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"DETERMINATION OF PARTIAL AND TOTAL IONIZATION CROSS SECTIONS FOR THE PRODUCTION OF CATIONS IN ELECTRON-ASTATINE COLLISION"

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Abstract: -
Partial ionization cross sections corresponding to the production of cations At^{q+} (q=1- 5) in the electron impact ionization of At have been calculated using a modified Jain-Khare semi-empirical formalism. As no previous experimental and/ or theoretical data is available for comparison, we have derived the partial and total ionization cross-sections with energies varying from ionization thresholds to 2800 eV.

Key Words: Partial, electron impact, spans, cross section.

INTRODUCTION:

Hot-bearer qualities for a numerous gate Fin FET were examined. It was discovered that the nonlocal impact and arrangement opposition are unmistakable highlights for the concealment of effect ionization in a thin blade of the Fin FET. The effect of nonlocal impact and arrangement opposition on the effect of ionization winds up more grounded as the blade width diminishes. In this manner, hot transporter age is decreased, and subsequently, the dependability is improved with balance width scaling. This, thus, can be considered increasingly forceful scaling. From the customary SCM, a refined explanatory impact ionization model catching the nonlocal impact and arrangement opposition was created and checked with estimation information [1-5]. The body thickness reliance of EII for a multi-gate Fin FET is displayed. It is discovered that the non-local impact and arrangement opposition are particularly highlighted in decreased EII in the multi gate Fin FET and these impacts become increasingly articulated as body thickness diminishes. EII steady Bi is recently separated by thinking about the arrangement opposition and nonlocal bearer warming impact [14].

A refined diagnostic SCM is created from the past model and redid for numerous gate gadgets. The new SCM is then contrasted and estimation information and great understanding are watched. With the scaling of CMOS into sub-45-nm innovation hubs, concealment of short-channel effects (SCEs) winds up troublesome in a planar single

electron gate (SG) MOSFET. MG structure is included by ultrathin-body thickness, which is a basic parameter describing SCE. With gadget scaling, HCEs have been a conspicuous issue for as lon gas three decades. It is normally acknowledged that the substrate current I Sub emerging from the EII procedure close to the channel edge can give significant direction in assessing the gadget's unwavering quality. Along these lines, the demonstration of HCE for an MG-MOSFET is auspicious just as fundamental. There have been a couple of concentrates on HCE in a multi-gateFin-FET [6-9]. These examinations endeavor to explore the reliance on blade width, as this is a significant parameter to oversee SCE. While they all exhibited outcomes showing that a smaller balance is more insusceptible to hot-bearer debasement than a more extensive balance, the components are still under discussion. A noteworthy trouble in examination lies in the estimation of ISub. As the Fin FET is commonly manufactured on a silicon-on-protector substrate, ISub can't be estimated because of its skimming body. In any case, in our past work, an exceptional structure called body- tied Fin FET was created on a mass wafer, estimating ISub conceivable because the Si body of the gadget is attached to the substrate. We contended that huge S/D obstruction assumes a noteworthy job in improved hot-bearer resistance of restricted balance gadgets. In any case, they propose that a blend of a non-nearby impact and arrangement obstruction is significant in the hot-bearer system of Fin FET

P. E. Dodd (2007) et al: We have considered the effect of substantial particle energy and the job of atomic communications on SEU in CMOS IC. Over limit LET for DI-instigated SEE, little distinction is normally seen in single electron occasion upset & hook up cross sections estimated utilizing low versus high energy overwhelming particles. Beth at asit may, beneath the limit LET for DI-instigated upset, we find huge contrasts among low-high-energy overwhelming particle test outcomes. The information proposes that auxiliary particles created by atomic cooperation assume a job in deciding the SEU hardness of in corporated circuit, particularly at low LET. Inspite of the fact that the cross sections for atomic response instigated SEE from substantial particles are little, high-energy overwhelming particle testing might be mandatory, contingent upon the general mistake rate necessities of a given framework. The nearness of huge substantial particle atomic association impacts will challenge current techniques for dissecting and anticipating SEE marvels [10-13]. The impacts of overwhelming particle energy and atomic associations on the SEU and SEL reaction of business and radiation-solidified CMOSICs are investigated. Over the limit LET for DI-prompted upset, little distinction is seen in single electron occasion upset & lock up cross areas estimated utilizing low versus high energy substantial particles. In any case, noteworthy contrasts among low and high-energy substantial particle test outcomes are seen underneath the limit LET for single electron hub DI-actuated miracles. The information proposes that auxiliary particles created by atomic co-operations assume a job in deciding the SEU hardness of the coordinated circuit. The job of atomic co-operation & suggestions for radiation hardness confirmation & rate forecast are examined. Ground-based overwhelming particle testing for SEE is frequently used to think about the physical components adding to SEE and gauge the on-circle error rate. Before, run-of-the-mill quickening agent offices utilized for SEE testing have given particles whose energy is on the request of a couple of (1–10) MeV per nucleon [16-18]. With the approach of multi-micron thick gadgets over layers and flip-chip bundling, the use of offices in the 10–100 MeV/u range has expanded significantly. Be that as it may, overwhelming particle energies in regular space conditions venture into many GeV/u, with a pinnacle motion at a couple of 100 MeV/u. With a couple of exemptions, such particle energies are not accessible in ground-based test offices & worries about the devotion of quickening agent tests for re-enacting the reaction of IC in genuine space radiation conditions have come about. Past examinations in the writing have in some cases appeared in SEU reaction with particle energy and indifferent cases have not. Recently, the job of atomic connections between high-energy particles & material in incorporated circuits has gotten developing consideration [19-20].

Normally, substantial particle-prompted SEU results from DI brought about by the arrival of electron-hole sets along the way of a vigorous charged molecule occurrence on an incorporated circuit. Even though at times annoys because proton and neutron- prompted SEUs are for most part credited to ionization by response items (e.g., spoliation response items or Si draws back from Coulomb scattering) created by implication by atomic communications between an incident lively molecule and material in IC. Koga recommended that particles

through exceptionally lower LET may cause SEUs because of atomic co-operations that would be discernible I felt LET for DI-instigated upsets was high. All more recently, Warren, et al's queries freezed 4-MB SRAM has certified such an instrument using high-energy overwhelming particle SEU watched for LET less than 2 MeV-cm/mg in an SRAM having an immediate ionization disturbed limit LET of more noteworthy. Tragically, lower-energy information was introduced to all more indisputably demonstrating that higher-energy atomic collaborations were instruments for watched outcomes. They demonstrated information taken at high-& low-energy substantial particle quickening agents showing that now and again huge contrasts happen between SEU cross areas as a component of particle energy. Because of impacts of atomic co-operations as defined in restricted information that was accessible did not very large bolster this speculation [21-23]. Likewise, it was demonstrated that it is basic to perform SEE estimations beneath immediate ionization edge at adequately high particle fluencies to guarantee that any distinctions because of particle energy impacts will be settled. They define higher and lower-energy estimations of SEE in a variety of ICs from various producers. Different design ICs tried incorporating business & radiation- solidified gadgets manufactured in mass silicon and SOI technology. ICs considered here are essentially CMOSSRAMs, yet additionally incorporate a simple to-computerized converter (ADC). While past investigations have concentrated solely on the effect of particle energy and the job of atomic associations on SEU reaction and investigated the significance of particle energy on single electron occasion lock up (SEL) reaction. At long last, ramifications for hardness affirmation and SEE rate forecast are examined [16]

THEORY: -

The few body issue, of which the three body issue is the most basic unsolved issue in physics, is one of the most fundamental. The quantum wave equation for three particle lacks an analytical solution, hence numerical approximations must be constructed [24].

Targets that undergo single ionization due to charged particle interactions are considered to be among the most stringent tests for theoretical predictions. By comparing theoretical estimates with extensive experimental data, it is possible to perform highly sensitive tests of theoretical models. The most detailed experiments for single ionization by charged particles involve measuring energies of particles. The theoretical predictions for these processes are often referred to as full differential cross sections (FDS) or triply differential cross sections (DCS), even though they technically involve fivefold differential calculations [16-18].

Three separate close coupling approximations have been developed for electron-induced ionization of atoms, and they yield fit with experimental results for ionization of atomic molecules: Bray and Stelbovics developed the convergent close coupling (CCC), Colgan and Pindzola developed the time-dependent close coupling approximation (TDCC), and Rescigno et al. developed the exterior complex scaling (ECS). The distorted-wave Born approximation (DWBA) method is the most flexible theoretical approach to more complicated targets. The three- body distorted-wave (3DW) technique is presented for ionizing atoms by electron impact. This method adds the post collision interaction (PCI) to all orders of perturbation theory, making it a standard DWBA. A DWBA technique would typically be suitable for higher energies but not for lower energies [26].

Create the molecular three body distorted wave (M3DW) approximation for the case of molecules [12], and we have examined the ionization of numerous distinct targets using this technique. Due to the totally numerical nature of this method, the Total DCS for a single position of the molecule must be calculated using a numerical 6-dimensional (6D) integral. The requirement for a complete 6D integral arises from the precise inclusion of PCI. By computing the mean of all positions must be carried out because the majority of experimental observations do not reveal the orientation of the molecule at the moment of ionization.

The M3DW method computes the distorted waves for continuum electrons utilizing a spherically symmetric distorting potential. This suggests that the distorted waves remain unaffected by the molecule's orientation, which could be a notable limitation. Recently, Gong et al. introduced a multicenter three distorted-wave technique (MCTDW), wherein the distorted waves vary based on the molecule's orientation, addressing this drawback.

The wave functions and potentials were expanded employing the single-center expansion method to address the multicenter Schrödinger equation, as detailed in references [27]. This procedure involves disregarding the off-

diagonal elements, leading to a series of coupled differential equations, which subsequently yield a series of uncoupled partial-wave equations.

In the MCTDW approach, the Ward-Macek approximation is utilized to approximate the post- collision interaction, PCI, occurring between the two departing electrons, a method that may encounter challenges. Conversely, the M3DW method rigorously incorporates PCI across all levels of perturbation theory.

The interstellar medium (ISM) has a rich chemical history and makes up about 5% of the galaxy's total mass. Although hydrogen and helium make about 98% of the ISM, more than 200 distinct molecular species have been unequivocally discovered in these areas. Terrestrial laws of chemical stability merely don't apply in interstellar space due to the extremely low temperatures and collision rates. As a result, wide variety of species that would be extremely wobbly on Earth can accumulate to considerable deliberations in the idealistic environment. But in addition to the numerous "alien" molecules that have been found in celestial gas clouds, here are also a large number of "familiar friends," such as basic triatomic and diatomic molecules and higher sophisticated inherent compounds like aldehydes, alcohols, thiols, nitriles, and polyaromatic and aromatic compounds. Recently, positive identifications of molecules or particles as big as buckyballs have been made in The Interstellar Medium (ISM) [19].

In the commencement of molecule-ion chemistry within interstellar gas clouds, photoionization plays a limited role since visible and UV light with energy for ionizing molecules and atoms only reaches the outer parts of a cloud because of scattering and optical absorption. Although it has a significantly greater penetration depth, infrared light lacks the energy to ionize. Rather, the most frequent method of ionization is by collisions with cosmic rays, which are incredibly high-energy particles released by stars. Approximately 89% of cosmic rays are composed of protons, with the remaining 9% consisting of alpha particles, and the other 2% being composed of heavier nuclei, electrons, and other many more unusual particles [20].

The ISM contains a large number of lower-energy electrons alongside higher-energy cosmic ray electrons. These have roughly Maxwellian energy (ME) distributions that span the range of energy to a few tens of eV (electron volts) and are produced by solar winds, photoionization, and Auger processes. It follows that low-energy electron scattering processes are probably important in the ISM, confirming the presence of abundant electrons in cometary comas. As more and more probes are sent to explore diverse facets of space region, precise electron impact EI are also necessary for enable assessable examination of data of mass-spectrometer obtained through these delegations. Under this study, we offer the cross-sections for nine compounds, whose existence in the ISM has been verified, but which have not been widely published before. The cross-sections span from 0 to 300 eV. [12]

JAIN-KHARE FORMALISM:-

The calculations in question utilize the modified semi-empirical formalism developed by Jain- Khare. Essentially, the single differential cross sections across the complete solid angle (Ω) as a function of secondary electron energy (ε) for producing the (i^{th}) type of ion during molecule ionization by incident electrons of energy (E) are described by[25]:

$$[d\sigma_i / d\varepsilon = (R.\theta)\,] \qquad (1)$$

Here, (R) represents the Rydberg constant and (θ) denotes the scattering angle. The formulation hinges on dipole oscillator strengths ($df_i/d\omega$) as key parameters. These oscillator strengths, or appearance potentials, are directly proportional to the photoionization cross-sections. We've employed partial photoionization cross-section datasets within the energy range provided by Brion using (e,e) spectroscopy. The accuracy of the determined oscillator strength scales was estimated to be better [26-27]. In the photon energy range, total valence photo absorption oscillator strength data measured by Brion was utilized, while extrapolations for higher photon energy were performed via the Thomas-Reiche-Kuhn (TRK) sum rule. These total photo absorption cross-sections were then distributed into ionic fragments, assuming constant ionization efficiency above the dipole breakdown limit of approximately 25 eV.

However, evaluating this distribution quantum mechanically requires suitable wave functions and transition

probabilities corresponding to cation production. For dissociative ionization of polyatomic molecules, reliable probabilities for different dissociative ionization processes are lacking. The collision parameter and energy parameter ($\varepsilon 0$) are evaluated similarly to other polyatomic molecules. The vertical onsets or ionization potentials corresponding to various cations, along with photoionization measurements, are also provided [26-28]. In the present cross-section evaluations, the estimated uncertainty is roughly the same as for the measurement of photoionization cross-sections. The double differential cross sections as a function of energy and angle are obtained by differentiating the equation of the semi-empirical formula with respect to the solid angle (Ω):

$$\frac{d^2\sigma_i}{dEd\Omega}(E,W,\theta) = \sum_{i=i}^{N} Q_i(E,W,\theta) \quad (2)$$

The double differential cross sections are angularly dependent in all scattering geometries; thus, the oscillator strength must also be angle-dependent. In this regard, we utilize angular oscillator strengths derived in the optical limit (Bethe regime), where angular momentum transfer ($k \to 0$):

$$\left[f_{lm}(\omega,W,\theta) = \frac{\Omega}{4\pi} \sum_{m'} \sigma_{lm'}(\omega,W)/\sigma_{lm}(\omega)\left[\frac{(1-\beta W^3/3)}{2\omega}+1\right]\right] \quad (3)$$

where (β) is an energy-dependent asymmetric parameter. Its evaluation is challenging due to the absence of molecular ion wave functions in ground and excited states. In valence shell ionization of atomic molecules, we compute (β) as the ratio of Bethe spectral transitions ($S_i(W)$) to the squared dipole matrix ($M_i^2(W)$). The oscillator strength in the equation is a derived form in forward scattering corresponding to ($k \to 0$) and ($\theta \to 0$).

The partial ionization cross-section is obtained by integrating the energy-dependent single differential cross-sections over the entire energy loss [29]:

$$[\sigma_l = \int \left(\frac{d\sigma_l}{dE}\right) dE \quad (4)$$

And the total electron impact ionization cross-section is obtained by:

$$\lfloor\sigma_{tot}(E,W) = \sum_l \sigma_l(E,W)\rfloor \quad (5)$$

In plasma processes, the ionization rate coefficients ((R_i)) are crucial, determined using our calculated partial and total ionization cross-sections of molecules, alongside the Maxwell- Boltzmann distribution of temperature/energy [30-33]:

$$[\ R_i = \int_0^\infty 4\pi/\sqrt{2\pi mkT}\, e^{-E/kT}\ Q_i(E)dE \quad (6)$$

Here, (k), (T), and (m) are the Boltzmann constant, absolute temperature, and mass of the electron, respectively [29].

Result and Discussion: -

In this paper we are showing the results of the absolute partial ionization cross section

measurements for the At are calculated from threshold to 2800 eV by the use of modified Jain-Khare approach [29]. To the best of our knowledge there are no other experimental data or theoretical computations against which we can compare the present results.

Energy(eV)	At^{+}	Energy(eV)	At^{++}	Energy(eV)	At^{+++}
13	0.00781				
14	0.0312	14	0.042474	14	0.014701
15	0.0985	15	0.134362	15	0.082427
20	0.552628	20	0.575505	20	0.47399
25	0.945792	25	0.944807	25	0.84275
30	1.22421	30	1.20899	30	1.11413
35	1.41234	35	1.38886	35	1.30222
40	1.53638	40	1.5088	40	1.42978
45	1.61651	45	1.58651	45	1.5142
50	1.66569	50	1.63522	50	1.56875
55	1.69386	55	1.66296	55	1.60155
60	1.70655	60	1.67653	60	1.61954
65	1.70906	65	1.67925	65	1.62613
70	1.70347	70	1.67504	70	1.62535
75	1.69303	75	1.66496	75	1.6183
80	1.6782	80	1.65168	80	1.60775
85	1.6613	85	1.63512	85	1.59362
90	1.64192	90	1.61733	90	1.57805
95	1.62199	95	1.59764	95	1.56035
100	1.6006	100	1.57782	100	1.54238
105	1.57948	105	1.55683	105	1.52306
110	1.55747	110	1.53636	110	1.50413
115	1.5362	115	1.51512	115	1.4843
120	1.51434	120	1.49473	120	1.46524
125	1.49347	125	1.4738	125	1.44552
130	1.47217	130	1.45392	130	1.42679
135	1.452	135	1.43363	135	1.40754
140	1.43148	140	1.41446	140	1.38936
145	1.41215	145	1.39494	145	1.37077
150	1.39251	150	1.37659	150	1.35329
155	1.37406	155	1.35793	155	1.33544
160	1.35534	160	1.34042	160	1.31871
165	1.33778	165	1.32262	165	1.30163
170	1.31997	170	1.30595	170	1.28566
175	1.30328	175	1.289	175	1.26934
180	1.28634	180	1.27315	180	1.25412
185	1.27048	185	1.25701	185	1.23854
190	1.25438	190	1.24195	190	1.22405
195	1.2393	195	1.22659	195	1.2092
200	1.22399	200	1.21224	200	1.19536
210	1.19507	210	1.18394	210	1.168
220	1.16754	220	1.15697	220	1.14188

230	1.1413	230	1.13126	230	1.11694
240	1.11627	240	1.10671	240	1.09312
250	1.09236	250	1.08326	250	1.0703
260	1.06951	260	1.06083	260	1.04847
270	1.04766	270	1.03934	270	1.02754
280	1.02671	280	1.01877	280	1.00747
290	1.00665	290	0.999033	290	0.988208
300	0.987407	300	0.980081	300	0.969701
310	0.968923	310	0.961898	310	0.951922
320	0.95116	320	0.944396	320	0.934809
330	0.934089	330	0.927579	330	0.918346
340	0.917657	340	0.911371	340	0.902489
350	0.90183	350	0.895775	350	0.88719
360	0.886574	360	0.880729	360	0.872445
370	0.871865	370	0.866218	370	0.858214
380	0.857677	380	0.852213	380	0.844464
390	0.843972	390	0.838686	390	0.831188
400	0.830729	400	0.825615	400	0.818344
410	0.81793	410	0.81296	410	0.805917
420	0.805552	420	0.800736	420	0.79389
430	0.793577	430	0.78889	430	0.782244
440	0.78197	440	0.77742	440	0.770968
450	0.770731	450	0.766308	450	0.760045
460	0.759835	460	0.755527	460	0.749436
470	0.749269	470	0.745077	470	0.739152
480	0.73902	480	0.734929	480	0.729152
490	0.72907	490	0.725087	490	0.719452
500	0.719404	500	0.71553	500	0.710034
520	0.700886	520	0.697196	520	0.69196
540	0.683383	540	0.679851	540	0.674853
560	0.666792	560	0.663436	560	0.658661
620	0.621917	620	0.61896	620	0.614756
640	0.608384	640	0.605542	640	0.601491
660	0.595483	660	0.59275	660	0.588862
680	0.583157	680	0.580513	680	0.576767
700	0.571385	700	0.568842	700	0.565221
720	0.560112	720	0.557654	720	0.554161
740	0.549317	740	0.546954	740	0.543578
760	0.538972	760	0.536666	760	0.533395
780	0.529039	780	0.526812	780	0.523652
800	0.519497	800	0.517336	800	0.514269
825	0.508105	825	0.506011	825	0.503058
900	0.476935	900	0.475065	900	0.472406
925	0.467458	925	0.465643	925	0.463066
950	0.458369	950	0.456625	950	0.454149

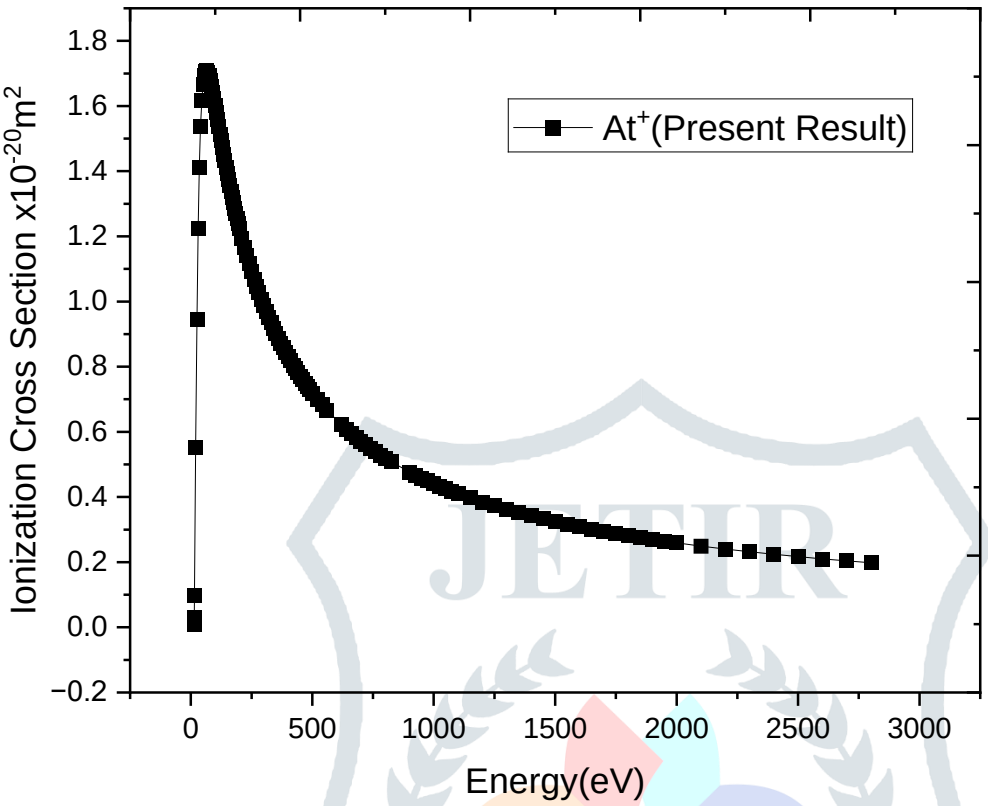
975	0.449679	975	0.447977	975	0.445576
999	0.441653	999	0.440006	999	0.437679
1000	0.441322	1000	0.439694	1000	0.437367
1025	0.433312	1025	0.43172	1025	0.429466
1050	0.425603	1050	0.424062	1050	0.421863
1075	0.418194	1075	0.416694	1075	0.414545
1100	0.411061	1100	0.40961	1100	0.407526
1150	0.397557	1150	0.396178	1150	0.394207
1200	0.38499	1200	0.38368	1200	0.381814
1250	0.373256	1250	0.37201	1250	0.370227
1300	0.362287	1300	0.361102	1300	0.359403
1350	0.351991	1350	0.350862	1350	0.34923
1400	0.342316	1400	0.341238	1400	0.339675
1450	0.333194	1450	0.332166	1450	0.330669
1500	0.324599	1500	0.3236	1500	0.322168
1550	0.316466	1550	0.315515	1550	0.314137
1600	0.308761	1600	0.307829	1600	0.306516
1650	0.301462	1650	0.300568	1650	0.299304
1700	0.294529	1700	0.293661	1700	0.292408
1750	0.28793	1750	0.287089	1750	0.285887
1800	0.281644	1800	0.280829	1800	0.279675
1850	0.27565	1850	0.274875	1850	0.273743
1900	0.269929	1900	0.269174	1900	0.268086
1950	0.264455	1950	0.263728	1950	0.262663
2000	0.259222	2000	0.258503	2000	0.257483
2100	0.249402	2100	0.248726	2100	0.247761
2200	0.240355	2200	0.23972	2200	0.238791
2300	0.231987	2300	0.231387	2300	0.23051
2400	0.224231	2400	0.223655	2400	0.222825
2500	0.21702	2500	0.216473	2500	0.21567
2600	0.210283	2600	0.209755	2600	0.209003
2700	0.20399	2700	0.203492	2700	0.20277
2800	0.198092	2800	0.197607	2800	0.19691

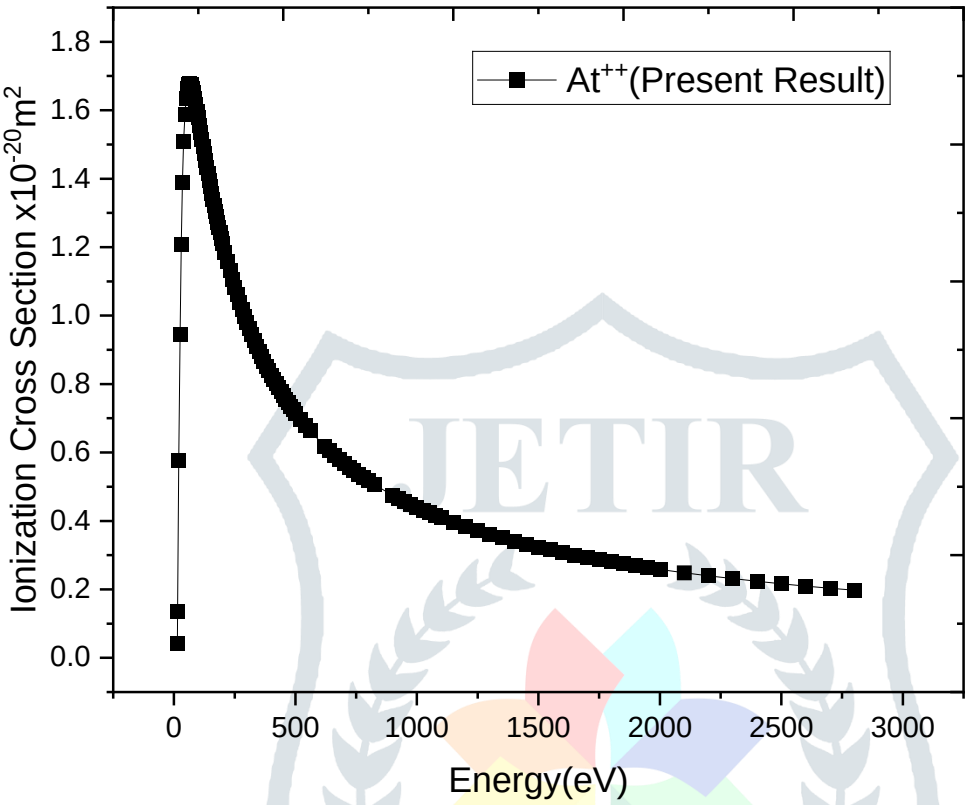
Energy(eV)	At^{++++}	Energy(eV)	At^{+++++}	Energy(eV)	TIC
				13	0.00781
14	0.000709			14	0.089083
15	0.053957	15	0.042536	15	0.411781
20	0.415263	20	0.460737	20	2.478123
25	0.782473	25	0.803584	25	4.319406
30	1.05788	30	1.05996	30	5.66517

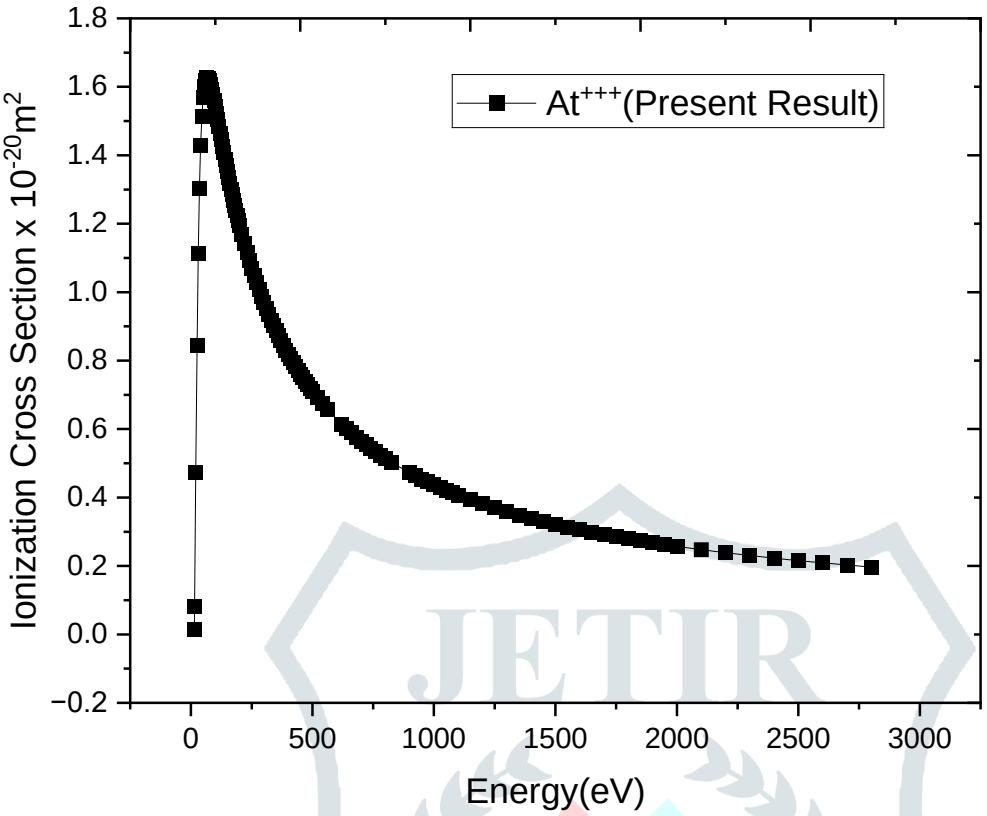
35	1.25094	35	1.24086	35	6.59522
40	1.38322	40	1.36528	40	7.22346
45	1.47184	45	1.44958	45	7.63864
50	1.53004	50	1.50478	50	7.90448
55	1.56601	55	1.53973	55	8.06411
60	1.58676	60	1.55942	60	8.1488
65	1.59575	65	1.5688	65	8.17899
70	1.59709	70	1.56984	70	8.17079
75	1.59191	75	1.56569	75	8.13389
80	1.58303	80	1.55678	80	8.07744
85	1.57039	85	1.54545	85	8.00588
90	1.55617	90	1.53125	90	7.92472
95	1.53968	95	1.51618	95	7.83584
100	1.52281	100	1.49932	100	7.74293
105	1.50449	105	1.48246	105	7.64632
110	1.48648	110	1.4644	110	7.54884
115	1.46749	115	1.44688	115	7.44999
120	1.44921	120	1.42847	120	7.35199
125	1.43021	125	1.41091	125	7.25391
130	1.41215	130	1.39267	130	7.1577
135	1.39351	135	1.37542	135	7.0621
140	1.37592	140	1.35761	140	6.96883
145	1.35786	145	1.34092	145	6.87664
150	1.3409	150	1.32367	150	6.78696
155	1.32351	155	1.30758	155	6.69852
160	1.30723	160	1.29102	160	6.61272
165	1.29056	165	1.27556	165	6.52815
170	1.27501	170	1.25969	170	6.44628
175	1.25905	175	1.24492	175	6.36559
180	1.24417	180	1.22973	180	6.28751
185	1.22893	185	1.21562	185	6.21058
190	1.21476	190	1.20109	190	6.13623
195	1.20021	195	1.1876	195	6.0629
200	1.18664	200	1.17371	200	5.99194
210	1.15982	210	1.14758	210	5.85441
220	1.13417	220	1.12257	220	5.72313
230	1.10967	230	1.09863	230	5.5978
240	1.08624	240	1.07571	240	5.47805
250	1.06379	250	1.05378	250	5.36349
260	1.04229	260	1.03274	260	5.25384
270	1.02168	270	1.01253	270	5.14875
280	1.00189	280	0.993142	280	5.047982
290	0.982881	290	0.974516	290	4.951288
300	0.964617	300	0.956589	300	4.858395
310	0.947063	310	0.939386	310	4.769192

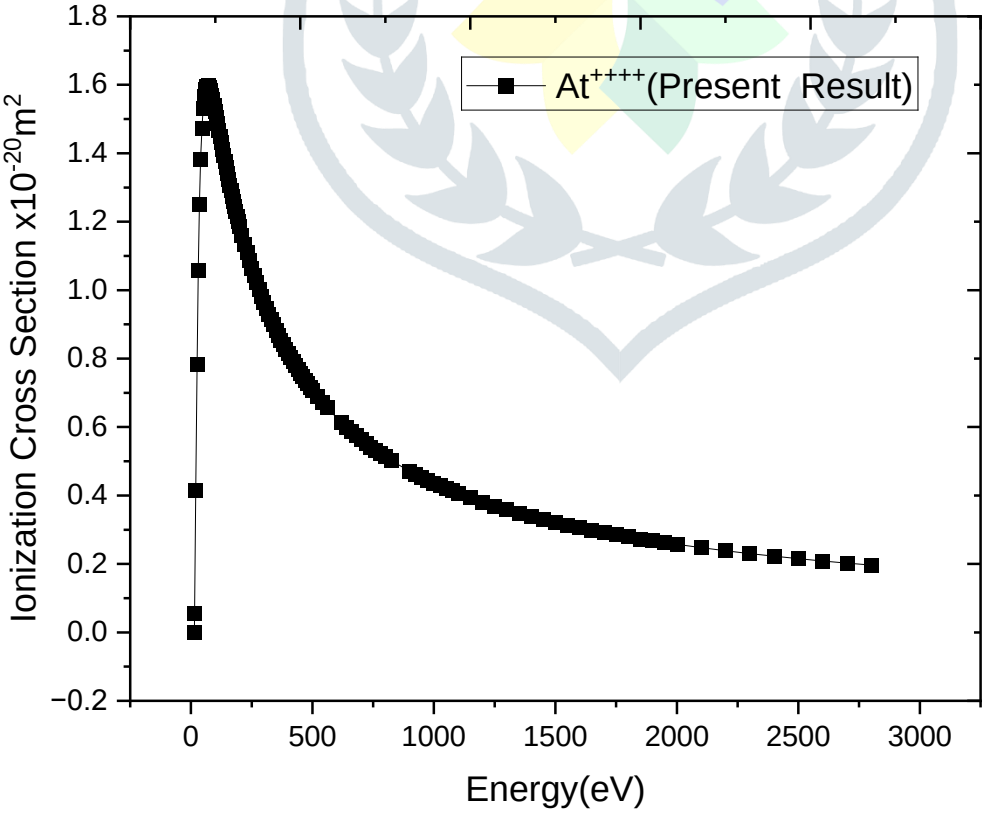
320	0.930161	320	0.922786	320	4.683312
330	0.91389	330	0.906787	330	4.600691
340	0.89819	340	0.891379	340	4.521086
350	0.883071	350	0.876502	350	4.444368
360	0.868487	360	0.862158	360	4.370393
370	0.854418	370	0.848283	370	4.298998
380	0.840799	380	0.834885	380	4.230038
390	0.827652	390	0.821936	390	4.163434
400	0.814923	400	0.809386	400	4.098997
410	0.802628	410	0.797268	410	4.036703
420	0.790702	420	0.785519	420	3.976399
430	0.77916	430	0.774128	430	3.917999
440	0.767979	440	0.763104	440	3.861441
450	0.757147	450	0.752404	450	3.806635
460	0.74663	460	0.742034	460	3.753462
470	0.736422	470	0.731934	470	3.701854
480	0.726517	480	0.722166	480	3.651784
490	0.716885	490	0.712647	490	3.603141
500	0.707539	500	0.703393	500	3.5559
520	0.689604	520	0.685677	520	3.465323
540	0.672616	540	0.668878	540	3.379581
560	0.656536	560	0.652969	560	3.298394
620	0.612917	620	0.609787	620	3.078337
640	0.599739	640	0.596748	640	3.011904
660	0.58717	660	0.584278	660	2.948543
680	0.575142	680	0.572392	680	2.887971
700	0.563675	700	0.561003	700	2.830126
720	0.552676	720	0.550093	720	2.774696
740	0.542133	740	0.53965	740	2.721632
760	0.532013	760	0.529615	760	2.670661
780	0.522324	780	0.520021	780	2.621848
800	0.512999	800	0.510761	800	2.574862
825	0.501827	825	0.499689	825	2.51869
900	0.471325	900	0.469395	900	2.365126
925	0.462021	925	0.460185	925	2.318373
950	0.453141	950	0.451333	950	2.273617
975	0.444603	975	0.442866	975	2.230701
999	0.436739	999	0.435059	999	2.191136
1000	0.436426	1000	0.434751	1000	2.18956
1025	0.428535	1025	0.426929	1025	2.149962
1050	0.420969	1050	0.419383	1050	2.11188
1075	0.413682	1075	0.41216	1075	2.075275
1100	0.406693	1100	0.405201	1100	2.040091
1150	0.393436	1150	0.392016	1150	1.973394
1200	0.381077	1200	0.379724	1200	1.911285

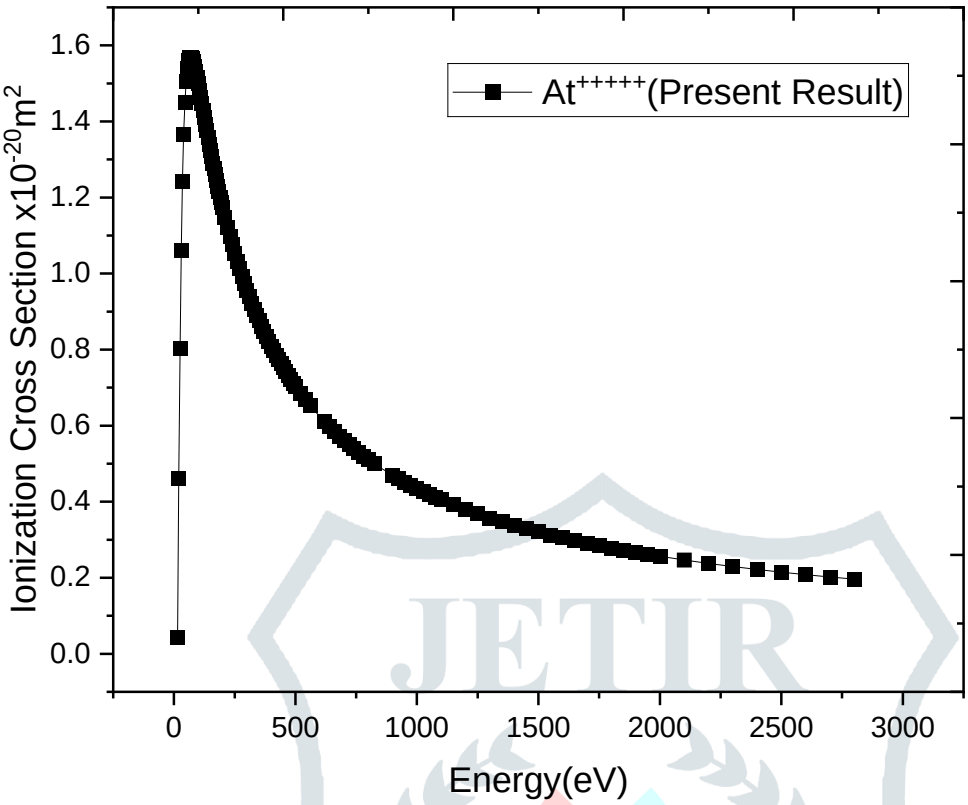
1250	0.369528	1250	0.368257	1250	1.853278
1300	0.358754	1300	0.357539	1300	1.799085
1350	0.348614	1350	0.347456	1350	1.748153
1400	0.339088	1400	0.337986	1400	1.700303
1450	0.330111	1450	0.329054	1450	1.655194
1500	0.321637	1500	0.320636	1500	1.61264
1550	0.313613	1550	0.312624	1550	1.572355
1600	0.306018	1600	0.305059	1600	1.534183
1650	0.298828	1650	0.297916	1650	1.498078
1700	0.291961	1700	0.291078	1700	1.463637
1750	0.285448	1750	0.284613	1750	1.430967
1800	0.279253	1800	0.278437	1800	1.399838
1850	0.273335	1850	0.27254	1850	1.370143
1900	0.267694	1900	0.266917	1900	1.3418
1950	0.262286	1950	0.261548	1950	1.31468
2000	0.25711	2000	0.25639	2000	1.288708
2100	0.24742	2100	0.24673	2100	1.240039
2200	0.238464	2200	0.237825	2200	1.195155
2300	0.230192	2300	0.22958	2300	1.153656
2400	0.222538	2400	0.221965	2400	1.115214
2500	0.215392	2500	0.214842	2500	1.079397
2600	0.208732	2600	0.208206	2600	1.045979
2700	0.202525	2700	0.202032	2700	1.014809
2800	0.196674	2800	0.196203	2800	0.985486

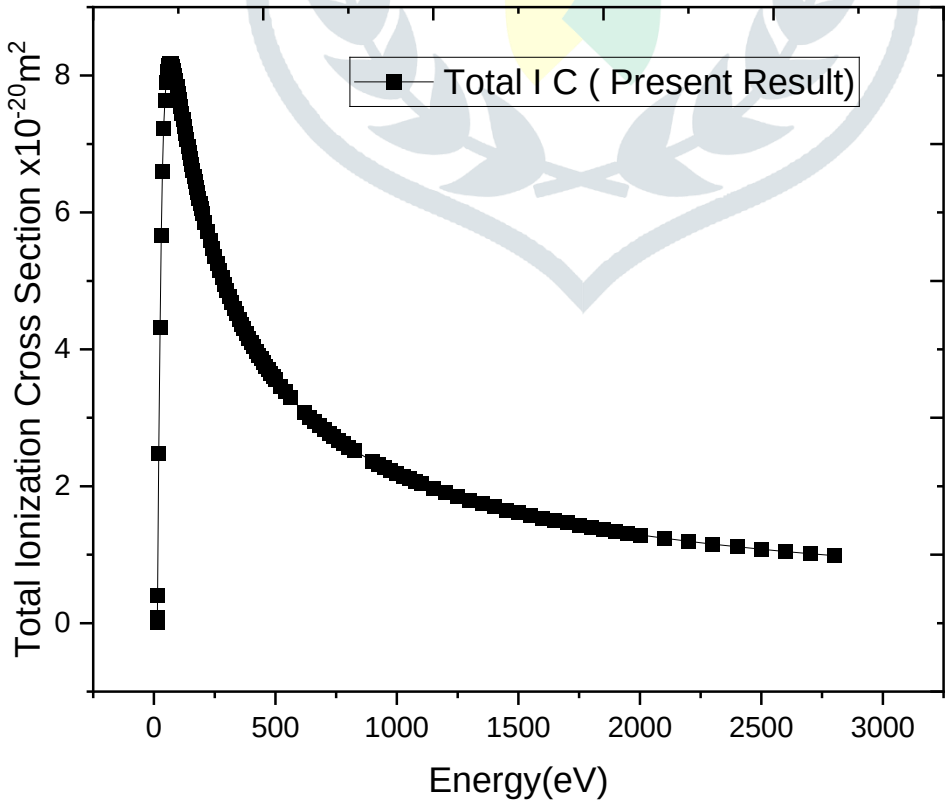

Ionization Cross Section x10-20m2
Energy(eV)
At+(Present Result)
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
−0.2
0
500
1000
1500
2000
2500
3000


At++(Present Result)
Ionization Cross Section x10-20m2
Energy(eV)
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
0
500
1000
1500
2000
2500
3000


At+++(Present Result)
Ionization Cross Section x 10-20m2
Energy(eV)
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
−0.2
0
500
1000
1500
2000
2500
3000


At++++(Present Result)
Ionization Cross Section x10-20m2
Energy(eV)
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
−0.2
0
500
1000
1500
2000
2500
3000


Ionization Cross Section x10-20m2
At++++++(Present Result)
Energy(eV)
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
0
500
1000
1500
2000
2500
3000


Total Ionization Cross Section x10-20m2
Total I C (Present Result)
Energy(eV)
0
2
4
6
8
0
500
1000
1500
2000
2500
3000

CONCLUSION: The modified Jain–Khare[15] semi-empirical formulation has been employed to evaluate the partial single- differential cross-sections for the At molecule from threshold to electron energy of 2800 eV. The calculations were made for the production of the 5 singly charged ions At^{+}, At^{++}, At^{+++}, At^{++++}, At^{+++++} ions produced via, direct and dissociative ionization of Ac by electron impact [21]. In all the ionization processes, the theoretical results predict the clear appearance of the threshold behavior of the cross-sections. Undoubtedly, the present results may be useful in plasma processes, astrochemistry and fusion research. Hence, all these investigations also support the successfulness of the semi-empirical approach in the calculation of partial differential cross- sections for molecules.

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