

$$I_5(y_k^2 , y_j^2) = I_3 (\beta_i^2 , y_k^2) - I_4 (y_k^2 , y_j^2) (y_k^2 + y_j^2) + I_3 (\beta_i^2 , y_j^2) \tag{3.28}$$

The mean excitation energy for hydrogen and helium are taken as .465 and 1.3 respectively. For the calculation of the third Glauber term we followed Yates (1974) and obtained

$$f_{G3}^{H} (\lambda) = - \frac{y^4}{16 k_i^2} \left(\frac{\partial}{\partial y} \right) (q^2 + y^2)^{-1} \left[4 \left\{ \log \frac{(q^2 + y^2)}{yq} \right\}^2 + \frac{\pi^2}{3} - 2A(q, y^2) \right] \tag{3.29}$$

where $A(q, y^2) = 2\left(\ln \frac{q}{y}\right)^2 + \frac{\pi^2}{6} + \sum_{n=1}^{\infty} \frac{(-q^2/y^2)^n}{n^2}$ for $\frac{q}{y} < 1$

$$= \sum_{n=1}^{\infty} \frac{(-y^2/q^2)^n}{n} \qquad (3.30)$$

Singh and Tripathi (1980) had evaluated the Glauber term and of Yates (1974) and the simplified form of this was given by

$$f_{G_3}^{He} = \frac{2}{3\pi^2 k_i^2} \left[X_{31} + 3X_{32} \right] \qquad (3.31)$$

X_{31} and X_{32} are defined quantities .

Exchange is included through Ochkur approximation (Joachain 1975).

$$g_o = -\frac{2}{k_i^2} \int \underset{j}{\pi} dr_j \; \exp\left(i \, \underline{q} \cdot \underline{r}_j \right) \psi_i^*(\underline{r}_j) \, \psi_i(\underline{r}_j) \qquad (3.32)$$

Substituting (3.13) in above equation, we get for hydrogen atom.

$$g^H = \frac{y^4}{k_i^2 (y^2 + q^2)^2} \qquad (3.33)$$

and we will get for helium by substituting (3.14) in (3.32)

$$g^{He} = -\frac{8}{k_i}\sum_{k=1}^{3} A(k) / [q^2 + y(k)^2]^2 \qquad (3.34)$$

where $A(1) = A^2 y'$, $A(2) = B^2 y''$,

$A(3) = AB(y' + y'')$ and $y(1) = 2.82$,

$y(2) = 5.22$, $y(3) = 4.02$.

The calculations for Li atom are given in the previous chapter. The scattering amplitudes are calculated using the above equations.

The differential cross sections can be obtained from the following relation for hydrogen

$$DCS^{H} = \frac{1}{4}|f_d + g|^2 + \frac{3}{4}|f_d - g|^2 \qquad (3.35)$$

and for helium atom we use the relation

$$DCS^{He} = |f_d - g|^2 \qquad (3.36)$$

$$DCS^{Li} = |f_d|^2 \qquad (3.37)$$

f_d is the direct scattering amplitude.

The calculations for $f_{\omega 2}$ term for hydrogen helium and lithium will be shown in next chapter.

The state field can be defined as

$$V_{st} = \langle \psi_i \mid Vd \mid \psi_i \rangle ,$$

where Vd is the interaction between the incident election and target atom. The Cox and Bonham static potential is given by

$$V_{st} = Z \sum_{j=1}^{m} \gamma_i \; e^{-\lambda_i r}/r \qquad (3.38)$$

where Z is the atomic number γ_j and λ_j 's are the potential field parameter . The first Born amplitude is given by

$$f_{B1} = 2Z \sum_{j=1}^{m} \frac{\gamma_i}{(q^2 + \lambda_j^{\,2})} \qquad (3.39)$$

Following the same method explained earlier the real and imaginary parts can be as follows.

$$R_e\, f^{(2)}_{HEA} = \frac{Z}{2\, k_i^{\,2}} \sum_{i,j=1}^{m} \frac{\gamma_i \;\; \gamma_j (\lambda_i + \lambda_j)}{q^2 + (\lambda_i + \lambda_j)^2} \qquad (3.40)$$

$$I_m\, f^{(2)}_{HEA} = \frac{Z^2}{\pi\, k_i} \sum_{i,j=1}^{m} \gamma_i\, \gamma_j\, I_1\,(C, \lambda_i, \lambda_j) \qquad (3.41)$$

For the calculation of Das method we need second Born term.

$$f_{B2} = 4\,Z^2 \sum_{i,j} \gamma_i\,\gamma_j \int \frac{dk}{(k^2 - k^2 - i\epsilon)}$$

$$\frac{1}{(\lambda_i^2 + |\underline{K} - k_i|^2)\,(\lambda_j + |\underline{K} - k_i|^2)}$$

$$= 4z^2 \sum_{i,j} \gamma_i\,\gamma_j\,(A_R + i\,A_I) \qquad (3.42)$$

$$\mathrm{Re}\ f_{B2} = 4z^2 \sum_{i,j} \gamma_i\,\gamma_j\,A_R$$

$$I_m\ f_{B2} = 4\,z^2 \sum_{i,j} \gamma_i\,\gamma_j\,A_I$$

For $\lambda_i \neq \lambda_j$ the values of A_R and A_I are as follows

$$A_R = \frac{1}{2P}\ \tan^{-1}\left(\frac{2\,PA}{A^2 - P^2 + B^2}\right) \qquad (3.43)$$

and

$$A_I = \frac{1}{4P}\ \ln\left[\frac{A^2 + P^2 + B^2 + 2PB}{A^2 + P^2 + B^2 - 2PB}\right] \qquad (3.44)$$

$$P^2 = K_i^2\,q^4 + 2\,k_i^2\,(\lambda_i^2 + \lambda_j^2) + q^2\,(\lambda_i^2\,\lambda_j^2) + k_i^2\,(\lambda_i^2 - \lambda_j^2)^2$$

$$A = \lambda_i^2\,\lambda_j + \lambda_i\,\lambda_j^2$$

$$B = k_i(q^2 + \lambda_i^2 + \lambda_j^2 + 2\lambda_i \lambda_j)$$

For $\lambda_i = \lambda_j$

$$A_R = \frac{1}{q(\lambda_i^4 + 4k_i^2\lambda_i^2 + k^2q^2)^{1/2}}$$

$$\tan^{-1}\left[\frac{q\lambda}{2(\lambda_i^4 + 4k_i^2\lambda_i^2 + k^2q^2)^{1/2}}\right]$$

$$A_I = \frac{1}{q(\lambda_i^4 + 4k_i^2\lambda_i + k^2q^2)^{1/2}} \ln$$

$$\left[\frac{(\lambda_i^4 + 4k_i^2\lambda_i^2 + k_i^2q^2)^{1/2} + k_iq}{(\lambda_i^4 + 4k_i^2\lambda_i^2 + k_i^2q^2)^{1/2} - kq}\right] \tag{3.45}$$

a^D and b^D will be obtained by using the formula (1.55)

Putting $z = 1$, $z = 2$, $z = 3$ in the above equations the corresponding terms for hydrogen, helium and lithium atoms will be obtained. The values of λ_i's and γ_i's are given in the table. The total cross section for the present method is obtained through the equation

$$\sigma^{HI} = \frac{4\pi}{k_i}\left[a\, I_m f^{(2)}_{HEA} + b \,\mathrm{Re}\, f^{(2)}_{HEA}\right]_{\Theta = 0} \tag{3.46}$$

For simple HHOB the total cross section will be obtained using

$$\sigma^{HHOB} = \frac{4\pi}{k_i} [I_m f^{(2)}_{HEA}]_{\Theta=0} \qquad (3.47)$$

For D as method,

$$\sigma^{D} = \frac{4\pi}{k_i} [a^D I_m f_{B2} + b^D Re f_{B2}]_{\Theta=0} \qquad (3.48)$$

3.4 Results and Discussions :

3.4.1 Hydrogen Atom :-

The values of parameter a^{HI} and a^{HII} used in present method for hydrogen atom are shown in Table 3.1. The differential cross section and total cross section for the present method are compared with other theoretical results and available experimental data in Table 3.3 and 3.2 and in figures 3.1 to 3.3 . Eventhough the parameter a^{HI} are independent of angles a^{HII} are dependent on scattering angles. It can be seen in the table that a^{HII} increases with energy for a fixed angle but decreases with angle for a fixed energy. From the table it can be seen that for 100 eV the value of a^{HII} is less than a^{HI} from 40° onwards. At 200 eV the value of a^{HII} is less than 30° onwards and for 400 eV 30° onwards. Hence at low angles the differential cross section is high for HII and ωII method than respective HI and ωI methods. Due to the same reason the total cross sections are less than that obtained in EBS. Compairing our results with PI and Williams we can see that the present calculations are very near to the experimental values than PI. The difference between PI and our results are also not much noticeable. Hence we can justify the use of HHOB terms in place of second Born terms.

We have calculated the DCS upto 80° because the HHOB approximation and Wallace trajectory corrections will give good results on small angle region. At large angles they overstimate the results of other workers . From the table we can see that for angles more than 40° the values of ωI and ωII are less than corresponding HI and ωII values. In ωI and ωII the $\frac{1}{k_i^2}$ term of HHOB approximation is replaced by the corresponding term in Wallace correction. The values of ωI and ωII showed more agreement with the experimental results than HI and HII . Hence the replacement of

Wallace term is justified. At 400 eV the agreement of our results with the experimental results are excellent. Hence we can conclude that our present method is very good for intermediate and higher energies for small angle region.

In table 3.2, the total collisional cross sections for different energies are shown for $\bar{e}$ - H scattering and compared with other data. It can be seen that our results are always smaller than those of EBS and de Heer et al results, the difference decreases with increase in energy. But Das results are always higher. The PI values are almost same as ours.

Thus from the above discussion, we conclude that the modification of the input trial scattering function in the present investigation improves the results of total collisional cross section and differential cross section at low scattering angles for electron by hydrogen. This improvement encourages us to apply HI, ωI, HII and ωII methods to other atoms. In the next section the results for the elastic scattering of electron by helium atom are presented.

3.4.2 Helium Atom

The differential cross section for helium atom for the energy range 200 eV and 400 eV are calculated using the expressions given in section 3.2 and 3.3 . The present DCS are compared with other theoretical and experimental data available in table 5. The results are found to be encouraging following the comparison. In fig. 3.5 and 3.6 the present results are compared with other recent data (modified Das (PI) of Kusum Lata, EBS results of Byron and Joachain (1977), experimental data of Bromberg (1974). In table 3.4 the values of parameter a^{HI} and a^{HII} calculated for helium atom are shown. From the table 3.4 we can see that the parameter a^{HII} decreases with increase of scattering angle for fixed energy as obtained in the case of hydrogen.

It can be seen from the table 3.4 that the present HII and ωII give better agreement with the experimental data upto 30^{o}. Afterward HII and ωII are lower than those of experimental data. The values of HI and ωI gives better agreement in these region. The calculations for DCS are carried out for energies 200 eV and 400 eV, since the study at few chosen energies is sufficient for the prediction of the behaviour at other energies, the present study was confined to only those energies with an abundance of data available.

At 400 eV it is found that the results of HI and wI yields better agreement with experimental results in comparison with HII and wII. It is noticed from fig. 3.5 that in HI method the differential cross sections are less than that in HII for low values of scattering angle and are greater than that in HII at large angles. This is due to the fact that in HI the parameter a^{HI} is independent of scattering angle and is roughly equal to the average value of the parameter a^{HII} which is used in HII method.

From the above discussion we can conclude that the present modified Das is well suited for $\bar{e}$ - He atom collision also.

3.4.3 Lithium atom :

The differential cross sections and totoal collisional cross sections are calculated for $\bar{e}$ - Li atom scattering for a variety of incident energies and a wide range of scattering angle using above disscussed modified Das method. The values of parameters a^{HII} and a^{HI} used for the calculations are shown in table 3.6.

We have calculated the DCS for energies 100 eV to 400 eV and total collisional cross sections for energies 100 eV to 1000 eV. Since the experimental values are not avilable in the energy range we have compared our present results with other theoretical data which are close to the experimental values. From table 3.6 we can see that the value of parameter a^{HI} is independent of angles but a^{HII} is dependent on angles. For a fixed energy the value of a^{HII} decreases with increase of angle. a^{HI} is always greater than a^{HII} for $\bar{e}$ - Li atom collision. Hence we can see from table 3.8 that the values for DCS using HI and wI methods are always greater than corresponding HII and wII for all energies and all angles.

For 100 eV we have compared our result with those of MGA and EBS. It is a well known fact that the EBS results over estimate the experimental results for all the energies. This being due to the fact that the Glauber series converge slowly. Hence the large values of our results compared with EBS is a good omen that our results are better than EBS results. Further the agreement between our results and MGA result shows that the present formulation is well suited for $\bar{e}$ - Li atom scattering.

For 200 eV we have compared our results with MGA and Tayal et al. For the angles up to 20^{0} our results of HI and WI increases the results of Tayal et al and afterward the difference decreases. The results of HII and WII are less than those of Tayal et al from 20^{0} onwards. For 300 eV and 400 eV we have compared the present result with Rao and Desai (1983). They have calculated the DCS using HHOB approximation picturing lithium as single electron system having an inner core. But we have done exactly by considering lithium as a 3 electron system. Further we have used the modified Das method. Hence the result of their calculations are slightly different than ours.

From the above discussions we can conclude that the present modified Das method using HHOB second Born term in place of Second Born term are well suited for $\bar{e}$ - H, $\bar{e}$ - He and $\bar{e}$ - Li atoms scattering problems. The Wallace type of trajectory correction improved the result.

3.4.4 Total elastic cross section (TECS)

The total elastic cross section using the static potential is calculated for hydrogen, helium and Lithium atoms. The calculations are done using the expressions given in the previous section. The results of the method, Das method and the HHOB approximation are shown in table 3.9 and figures 3.10 along with other theoretical and experimental data.

From table 3.9a we can see that result for 100 eV is less than those of Winters et al (1974). The HHOB result is still lesser. For more than 100 eV our results are some what higher than those of Winters et al, discrepancy being less than 4 %. From able 3.9b we can interfere that the present calculations for helium atom is slightly less than those of Winters et al for the whole energy range. HHOB results are still lower. Das results are higher than those of Winters et al. For lithium atom we have calculated the TECS from 100 eV to 1000 eV. We have compared the results of present calculations with those of Das method, HHOB approximation and the results of Guha and Ghosh (1979a). We can see from the table 3.9c that all the results are some what equal with slight difference.

From the above discussions we can conclude that the replacement of higher order Born terms using the HHOB approximation Born terms in Das method is justified in the limited range of energy of the incident electron.

Table : 3.1 : The values of parameters a^{HI} and a^{HII} for the elastic scattering of the electrons by hydrogen atom.

Energy (eV)	a^{HI}	Angle			a^{HII}				
		5	10	20	30	40	50	60	80
100	.787	.975	.935	.863	.813	.777	.746	.717	.668
200	.874	.979	.949	.901	.868	.839	.812	.785	.740
300	.911	.981	.956	.920	.893	.867	.841	.817	.777
400	.931	.983	.962	.932	.908	.883	.859	.838	.802

Table : 3.2 : The total collisional cross sections (in a_o^2) for the elastic scattering of electrons by hydrogen atom.

E eV	HI	ωI	PI	Das	DR	EBS
100	5.951	5.896	5.778	8.453	6.85	3.343
200	3.818	3.747	3.774	4.828	4.18	4.315
300	2.863	2.830	2.841	3.440	3.06	3.119
400	2.308	2.289	2.295	2.695	2.43	2.466
500	1.942	1.930	1.935	2.226	—	2.051
600	1.692	1.684	1.519	1.706	—	1.587

Dr. The adopted values of de Hees et al (1977).

Table : 3.3 : The differential cross sections ($a_o^2 \; s_r^{-1}$) for the elastic scattering of the electrons by the hydrogen atom.

100 eV

Angle (deg.)	HI	ωI	HII	ωII	PI	Williams
5	3.501	3.252	4.081	4.070	3.51	-
10	2.301	1.998	2.280	2.293	2.00	-
20	8.470(-1)	8.548(-1)	8.843(-1)	9.281(-1)	8.21(-1)	1.10
30	4.068(-1)	4.882(-1)	4.478(-1)	4.936(-1)	3.85(-1)	5.09(-1)
40	2.148(-1)	2.129(-1)	2.139(-1)	2.124(-1)	1.91(-1)	2.88(-1)
50	1.118(-1)	1.073(-1)	1.227(-1)	1.128(-1)	1.01(-1)	1.32(-1)
60	7.888(-2)	7.276(-2)	7.578(-2)	6.479(-2)	5.77(-2)	7.22(-2)
80	4.011(- 2)	2.834(-2)	3.640(-2)	2.680(-2)	2.33(-2)	2.95(-2)

Table : 3.3 : contd.

200 eV

Angle	HI	ωI	HII	ωII	PI	Williams
5	1.897	1.883	2.088	2.013	1.90	-
10	1.062	1.081	1.106	1.060	1.04	-
20	4.009(-1)	4.138(-1)	4.077(-1)	3.891(-1)	3.89(-1)	4.19(-1)
30	1.653(-1)	1.607(-1)	1.651(-1)	1.606(-1)	1.51(-1)	1.72(-1)
40	7.671(-2)	7.329(-2)	8.009(-2)	6.869(-2)	6.43(-2)	7.06(-2)
50	4.142(-2)	3.355(-2)	4.026(-2)	3.302(-2)	3.69(-2)	3.14(-2)
60	2.089(-2)	1.851(-2)	2.415(-2)	2.094(-2)	1.67(-2)	1.87(-2)
80	1.235(-2)	7.773(-3)	1.128(-2)	5.244(-3)	6.45(-3)	8.59(-3)

Table : 3.3 : Contd... 400 eV

Angle	HI	ωI	HII	ωII	PI	Williams
5	1.047	1.166	1.188	1.198	1.14	-
10	6.033(-1)	6.394(-1)	6.397(-1)	6.459(-1)	6.21(-1)	-
20	1.722(-1)	1.741(-1)	1.771(-1)	1.801(-1)	1.70(-1)	1.96(-1)
30	5.488(-2)	5.244(-2)	5.760(-2)	6.031(-2)	5.11(-2)	6.17(-2)
40	1.972(-2)	1.931(-2)	2.524(-2)	1.955(-2)	1.90(-2)	2.06(-2)
50	1.097(-2)	9.057(-3)	1.180(-2)	9.118(-3)	8.56(-3)	9.47(-3)
60	6.418(-3)	4.859(-3)	6.812(-3)	4.823(-3)	4.48(-3)	4.38(-3)
80	2.896(-3)	1.957(-3)	3.461(-3)	1.826(-3)	1.68(-3)	1.57(-3)

Table : 3.4 : The values of parameters a^{HI} and a^{HII} for the elastic scattering of electrons by helium atom.

Energy	a^{HI}	Angle	a^{HII}					
eV		10	20	30	40	50	70	90
100	.563	.745	.701	.658	.619	.583	.523	.474
200	.695	.842	.798	.756	.716	.678	.611	.556
800	.764	.882	.841	.801	.761	.723	.655	.600
400	.807	.903	.865	.827	.788	.750	.683	.631
700	.875	.935	.902	.867	.830	.795	.734	.689

Table : 3.5 : The differential cross sections (a_o^2 s_r^{-1}) for $\bar{e}$ - He elastic scattering.

200 eV

Angle (deg.)	HI	ωI	HII	ωII	PI	Crooks and Rudd (1972)	Bromberg (1974)
10	9.817(-1)	1.173	1.130	1.162	1.06	1.93	1.12
20	5.028(-1)	5.452(-1)	5.354(-1)	5.067(-1)	5.29(-1)	7.13(-1)	5.27(-1)
30	2.675(-1)	3.058(-1)	2.749(-1)	2.551(-1)	2.76(-1)	3.25(-1)	2.76(-1)
40	1.584(-1)	1.615(-1)	1.601(-1)	1.435(-1)	1.49(-1)	-	1.52(-1)
50	9.064(-2)	9.418(-2)	8.989(-2)	7.485(-2)	8.36(-2)	1.03(-1)	8.91(-2)
70	4.151(-2)	4.253(-2)	3.893(-2)	2.983(-2)	3.14(-2)	4.23(-1)	3.72(-2)
90	3.147(-2)	3.213(-2)	1.426(-2)	1.282(-2)	1.50(-2)	2.33(-2)	1.90(-2)

Table : 3.5 : Contd...

E = 400 eV

Angle (deg.)	HI	ωI	HII	ωII	Crooks and Rudd(1972)	Bromberg (1974)
10	6.160(-1)	6.269(-1)	6.389(-1)	5.861(-1)	7.61(-1)	6.62(-1)
20	2.744(-1)	2.616(-1)	2.786(-1)	2.602(-1)	3.17(-1)	2.77(-1)
30	1.233(-1)	9.081(-2)	1.252(-1)	1.197(-1)	1.41(-1)	1.23(-1)
40	6.103(-2)	5.682(-2)	6.060(-2)	4.544(-2)	-	5.71(-1)
50	2.573(-2)	2.323(-2)	2.471(-2)	2.814(-2)	3.34(-2)	2.97(-2)
70	1.368(-2)	1.246(-2)	1.268(-2)	8.561(-3)	1.17(-2)	1.05(-2)
90	6.899(-3)	5.813(-3)	5.917(-3)	4.231(-3)	6.60(-3)	4.86(-3)

Table : 3.6 : a - The values of parameters a^{HII} for the elastic scattering of the electrons by lithium atom.

Angle	100	200	300	400
5	7.832(-1)	8.586(-1)	8.894(-1)	9.068(-1)
10	7.089(-1)	7.882(-1)	8.232(-1)	8.431(-1)
15	6.386(-1)	7.171(-1)	7.507(-1)	7.719(-1)
20	5.743(-1)	6.453(-1)	6.800(-1)	7.045(-1)
25	5.149(-1)	5.809(-1)	6.207(-1)	6.513(-1)
30	4.608(-1)	5.281(-1)	5.750(-1)	6.109(-1)
40	3.668(-1)	4.320(-1)	4.931(-1)	5.915(-1)
50		4.671(-1)	4.682(-1)	5.733(-1)
60	2.879(-1)	3.721(-1)	4.260(-1)	4.913(-1)
70		3.457(-1)	3.946(-1)	4.648(-1)
80		3.178(-1)	3.807(-1)	4.283(-1)
90	2.285(-1)	3.028(-1)	3.506(-1)	3.836(-1)
100	2.114(-1)	2.869(-1)	3.374(-1)	3.762(-1)
110	2.047(-1)	2.811(-1)	3.215(-1)	3.392(-1)
120	1.982(-1)	2.641(-1)	2.058(-1)	3.372(-1)
150	1.832(-1)	2.375(-1)	2.845(-1)	3.159(-1)

Table : 3.6 : b - The value of parameter a^{HI} for $\bar{e}$ - Li.

Energy	100	200	300	400	500
a^{HI}	8.029(-1)	8.993(-1)	9.351(-1)	9.531(-1)	9.611(-1)

Table : 3.7 : The total collisional cross section for the elastic scattering of electrons by lithium atom.

E eV	Present	EBS	EBS(IC)
100	18.942	19.9	18.5
200	10.464	11.1	10.3
400	5.728	6.08	5.67
700	3.501	3.72	3.48
1000	2.554	2.72	2.54

Table : 3.8 : The differential cross sections ($a_o^2 \, S_r^{-1}$) for $\bar{e}$ - Li elastic scattering E = 100 eV.

Angle	HI	ωI	HII	ωII	MGA	EBS
5	45.088	44.835	44.213	44.073	44.90	52.90
10	21.064	21.705	20.437	20.063	17.50	18.20
15	9.429	10.325	9.403	10.106	7.70	7.47
20	4.346	4.997	4.452	4.916	3.48	3.73
25	2.684	2.982	2.347	2.525	1.67	2.40
30	1.601	1.598	1.406	1.394	8.74(-1)	1.85
40	6.439(-1)	8.955(-1)	–	–	3.02(-1)	–
50	3.953(-1)	4.999(-1)	4.766(-1)	–	1.31(-1)	–
60	2.683(-1)	2.826(-1)	1.355(-1)	1.315(-1)	6.66(-2)	8.89(-1)
70	1.613(-1)	1.709(-1)	–	–	3.80(-2)	–
80	1.194(-1)	1.262(-1)	–	–	2.38(-2)	–
90	6.572(-2)	7.998(-2)	3.258(-2)	3.432(-2)	1.61(-2)	6.16(-1)

Table : 3.8 : Contd... E = 200 eV.

Angle	HI	ωI	HII	ωII	MGA	Tayal et al (1981)
5	31.887	32.168	30.908	30.838	28.50	24.60
10	13.071	13.493	12.807	13.178	10.40	12.00
15	5.207	5.408	5.080	5.334	3.81	
20	2.409	2.484	2.408	2.217	1.57	2.21
25	1.348	1.377	1.091	1.111	7.65(-1)	—
30	8.563	8.743(-1)	5.832(-1)	6.338(-1)	4.27(-1)	—
40	3.775(-1)	5.852(-1)	—	—	1.71(-1)	2.77(-1)
50	2.343(-1)	2.389(-1)	—	—	8.37(-2)	
60	1.372(-1)	1.811(-1)	7.133(-2)	7.282(-2)	4.58(-2)	1.03(-1)
70	8.191(-2)	8.374(-2)	—	—	2.71(-2)	—
80	4.525(-2)	4.648(-2)	—	—	1.70(-2)	4.22(-2)
90	2.865(-2)	2.932(-2)	1.568(-2)	1.597(-2)	1.13(-2)	—

Table : 3.8 : Contd... E = 300 eV.

Angle	HI	ωI	HII	ωII	Rao and Desai
5	26.484	26.345	26.145	26.013	–
10	9.214	8.947	9.074	8.888	8.410
15	3.212	3.286	3.017	3.076	–
20	1.503	1.522	1.284	1.300	1.193
25	8.615(-1)	8.703(-1)	6.604(-1)	6.676(-1)	–
30	5.349(-1)	5.419(-1)	3.878(-1)	3.921(-1)	3.818(-1)
40	2.402(-1)	2.433(-1)	1.707(-1)	1.724(-1)	1.079(-1)
50	1.384(-1)	1.401(-1)	8.120(-2)	8.204(-2)	1.079(-1)
60	7.289(-2)	7.551(-2)	4.263(-2)	4.307(-2)	7.199(-2)
70	3.764(-2)	3.826(-2)	2.182(-2)	2.208(-2)	5.216(-2)
80	2.711(-2)	2.753(-2)	1.522(-2)	1.539(-2)	3.998(-2)
90	1.371(-2)	1.401(-2)	8.800(-3)	8.912(-3)	3.212(-2)

Table : 3.8 : Contd... E = 400 eV.

Angle	HI	ωI	HII	ωII	Rao and Desai
5	22.593	22.564	22.386	22.357	—
10	6.819	6.667	6.637	6.501	5.675
15	2.242	2.245	2.200	2.262	—
20	1.028	1.029	8.558(-1)	8.808(-1)	7.273(-1)
25	5.852(-1)	6.699(-1)	4.632(-1)	5.214(-1)	—
30	2.707(-1)	4.156(-1)	2.757(-1)	3.046(-1)	2.356(-1)
40	3.056(-1)	3.048(-1)	2.563(-1)	2.358(-1)	1.137(-1)
50	1.109(-1)	1.114(-1)	7.939(-2)	7.951(-2)	6.700(-2)
60	5.058(-2)	5.067(-2)	3.649(-2)	3.671(-2)	4.432(-2)
70	2.735(-2)	2.742(-2)	1.931(-2)	1.943(-2)	3.188(-2)
80	1.438(-2)	1.445(-2)	6.435(-3)	6.664(-3)	2.419(-2)
90	7.786(-3)	7.908(-3)	5.549(-3)	5.650(-3)	1.927(-2)

Table :

The values of Cox and Bonham (1967) field parameters.

H	γ_i	0.0524	5.0360	-4.0876			
	λ_i	1.9986	1.8954	2.1161			
He	γ_i	1.0030	-0.6146	-0.1840	0.6116	0.1841	
	λ_i	2.4908	3.8608	6.1256	2.8522	5.1284	
Li	γ_i	1.3215	-0.2273	1.3369	1.4070	-1.6110	-0.9567
	λ_i	0.8737	7.9222	2.2645	3.8024	1.3839	2.7056

Table : 3.9 : a – Total elastic cross sections (a_o^2) for electron scattering by hydrogen.

Energy eV	Present	Das	HHOB	Winters et al
100	1.218	1.227	2.03	1.40
200	6.034(-1)	6.189(-1)	7.72(-1)	5.81(-1)
300	4.019(-1)	4.144(-1)	4.53(-1)	—
400	3.008(-1)	3.111(-1)	3.23(-1)	—

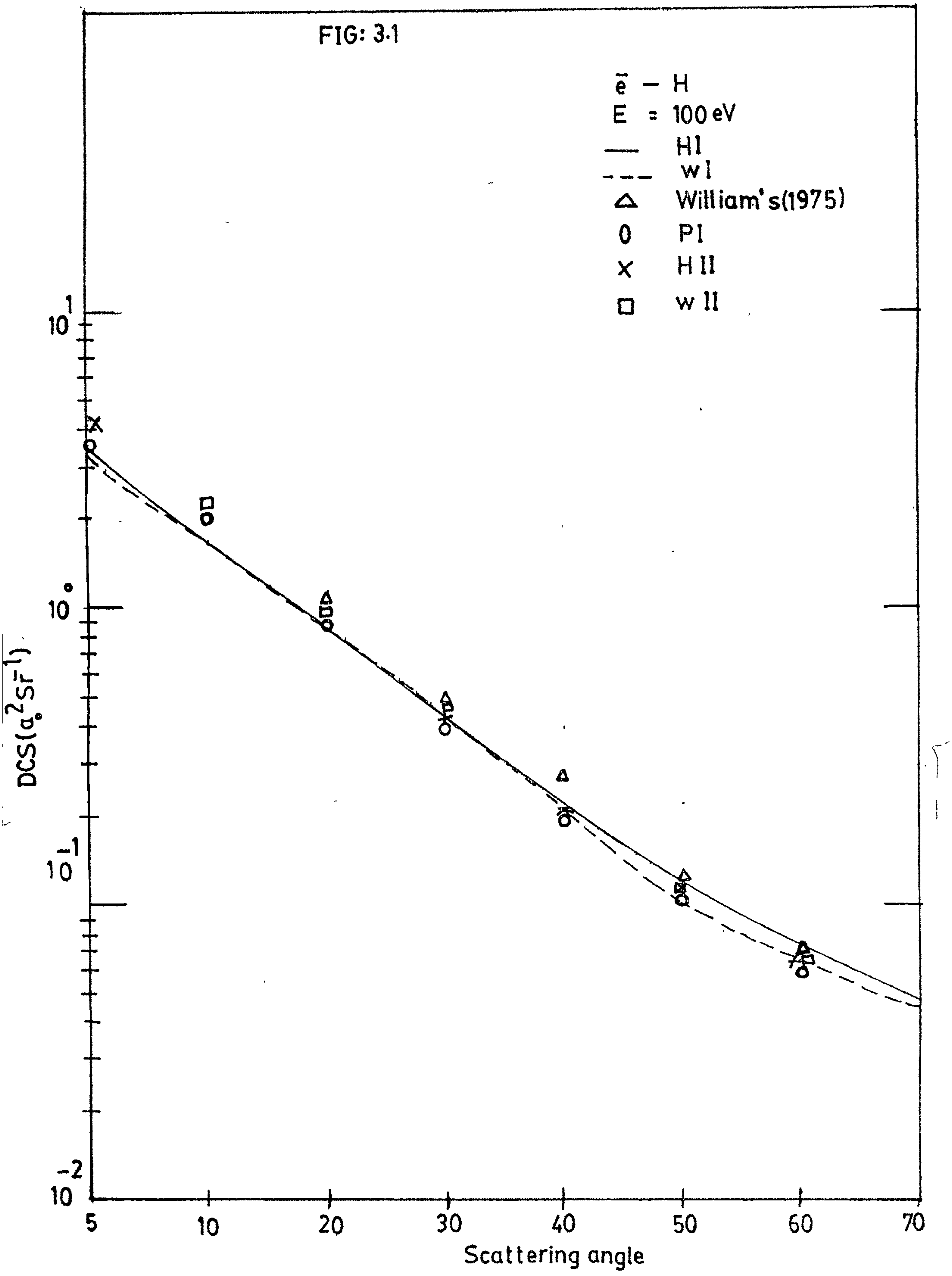
Table : 3.9 : b – Total elastic cross section (a_o^2) for electron scattering by helium.

Energy eV	Present	Das	HHOB	Winters
100	1.547	3.353	1.510	2.37
200	7.631(-1)	1.807	7.527(-1)	1.00
300	5.064(-1)	1.242	5.019(-1)	6.13(-1)
400	3.790(-1)	9.475(-1)	3.764(-1)	4.33(-1)
500	3.028(-1)	7.66(-1)	3.016(-1)	—
700	2.159(-1)	5.540(-1)	2.152(-1)	—

Table : 3.9 : c -Total elastic cross sections (a_o^2) for electron scattering by Lithium.

Energy eV	Present	Das	HHOB	Guha and Ghosh (1979)
100	10.430	11.305	10.414	10.430
200	5.118	6.033	5.107	5.027
300	3.409	4.115	3.402	—
400	2.556	3.121	2.553	—
500	2.044	2.513	2.042	—
600	1.703	2.102	1.702	—
700	1.459	1.807	1.459	1.392
900	1.135	1.410	1.134	—
1000	1.021	1.270	1.021	9.739(-1)

FIG: 3.1



ē – H
E = 100 eV
HI
wI
△ William's(1975)
0 PI
× H II
□ w II
10^1
10^0
10^-1
10^-2
DCS(a₀²Sr⁻¹)
5
10
20
30
40
50
60
70
Scattering angle

FIG: 3.2

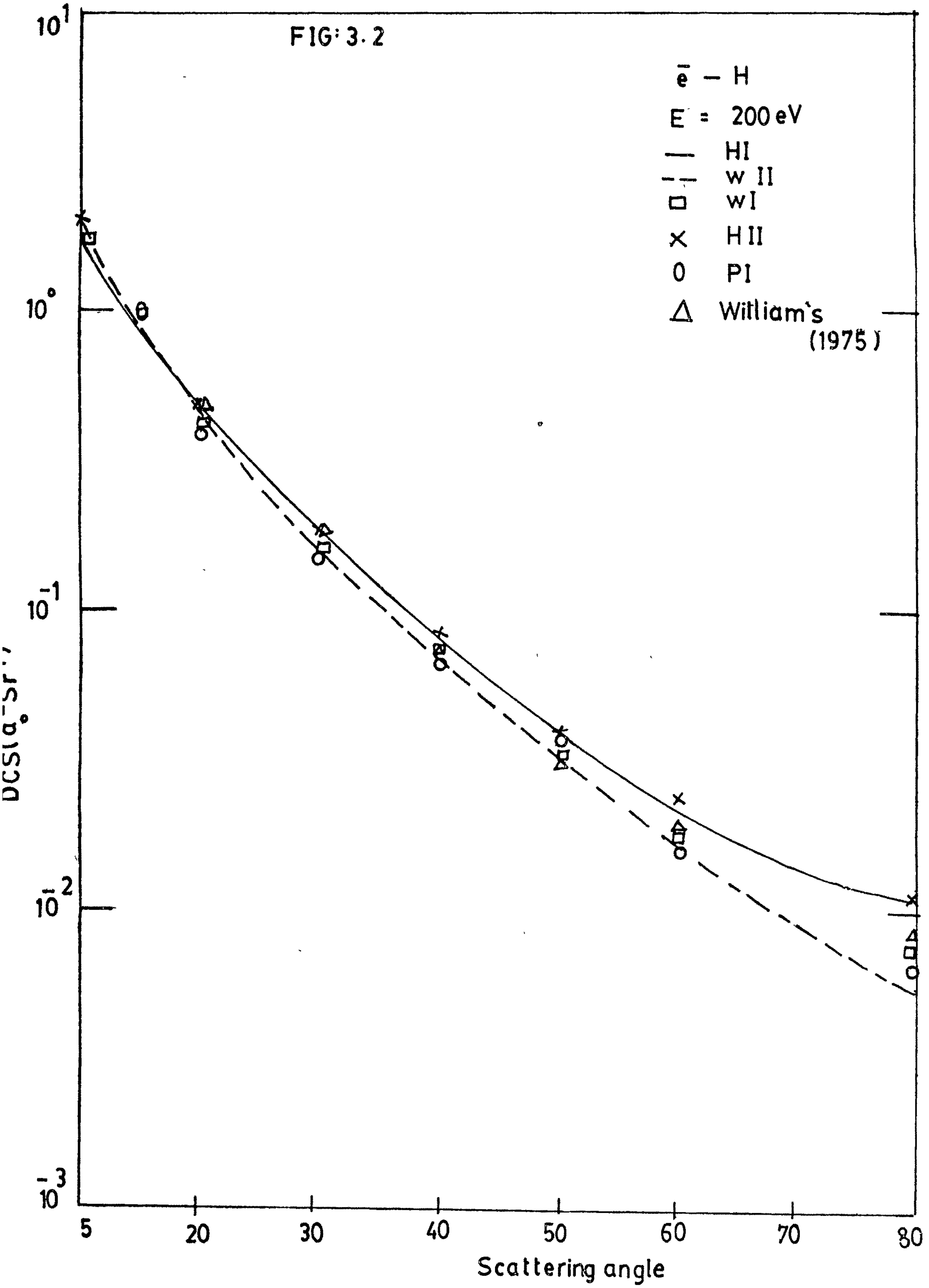
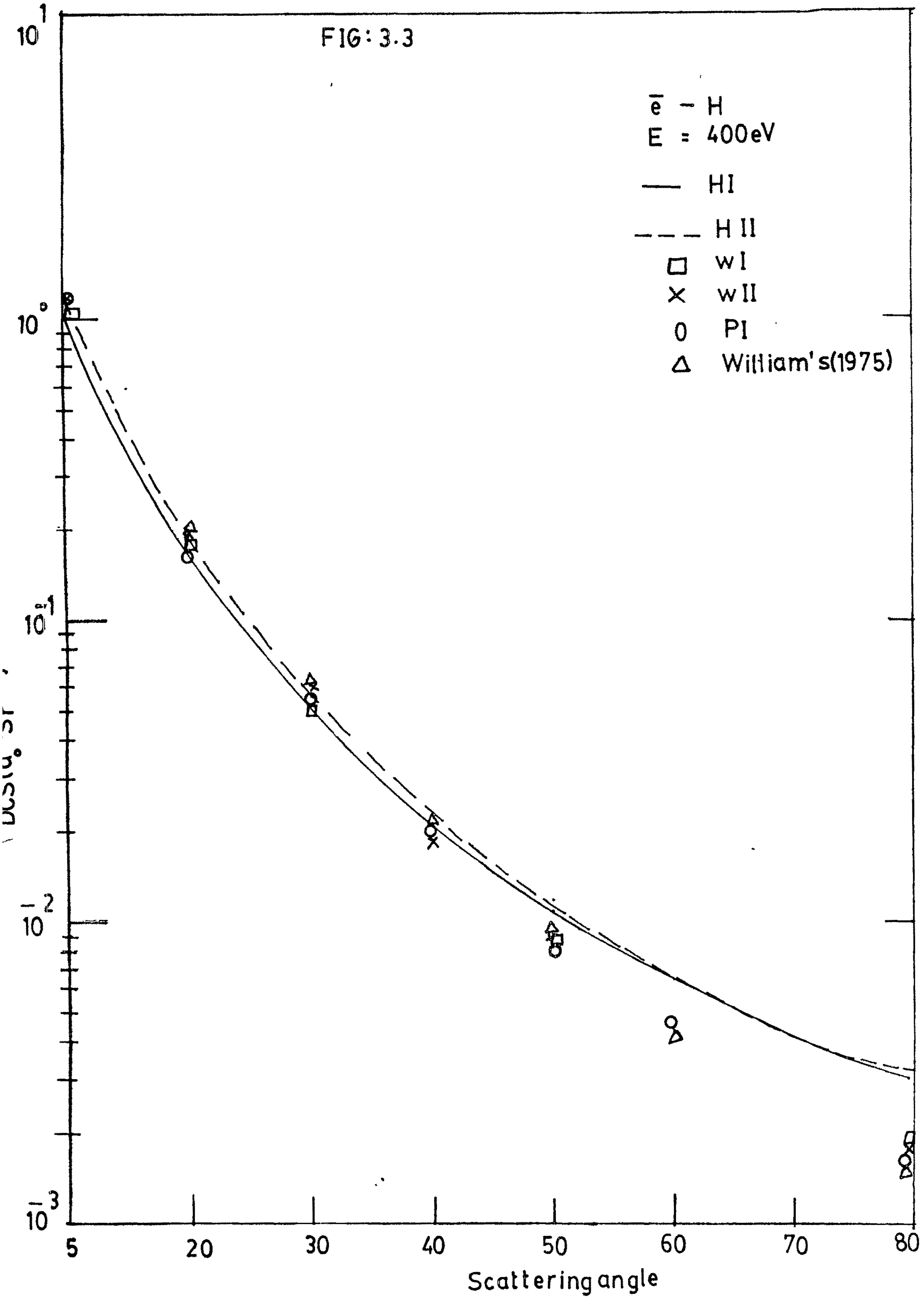

$\bar{e}$ – H
E = 200 eV
— HI
- - w II
□ wI
× H II
0 PI
△ William's (1975)
10^{1}
10^{0}
10^{-1}
10^{-2}
10^{-3}
$DCS(a_0^2 sr^{-1})$
5
20
30
40
50
60
70
80
Scattering angle

FIG: 3.3


$\bar{e}$ – H
E = 400eV
HI
H II
□ wI
× wII
0 PI
△ William's(1975)
10^{1}
10^{0}
10^{-1}
10^{-2}
10^{-3}
DCS(a_0^2 sr
5
20
30
40
50
60
70
80
Scattering angle

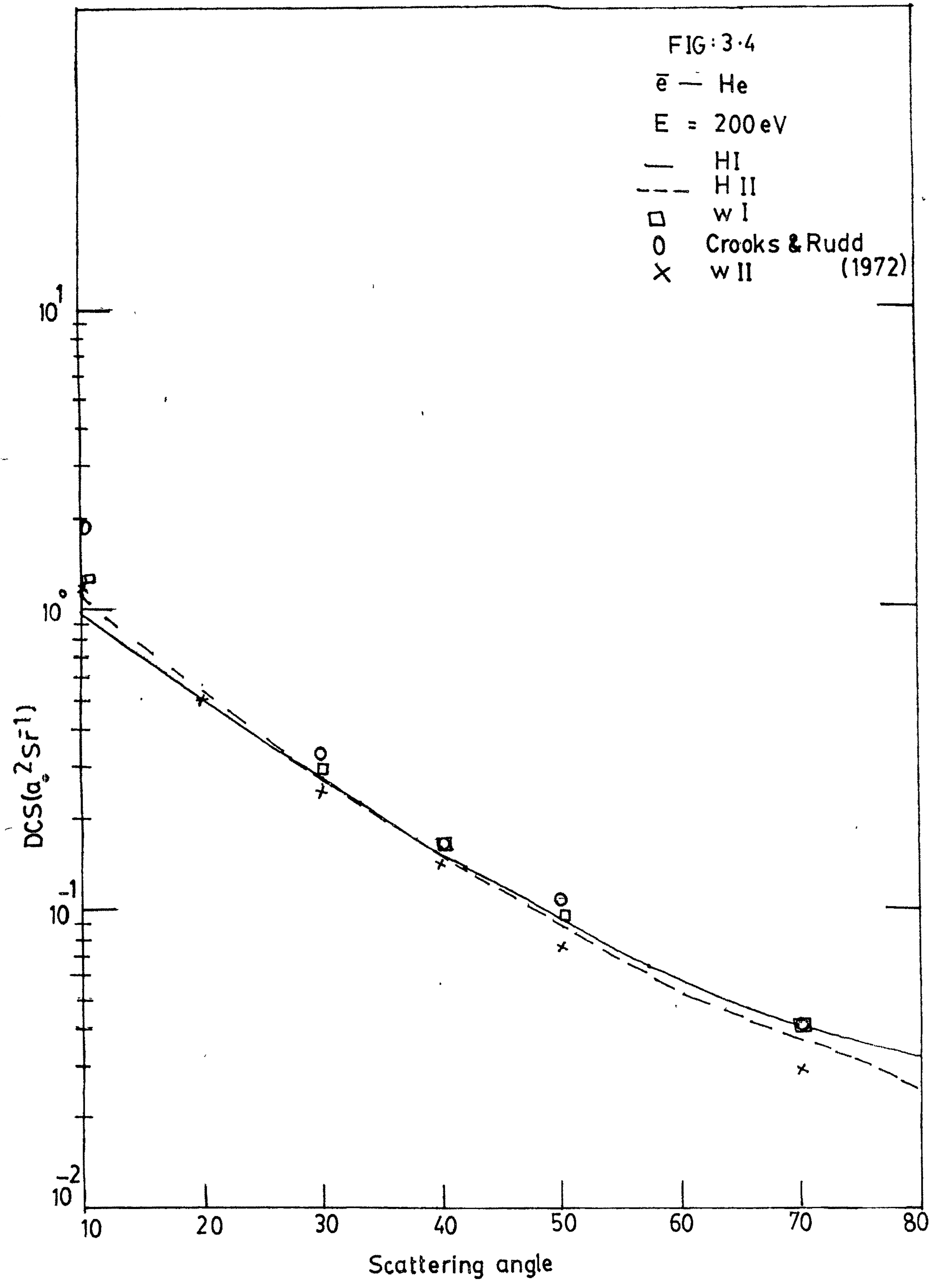


FIG:3·4

$\bar{e}$ — He
E = 200 eV
HI
H II
w I
Crooks & Rudd (1972)
w II
10^1
10^0
10^{-1}
10^{-2}
DCS($a_0^2 sr^{-1}$)
10
20
30
40
50
60
70
80
Scattering angle

FIG: 3.5

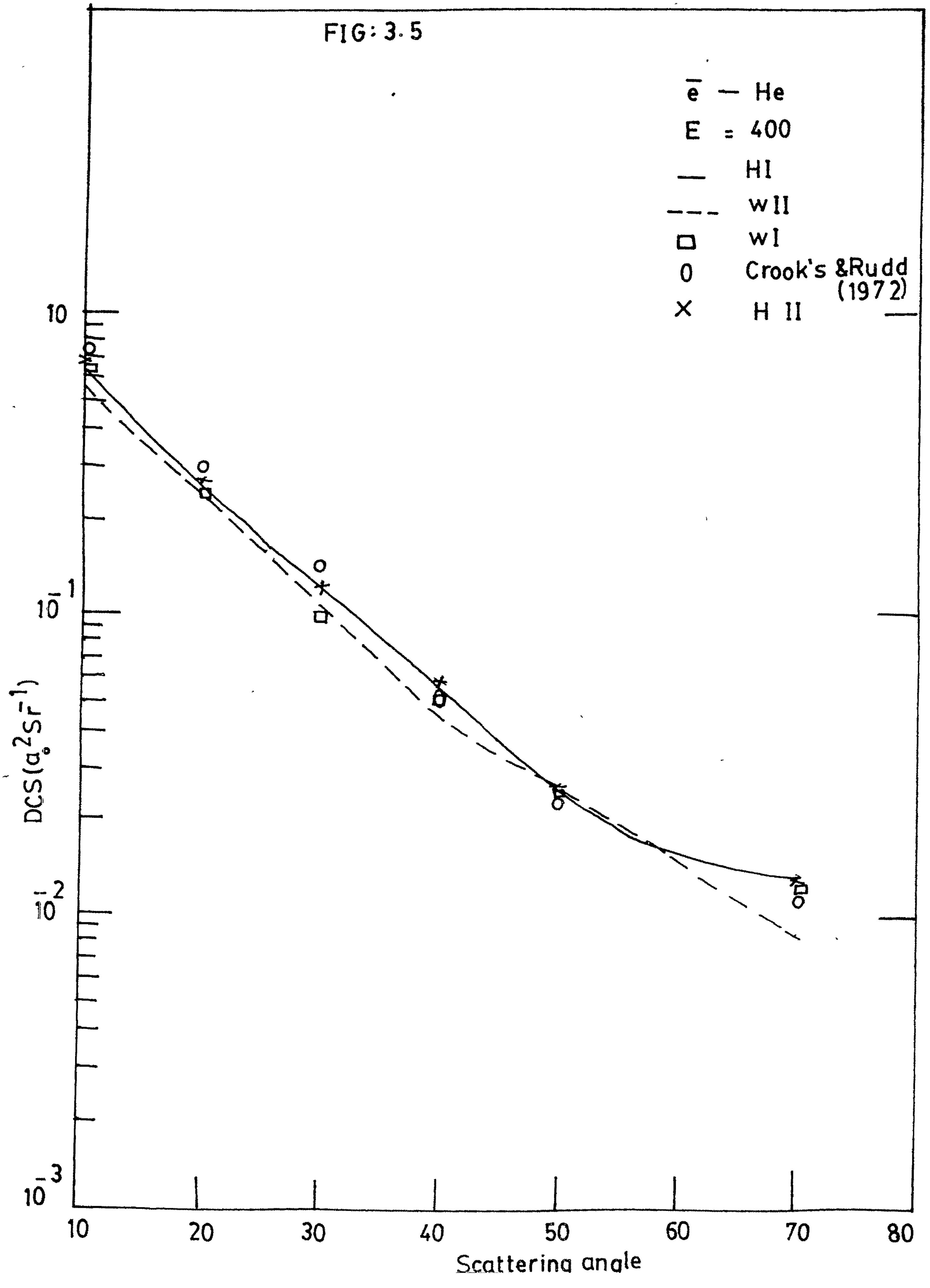
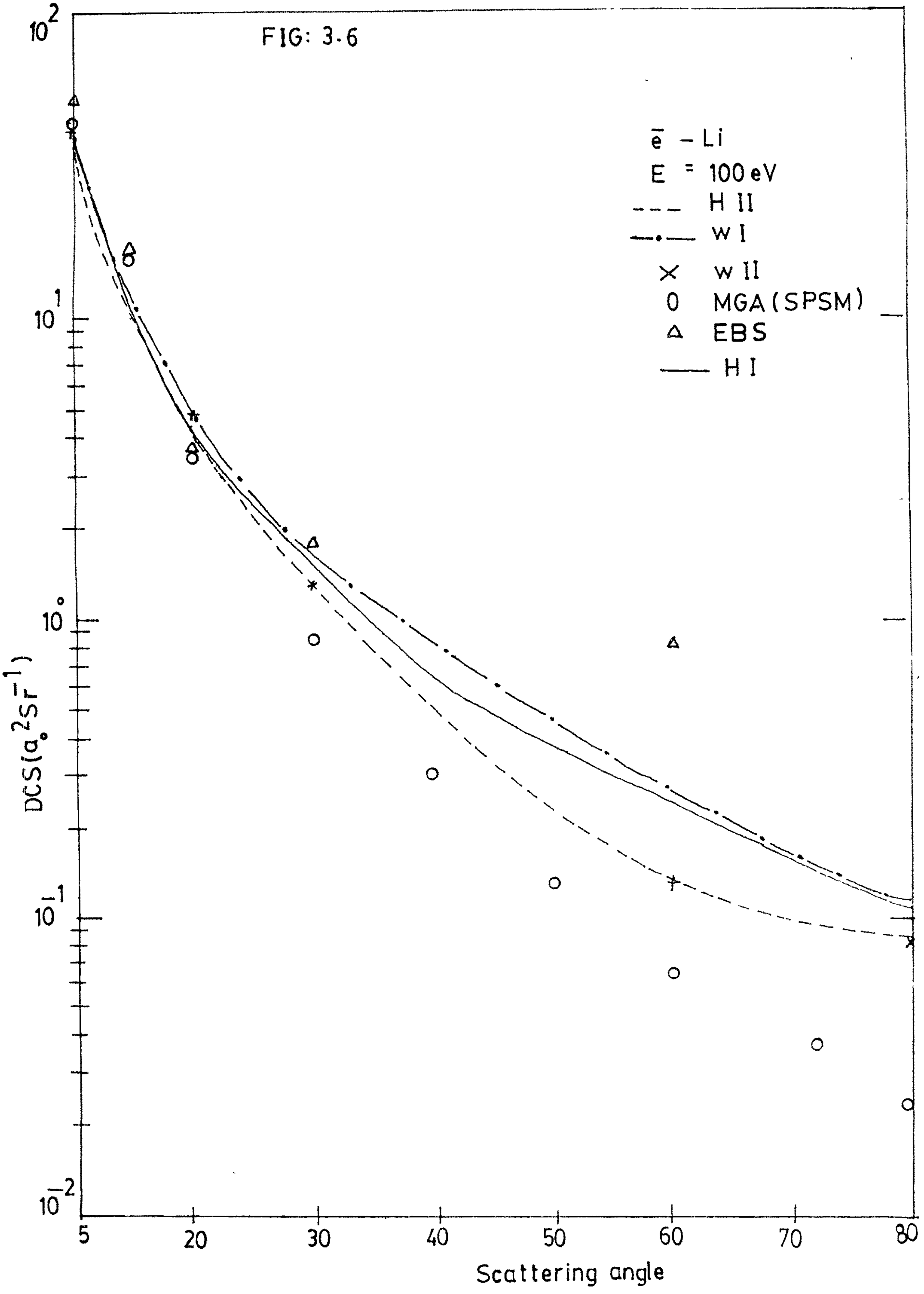
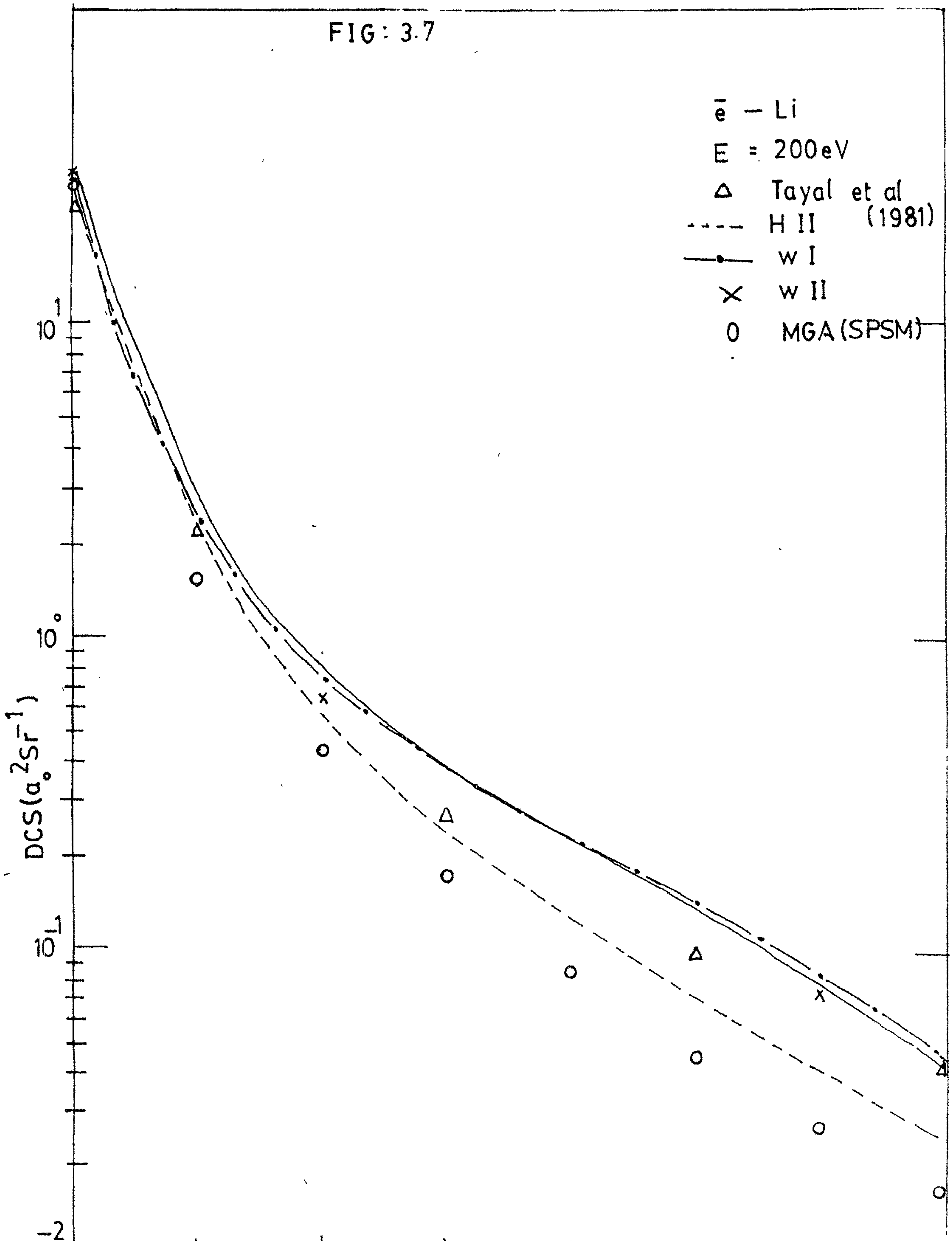

ē — He
E = 400
HI
wII
wI
0 Crook's &Rudd (1972)
H II
10
10^{-1}
10^{-2}
10^{-3}
DCS($a_0^2 Sr^{-1}$)
10
20
30
40
50
60
70
80
Scattering angle

FIG: 3·6



$\bar{e}$ – Li
E = 100 eV
H II
w I
w II
0 MGA (SPSM)
EBS
H I
10^2
10^1
10^0
10^{-1}
10^{-2}
DCS($a_0^2 Sr^{-1}$)
5
20
30
40
50
60
70
80
Scattering angle

FIG: 3.7



ē — Li
E = 200eV
Δ Tayal et al (1981)
- - - - H II
—•— w I
× w II
O MGA (SPSM)
DCS($a_0^2 Sr^{-1}$)
10^1
10^0
10^{-1}
10^{-2}
5
20
30
40
50
60
70
80
Scattering angle

FIG: 3.8

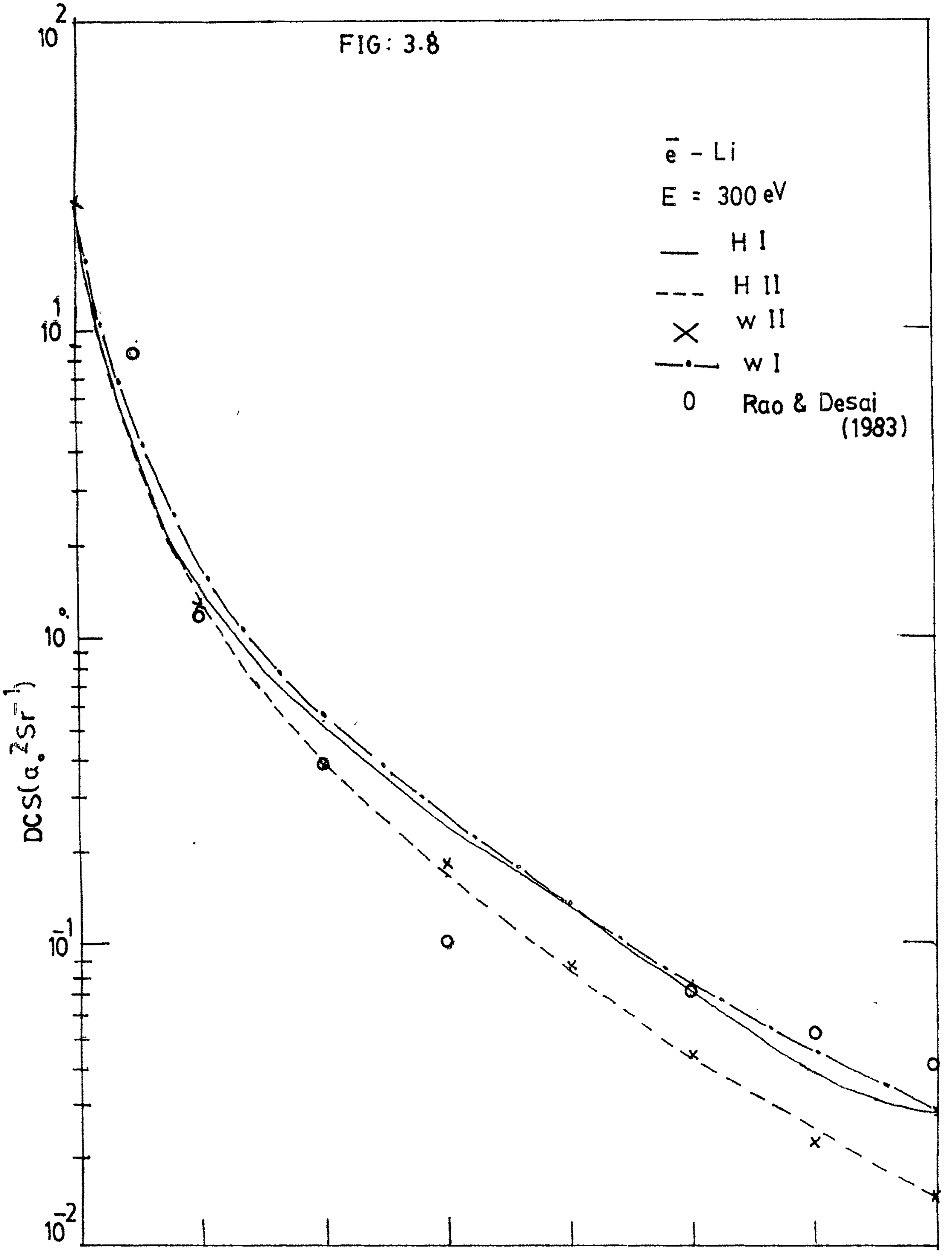
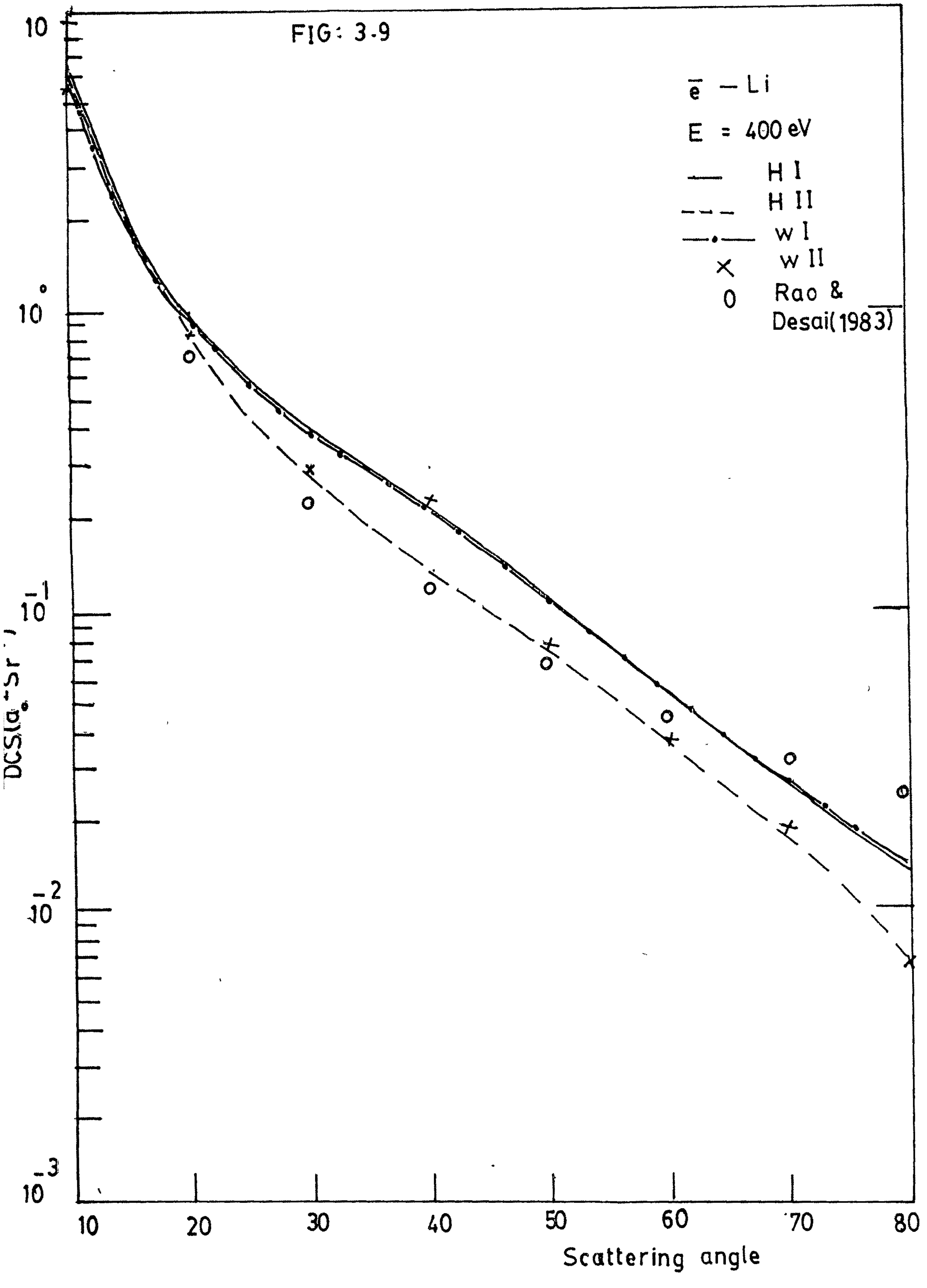

$\bar{e}$ - Li
E = 300 eV
H I
H II
w II
w I
0 Rao & Desai (1983)
10^{2}
10^{1}
10^{0}
10^{-1}
10^{-2}
DCS($a_0^2 Sr^{-1}$)
5
20
30
40
50
60
70
80
Scattering angle

FIG: 3-9



ē — Li
E = 400 eV
H I
H II
w I
w II
Rao & Desai(1983)
DCS(a₀² Sr⁻¹)
10
10⁰
10⁻¹
10⁻²
10⁻³
10
20
30
40
50
60
70
80
Scattering angle

FIG: 3.10a

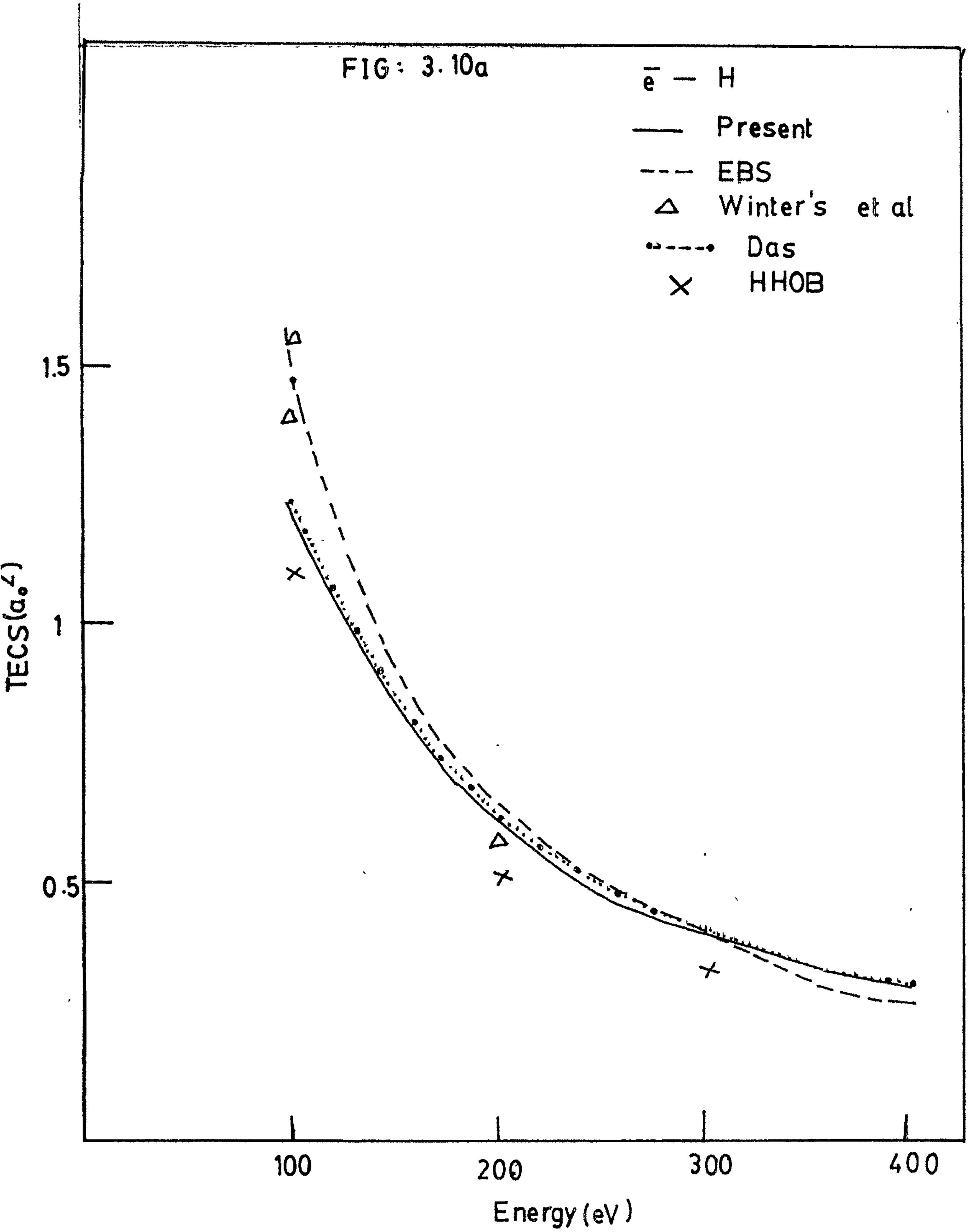

$\bar{e}$ — H
Present
EBS
Winter's et al
Das
HHOB
TECS(a_0^2)
1.5
1
0.5
100
200
300
400
Energy (eV)

FIG : 3.10 b

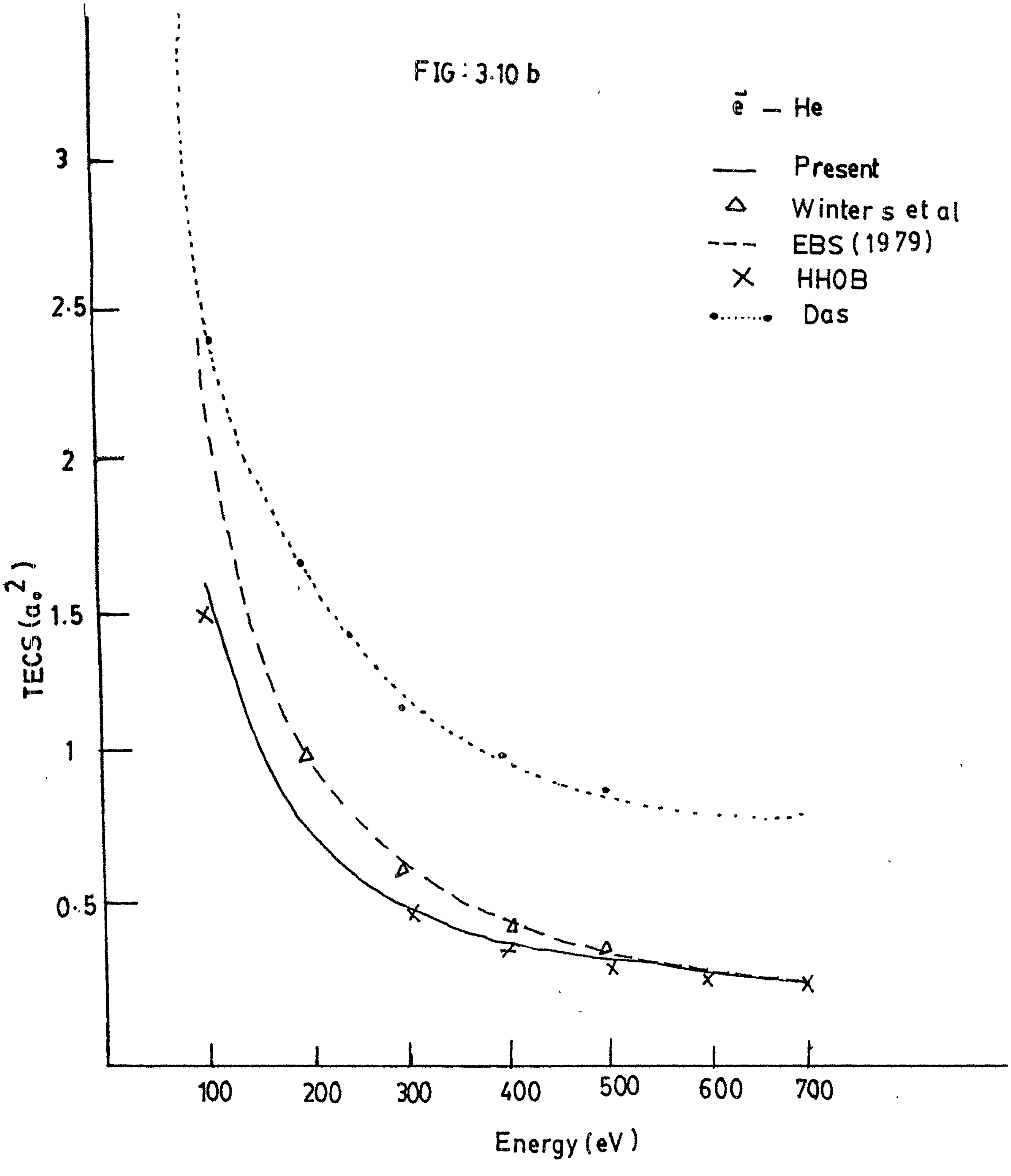
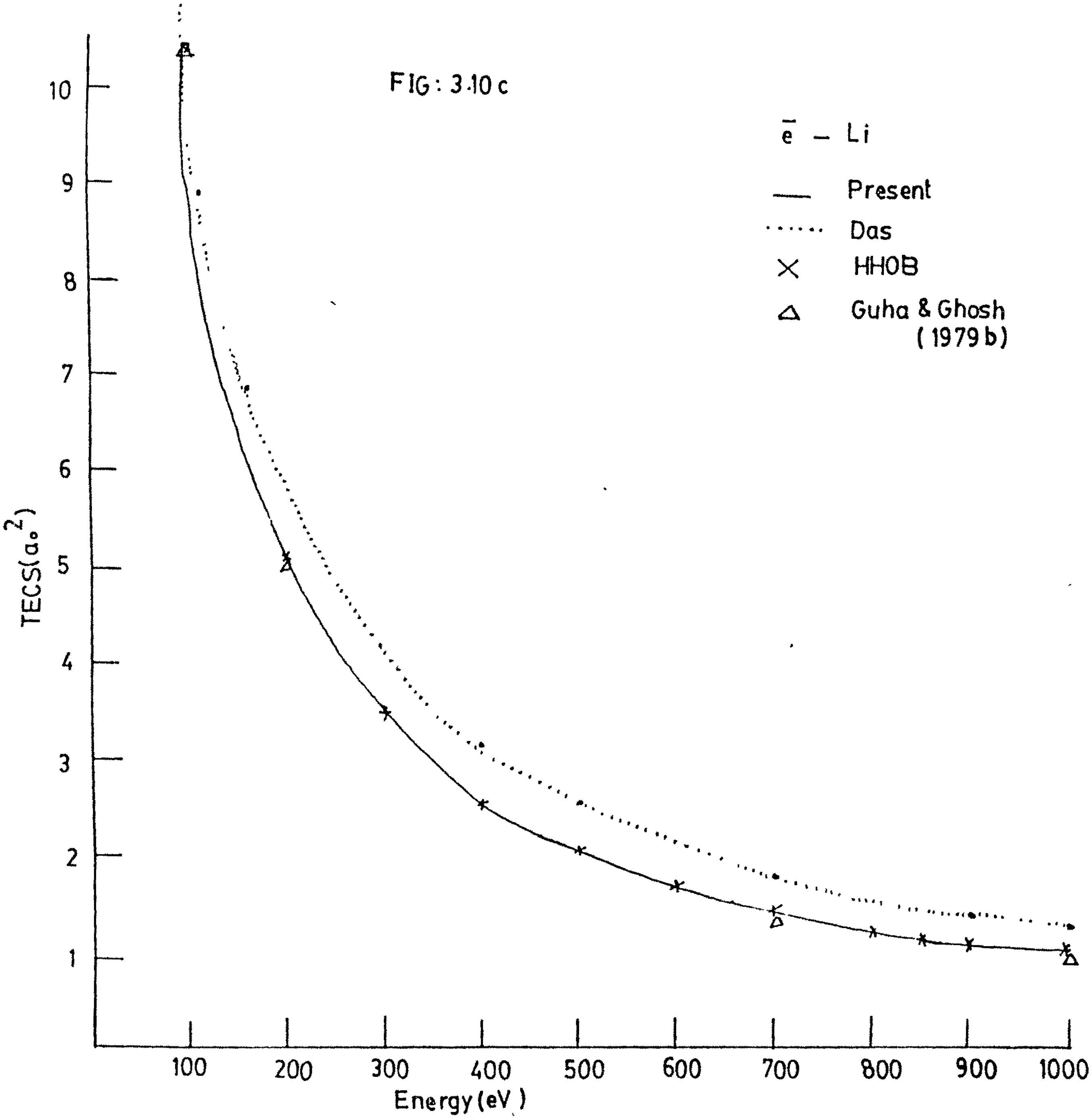

$e^- - He$
Present
Winters et al
EBS (1979)
HHOB
Das
TECS (a_0^2)
3
2.5
2
1.5
1
0.5
100
200
300
400
500
600
700
Energy (eV)

FIG: 3.10c


ē – Li
Present
Das
HHOB
Guha & Ghosh (1979b)
TECS(a_0^2)
10
9
8
7
6
5
4
3
2
1
100
200
300
400
500
600
700
800
900
1000
Energy (eV)