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Electron Impact N Subshells Ionization Cross Sections of $_{104}$Rf to $_{108}$Hs Near the N subshells Thresholds by Lotz's Equation

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Abstract

NonrelativisticN shell (σ^{nrel}_N) and σ^{nrel}_{Ni} (i =1,.,7) subshells ionization cross sections by electron impact on $_{104}$Rf $_{105}$Db, $_{106}$Sg, $_{107}$Bh, $_{108}$Hs atoms calculated. By using Lotz' equation in Matlab, (σ^{nrel}_N) and N σ^{nrel}_{Ni} cross section values obtained for 24 electron impact(E_0) values in the range of $E_{Ni}<E_0\leq 7E_{Ni}$ for each atom. Starting from $E_0=E_{Ni}$(subshell ionization threshold energies), σ^{nrel}_N and σ^{nrel}_N are increasing rapidly with E_0. For a fixed E_0 = 3,4keV, while Z value increases from $_{104}$Rf $\leq$ Z $\leq$ $_{108}$Hs atoms; σ^{rel}_N and σ^{rel}_{Ni} decrease. Results show that for smaller values of E_0(close to E_{Ni}), x-ray yields formation of N_i (i =,1,...,7) subshells decreases while competing other yields are increase. Results may help to understand similar findings which obtained from other electron impact excitation of N σ^{nrel}_N, subshells σ^{nrel}_{Ni} studies for single atoms.

Keywords: *Nonrelativistic σ^{nrel}_N, subshells σ^{nrel}_{Ni} subshells ionization cross sections calculations for $_{104}$Rf $_{105}$Db, $_{106}$Sg, $_{107}$Bh, $_{108}$Hs atoms, Near Ni subshells threshold region, Electron impact*

1. Introduction

N subshell Inner-shell ionization cross section measurements or calculations of atoms by electron impact are subjects of ongoing research for many years [1-5, 14, 16-21]. For the measurement of accurate and reliable electron impact ionization cross sections of atomic inner subshells, a multi-purpose electron-atom crossed beam system must be used. Due to the complexity of the physical process, during the measurements some uncertainty may occur. There are still less systematic theoretical studies on the subject. Inner shell ionization cross section studies help us to understand, Auger electron spectroscopy, x-ray source characterization of target atoms, astrophysics, fusion plasma physics, radiation protection, design of medical instrument, electron, photon bombardment of tissues with energy transfer in the study required [3, 4, 5]. This work is similar to work on Ni subshells ionization cross sections of $_{92}$U to $_{103}$Lr [21]. In this study, N shell and Ni subshells ionization cross section σ^{nrel}_N and σ^{nrel}_{Ni}(i= 1,..,7) for $_{104}$Rf $_{105}$Db, $_{106}$Sg, $_{107}$Bh, $_{108}$Hs atoms are calculated: For all atoms E_{0i}(i=1,..,14) electron impact values were chosen in the $E_{Ni} < E_{0i} < 7.E_{Ni}$ range where E_{Ni} ionization energy of ith N_i subshells for each atom. As a result of an electron impact on free neutral atom, ionization may occur at one of Ni subshells of that atom. Creation of electron holes in Ni subshells depends on how big the impact electron energy E_0 compare to E_{Ni} (i=1, 7) energies. If an atom A bombarded by an electron with sufficiently big E_0 under $E_{Ni}<E_0$ conditions, then neutral atom becomes excited ions A^{+*}. In addition to the scattered electron, probably an electron is ejected with specific energy from the proper N subshell respectively. Ni subshells are also emits photons which characterize the characteristic x-rays of N_i subshells of that atom. The sum of the intensity of the characteristic x-rays, the ionization probability of the occurrence of the event that σ is a measure of the cross section. Lotz put forward a semi-empirical formula at [1-4], for calculation of ionization cross sections for low energetic electrons impact excitation of free atoms at inner shells which was based on Born Approximation [6]. Lotz added a correction factor as a multiplier to the Bethe formula for developing Lotz's equation [1-4]. After Lotz, Pessa and Newell also used Lotz's equation for σ^{nrel}_{Ntotal} and for σ^{nrel}_{Ni} subshells ionization cross sections calculations for near ionization threshold electron impact energies of several atoms [4, 6]. Calculations carried out by using Lotz's equations in Matlab program [3, 4, 5, 6, 9]. E_{Ni} is the ionization energy of that N_i subshells. Calculations for σ^{nrel}_{Ntotal} and for σ^{nrel}_{Ni} by using the following Lotz's equation;

$$\sigma^{nrel}_{Ni} = a_i\, q_i \ln(E_0/E_i)/E_0E_i\, [1-b_i \exp(-c_i (E_0/E_i))] \quad (1)$$

Carried out: a_i, b_i, c_i constants and q_i of the ith subshell which were taken from Lotz [1-5]. q_i are the number of equivalent electrons at ith N_i subshell and E_{Ni} is the ionization energy of the ith subshell. The values of a_i, b_i, c_i and q_i are given in the same order for N_i (i=1, 2,,7) subshells. Used values of a_i, b_i, c_i constants and of q_i given in Method section below [1-4, 6]. For selected 14 electron impact values, by using the Eq.1 and from sum of calculated seven $\sigma^{rel}{}_{Ni}$ of each atom, N shell $\sigma^{nonrel}{}_{Ntotal}$ calculated.

2. Method

Nonrelativistic N shell and N_i subshells σ^{nrelL} and $\sigma^{nrel}{}_{Ni}$ for *$_{104}$Rf $_{105}$Db, $_{106}$Sg, $_{107}$Bh, $_{108}$Hs* atoms are calculated. Calculations done for 14 E_{0i}(i=1, 2,12) values which they chosen in energy range of $E_{N1i} \leq E_{0i} \leq 5{,}9.E_{N1i}$ for each atom. It means that for $_{104}$Rf used over all E_{0i} values fall in 0,85keV<E_0<4,925keV range. Used all energies in Matlab given in eV. E_{0i} values chosen according to the E_{N1i} of target atom which were taken from Gwyn and Porter [3, 19]. Calculations carried out by using written commands for Lotz's Eq.1 in MATLAB for each atom [1, 2, 3, 9-19]. The values of a_{Ni}, b_{Ni}, c_{Ni} parameters and q_{Ni} are given in the same order for N_i subshells as: For instance: a_{Ni} equal to (3, 2, 2,1,7 1,5…1,5.)10^{-14}cm^2(eV)^2; for b_{Ni} equal to (0.5, 0.92, 0,92, 0,7, 0,6…); for c_{Ni} equal to (0.6, 0.25, 0.19, 0,18,); and for q_{Ni} equal to (2, 2, 4,1,6, 1,2…) similar values used [1-2, 13-14]. By using the Eq.1 and using sum of calculated $\sigma^{nrel}{}_{Ni}$ subshell of each atom for 14 values of E_{0i} $\sigma^{nrel}{}_{Ltotal}$ of N shell calculated. Used N subshell electron binding energies given at Table.A in eV [3]. N subshell binding energies fall between M_5 and O_1(2s) subshell A. Electron impact energy values for each atom must be chosen between M_5(1s) shell and O_1(2s) subshell binding energies of that atom. For Ni subshell ionization; used any electron lost some parts of its energy as bremsstrahlung while incoming through atom and entering it, then passing Oi(i=1, 2,..5) subshells.

Table A: Used electron binding energies of E_{Ni}(i=1,,.7) subshells of $_{104}$Rf $_{105}$Db, $_{106}$Sg, $_{107}$Bh, $_{108}$Hs and $_{109}$Mt in, eV [3,19].

Atom Z	$E_{N7(eV)}$	$E_{N6(eV)}$	$E_{N5(eV)}$	$E_{N4(eV)}$	$E_{N3(eV)}$	$E_{N2(eV)}$	$E_{N1(eV)}$
$_{104}$Rf	1801	1392	1360	955	970	533	515
$_{105}$Db	1870	1442	1415	989	965	560	545
$_{106}$Sg	1941	1496	1460	1029	1110	590	575
$_{107}$Bh	2011	1546	1510	1073	1049	627	605
$_{108}$Hs	2083	1597	1530	1100	1070	641	625
$_{109}$Mt	2159	1650	1500	1144	1115	675	655

3. Results

Nonrelativistic cross section calculations for $_{104}$Rf, $_{105}$Db, $_{106}$Sg, $_{107}$Bh and $_{108}$Hs atoms carried out for 12 electron impact energies. $\sigma^{nrel}{}_{N}$ and $\sigma^{nrel}{}_{Ni}$ of Ni shell results for 12 E_{0i} were given in Table.1 to 5 under the name of each atom: $_{104}$Rf to $_{107}$Bh for 12 different energy and for $_{108}$Hs 24 different energy used. This calculations are similar to our earlier study of 78Pt to 92U [12, 13]. which were carried out for E_{0i} electron impact energy close to N subshell ionization threshold energy values of $_{104}$Rf to $_{108}$Hs atoms. For the same atomic results also given as colored graphs in a figure which named as same as that Table. These graphs helps to compare how each subshells $\sigma^{nrel}{}_{Ni}$ depends at any value of E_{0i} energy at any atom nonrelativistic N shell $\sigma^{nrel}{}_{Ntotal}$ and N_i subshells $\sigma^{nrel}{}_{Ni}$ calculations for each atom:$\sigma^{nrel}{}_{Ni}$ values are given in (b) in Tables 1-6 and in Figs.1-6. There are some common characteristics of $\sigma^{nrel}{}_{N}$: For each atom very close to threshold region; $\sigma^{nrel}{}_{N1}$ crosses $\sigma^{nrel}{}_{N2}$ and $\sigma^{nrel}{}_{N3}$ and crosses only $\sigma^{nrel}{}_{N3}$ other cross sections at higher energies region, namely through end region of graphs. Each $\sigma^{nrel}{}_{Ni}$ increases differently with electron impact energy. Z dependency of ionization cross sections for a fixed E_{0i} = 3,4 keV impact given in Table.6a and Figs.6a. All each $\sigma^{nrel}{}_{Ni}$ decrease with atomic number Z for 104≤ Z ≤108 range.

Table 1: Nonrelativistic Ni subshell ionization cross section of $_{104}$Rf in 10^5 b.

E_0(keV)	$\sigma_{N1}10^5$b	$\sigma_{N2}10^5$b	$\sigma_{N3}10^5$b	$\sigma_{N4}10^5$b	$\sigma_{N5}10^5$b	$\sigma_{N6}10^5$b	$\sigma_{N7}10^5$b	$\sigma_{Ntotal}10^5$b
0,85	-0,4071686	-0,2345178	-0,4598056	-0,0440686	-0,0625735	0,0144745	0,0178553	-1,1758
1,35	-0,1342508	-0,0538547	-0,0865446	0,0068934	0,0184277	0,0598358	0,0571379	-0,13236
1,76	-0,0492796	0,0059155	0,0362933	0,0291915	0,0540274	0,0816355	0,0759897	0,233773
2,35	0,0069313	0,0479579	0,1219727	0,0493767	0,0862715	0,1020627	0,0935468	0,508119
2,55	0,0178036	0,0565102	0,1392145	0,0543998	0,0942843	0,1071643	0,0979025	0,567279
2,8	0,0281151	0,0648161	0,1558369	0,0598057	0,102893	0,1126218	0,1025358	0,626624
3,1	0,0370942	0,0722343	0,1705149	0,0652747	0,1115813	0,1180692	0,1071457	0,681914
3,4	0,0435028	0,0776546	0,1810687	0,0698657	0,1188509	0,1225458	0,1108725	0,724361
3,7	0,0481192	0,0816388	0,1886443	0,0737556	0,1249863	0,1262379	0,1139211	0,757303
4,05	0,0519133	0,0849279	0,1947374	0,0775781	0,1309849	0,1297158	0,1167646	0,786622
4,5	0,0550653	0,0876799	0,1994708	0,0815862	0,1372299	0,1331531	0,1195104	0,813696
4,925	0,0568436	0,0891162	0,2016953	0,0846256	0,1419197	0,1355376	0,1213539	0,831092

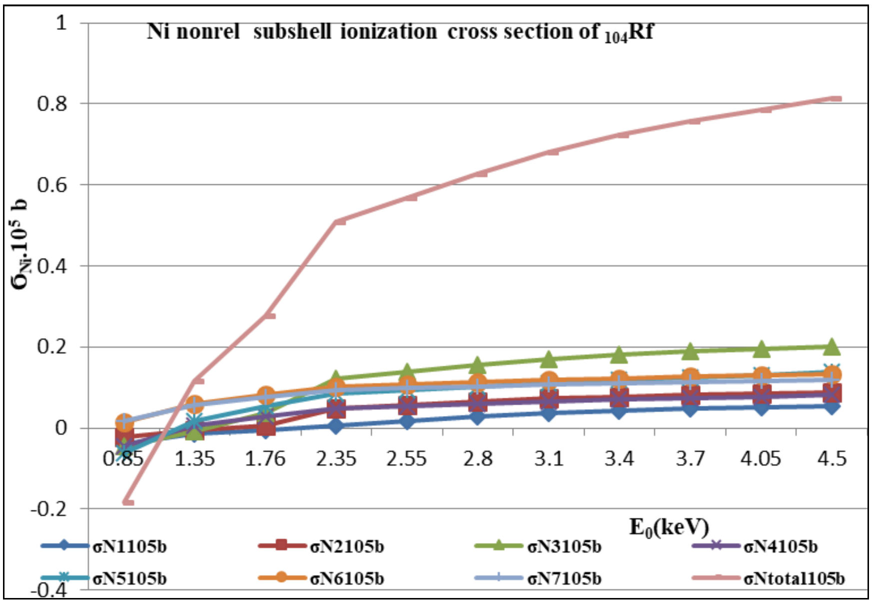

Fig 1a: Nonrelativistic Ni subshell ionization cross section of $_{104}$Rf in 10^5 b.

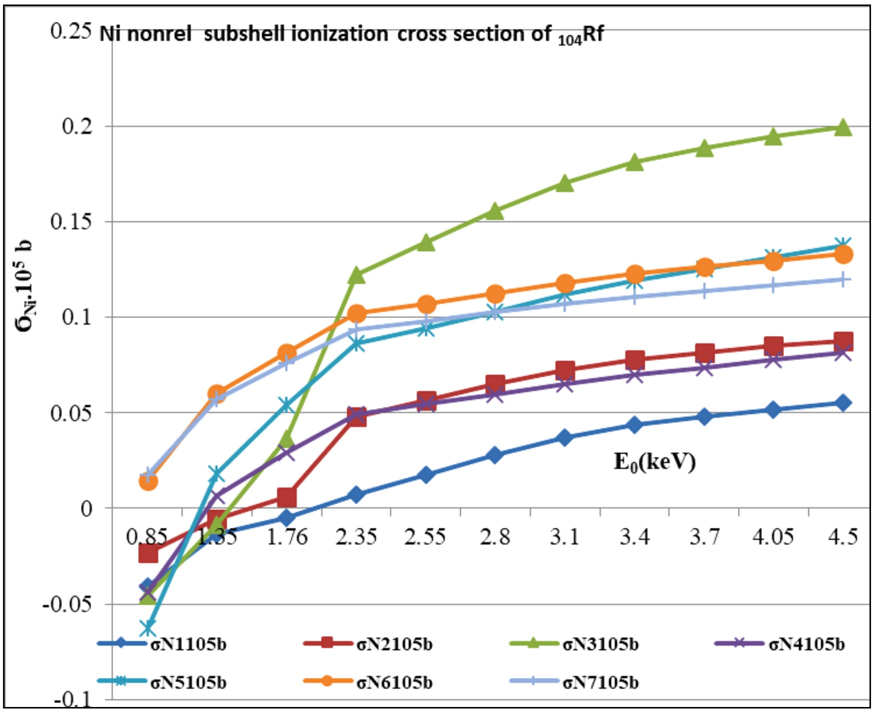

Fig 1b: Nonrelativistic Ni subshell ionization cross section of $_{104}$Rf in 10^5 b.

Table 2: Nonrelativistic Ni subshell ionization cross section of $_{105}$Db in 10^5 b.

E_o(keV)	$\sigma_{N1}10^5$b	$\sigma_{N2}10^5$b	$\sigma_{N3}10^5$b	$\sigma_{N4}10^5$b	$\sigma_{N5}10^5$b	$\sigma_{N6}10^5$b	$\sigma_{N7}10^4$b	$\sigma_{Ntotal}10^4$b
0,9	-0,362563	-0,207376	-0,404247	-0,038228	-0,044204	0,0155148	0,0173158	-1,02379
1,46	-0,107989	-0,038506	-0,054686	0,0104659	0,0426704	0,0589493	0,0544378	-0,03466
1,9	-0,034653	0,0135036	0,0522819	0,0306227	0,0786578	0,0712545	0,0712545	0,282922
2,4	0,0064976	0,0444467	0,1153571	0,0457574	0,1063211	0,0938847	0,0841855	0,49645
2,75	0,0229264	0,0574437	0,1415306	0,0535298	0,1202364	0,1017193	0,0907973	0,588184
3	0,0311261	0,0641374	0,1548567	0,0581136	0,1283808	0,1062972	0,0946399	0,637552
3,3	0,0383644	0,0701917	0,1667533	0,0627956	0,1366272	0,1109053	0,0984859	0,684123
3,6	0,0435924	0,0746638	0,1753801	0,0667604	0,1435309	0,1147221	0,1016478	0,720298
3,9	0,0473934	0,0779693	0,1816024	0,0701439	0,1493445	0,117888	0,1042484	0,74859
4,35	0,0512413	0,0813479	0,1876894	0,0743457	0,1564236	0,1216463	0,1072953	0,77999
4,65	0,0529348	0,0828229	0,1901625	0,0766714	0,1602502	0,1236091	0,1088597	0,795311
5	0,0542888	0,0839663	0,1918715	0,0789898	0,1639739	0,1254467	0,1102976	0,808835

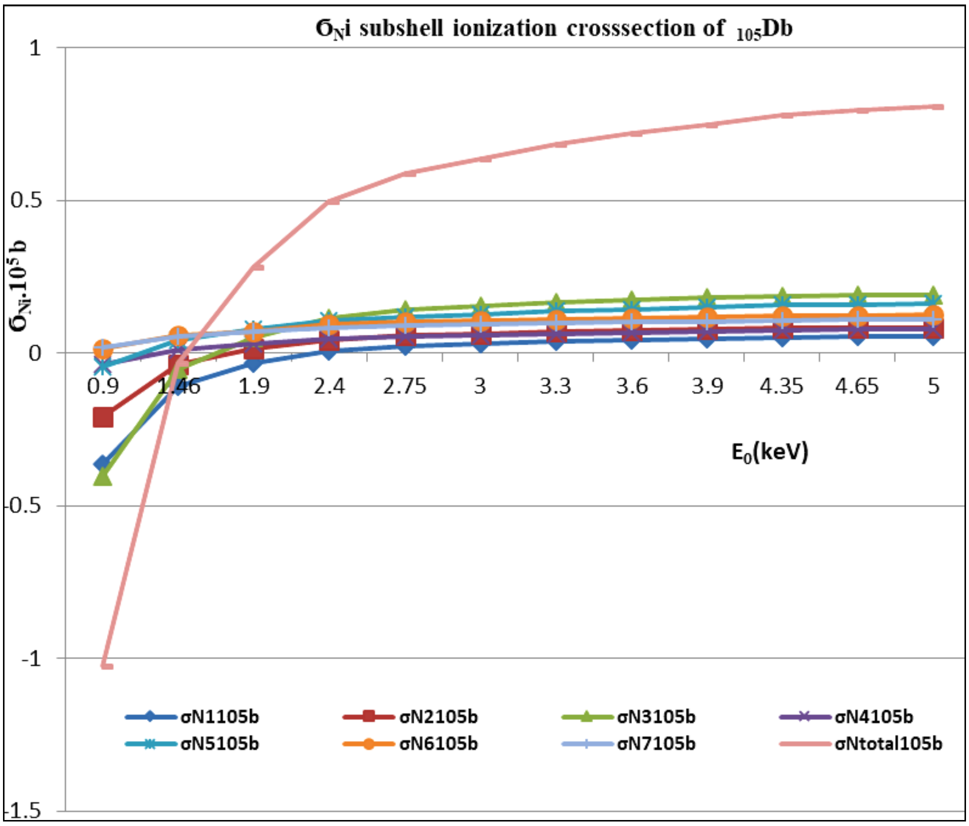

Fig 2a: Nonrelativistic Ni subshell ionization cross section of $_{105}$Db in 10^5 b.

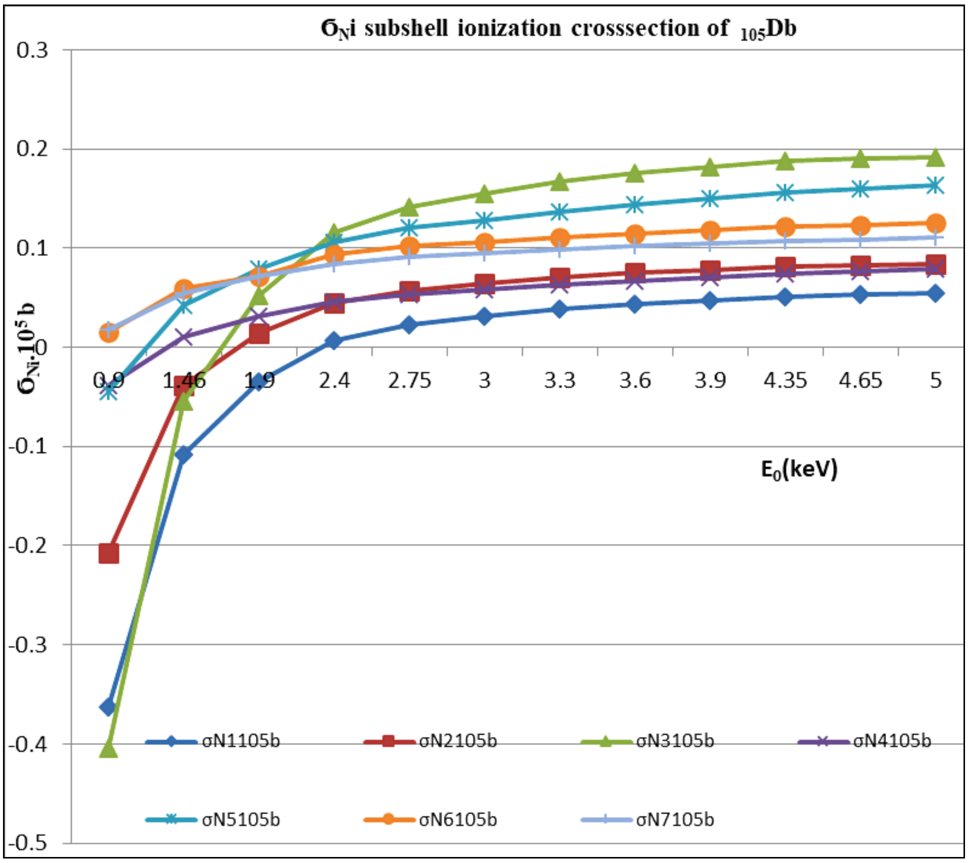

Fig 2b: Nonrelativistic Ni subshell ionization cross section of $_{105}$Db in 10^5 b.

Table 3: Nonrelativistic Ni subshell ionization cross section of $_{106}$Sg b in 10^5 b.

E_o(keV)	$\sigma_{N1}10^5$b	$\sigma_{N2}10^5$b	$\sigma_{N3}10^5$b	$\sigma_{N4}10^5$b	$\sigma_{N5}10^5$b	$\sigma_{N6}10^5$b	$\sigma_{N7}10^5$b	$\sigma_{Ntotal}10^5$b
0,95	-0,324407	-0,1855115	-0,3575611	-0,033129	-0,0361361	0,0152701	0,0175869	-0,90389
1,56	-0,0888594	-0,0305428	-0,0337108	0,0130171	0,0465222	0,0558071	0,0526135	0,014847
2	0,0268383	0,0133273	0,0571779	0,030652	0,078442	0,0727305	0,0672043	0,346372
2,5	0,0090448	0,0402843	0,1123923	0,0441798	0,102885	0,0860544	0,0786298	0,47347
2,75	0,0200723	0,0489777	0,1299613	0,0493611	0,1121897	0,0911734	0,0829916	0,5347271
3	0,0283147	0,0556642	0,1433255	0,0537931	0,1201014	0,0955364	0,0866863	0,5834216
3,3	0,0356148	0,0617592	0,1553262	0,0583268	0,1281262	0,0999368	0,0904015	0,6294915
3,65	0,0416416	0,0669478	0,1653139	0,0627544	0,1358755	0,1041613	0,0939331	0,6706276
4	0,0458242	0,0706529	0,1722134	0,0664486	0,1422426	0,107699	0,0967675	0,7018482
4,45	0,0493808	0,0738806	0,1779027	0,0703491	0,1488273	0,1110577	0,0995949	0,7309931
4,75	0,0509577	0,0753313	0,1802516	0,0725176	0,1524048	0,1128923	0,1010626	0,7454179
5,15	0,0523674	0,0766241	0,1820727	0,0749711	0,1563488	0,1148485	0,1025945	0,7598271

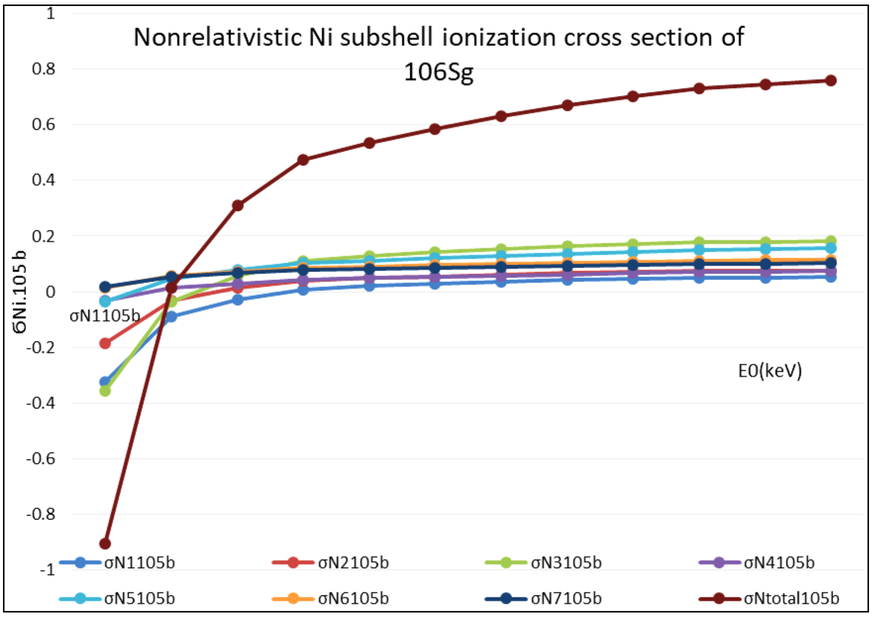

Fig 3a: Nonrelativistic Ni subshell ionization cross section of $_{106}$ Sg in 10^5 b.

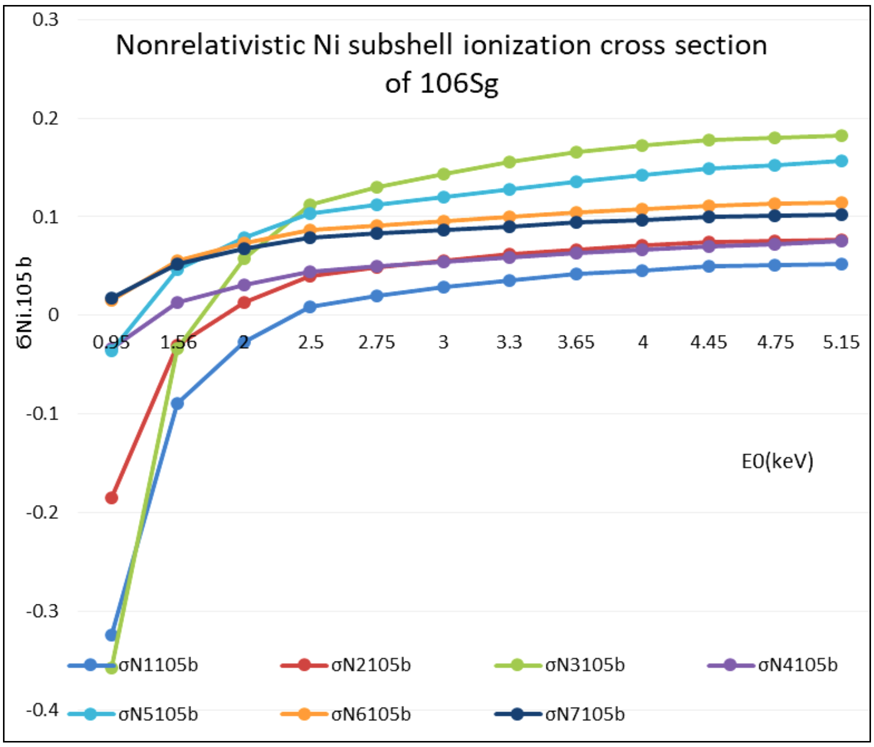

Fig 3b: Nonrelativistic Ni subshell ionization cross section of $_{106}$Sg in 10^5 b.

Table 4: Nonrelativistic Ni subshell ionization cross section of $_{107}$Bh i b in 10^5 b.

E_o(keV)	$\sigma_{N1}10^5b$	$\sigma_{N2}10^5b$	$\sigma_{N3}10^5b$	$\sigma_{N4}10^5b$	$\sigma_{N5}10^5b$	$\sigma_{N6}10^5b$	$\sigma_{N7}10^5b$	$\sigma_{Ntotal}10^5b$
1	-0,2924584	-0,1672185	-0,3207246	-0,0295961	-0,0295253	0,0154695	0,0172505	-0,8068029
1,45	-0,1176797	-0,0533508	-0,0816081	0,0032903	0,030676	0,0443175	0,0421083	-0,1322465
1,85	-0,0490584	-0,0061666	0,016846	0,0204661	0,0624813	0,0606362	0,0561592	0,1613639
2,1	-0,0234288	0,0122293	0,0549748	0,0283412	0,0770982	0,0683623	0,0627937	0,2803707
2,55	0,0056696	0,0340089	0,0997105	0,0391866	0,0971794	0,0791564	0,0720272	0,4269385
2,9	0,0195266	0,0448995	0,1217604	0,0456266	0,1090111	0,0855789	0,0774881	0,5038912
3,3	0,0299976	0,0534755	0,1388178	0,0515162	0,1197327	0,0914054	0,0824079	0,5673531
3,6	0,0354222	0,0580825	0,1477783	0,0551663	0,1262894	0,0949538	0,0853806	0,6030731
4	0,0405161	0,0625435	0,1562081	0,0592421	0,1334998	0,0988196	0,0885911	0,6394203
4,4	0,0439349	0,0656304	0,1617729	0,0626999	0,1393169	0,1018903	0,0911087	0,666354
4,8	0,0462172	0,0677383	0,1653096	0,0653869	0,1440251	0,1043204	0,0930696	0,6860671
5,3	0,0479869	0,0693913	0,1677138	0,0682283	0,1486644	0,1066336	0,0948928	0,7035111

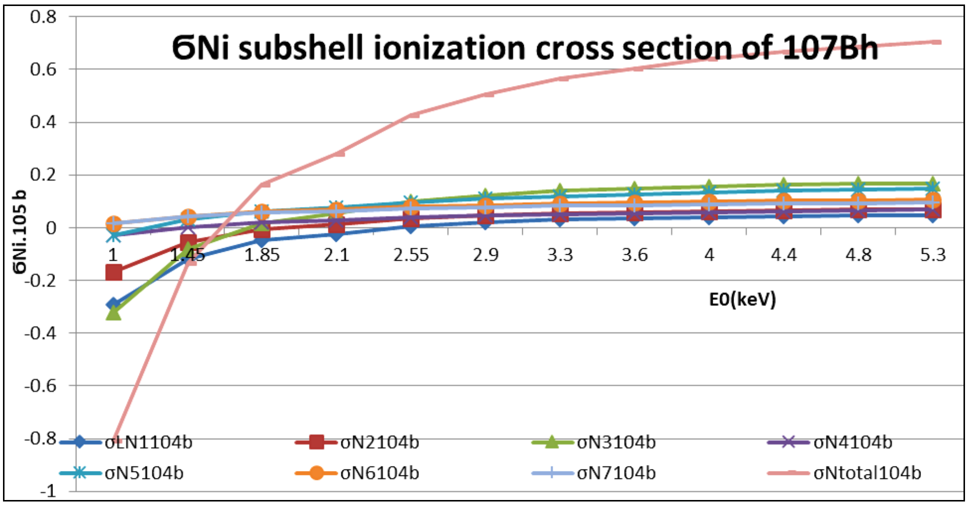

Fig 4a: Nonrelativistic Ni subshell ionization cross section of $_{107}$Bh i b in 10^5 b.

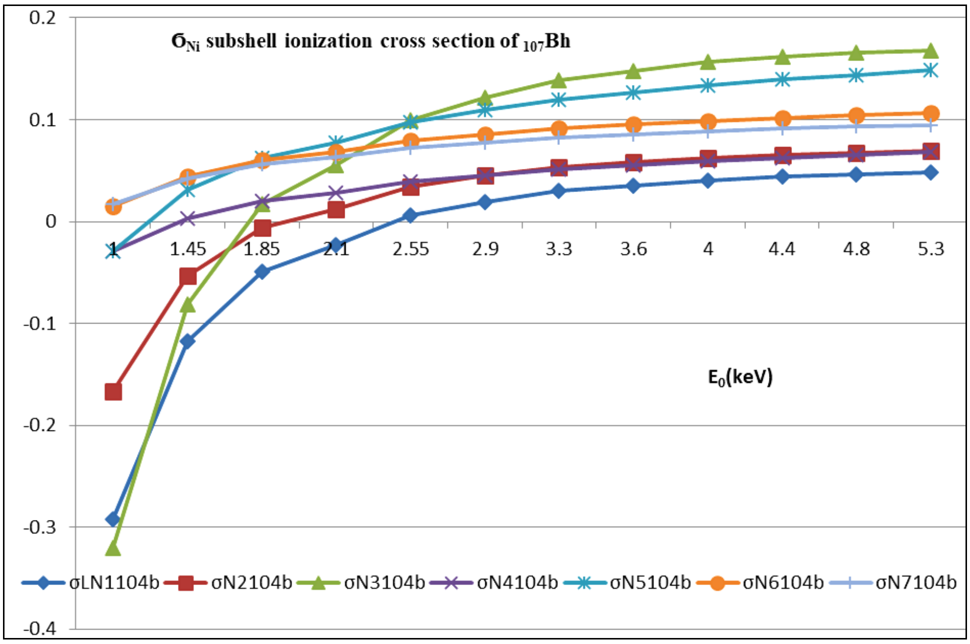

Fig 4b: Nonrelativistic Ni subshell ionization cross section of $_{107}$Bh in 10^5 b.

Table 5: Nonrelativistic Ni subshell ionization cross section of $_{108}$Hs in 10^5 b for 24 E_0(keV).

E_0(keV)	σN_1	σN_2	σN_3	σN_4	σN_5	σN_6	σN_7	σN_{total}
0,95	-0,2945	-0,191	-0,3771	-0,0385	-0,0571	-0,0022	0,0048	-0,9556
1,2	-0,1804	-0,1102	-0,2088	-0,0193	-0,0275	0,0241	0,0225	-0,4996
1,4	-0,1248	-0,0699	-0,1249	-0,0085	-0,0108	0,0399	0,0331	-0,2659
1,6	-0,08649	-0,04161	-0,06617	-0,00019	0,00211	0,05275	0,04171	-0,09789
1,8	-0,05909	-0,02087	-0,02323	-0,00653	0,01252	0,06341	0,04885	0,01506
1,95	-0,04337	-0,00875	0,00182	0,01078	0,01912	0,07029	0,05348	0,10337
2,2	-0,02349	0,00692	0,03411	0,01677	0,02842	0,08016	0,06009	0,20298
2,4	-0,01163	0,01649	0,05375	0,02081	0,03467	0,08688	0,06461	0,26558
2,5	-0,00671	0,02054	0,06203	0,02261	0,03749	0,08992	0,06664	0,29252
2,65	-0,00031	0,02586	0,07288	0,02512	0,04137	0,09413	0,06946	0,32851
2,8	0,00509	0,03042	0,08215	0,02738	0,04491	0,09797	0,07202	0,35994
3	0,0111	0,0355	0,0925	0,0302	0,0491	0,1026	0,0751	0,3961
3,2	0,0159	0,0398	0,1011	0,0326	0,0529	0,1067	0,0778	0,4268
3,4	0,0199	0,0433	0,1082	0,0348	0,0563	0,1103	0,0803	0,4531
3,6	0,0231	0,0463	0,1141	0,0367	0,0594	0,1136	0,0825	0,4757
3,8	0,0259	0,0488	0,1189	0,0385	0,0622	0,1166	0,0844	0,4953
4,3	0,0308	0,0534	0,1278	0,0424	0,0682	0,1227	0,0885	0,5338
4,7	0,0334	0,0559	0,1325	0,0449	0,0721	0,1265	0,0911	0,5564
5,7	0,0371	0,0594	0,1383	0,0497	0,0794	0,1332	0,0954	0,5925
6,8	0,0384	0,0605	0,1392	0,0531	0,0846	0,1371	0,0979	0,6108
7,9	0,0384	0,0601	0,1373	0,0554	0,0881	0,1387	0,0988	0,6168
8,9	0,0379	0,0591	0,1343	0,0567	0,0899	0,1388	0,0987	0,6154
9,2	0,0377	0,0588	0,1333	0,0571	0,0903	0,1387	0,0985	0,6144
10,4	0,0368	0,0571	0,1288	0,0577	0,0913	0,1374	0,0975	0,6066

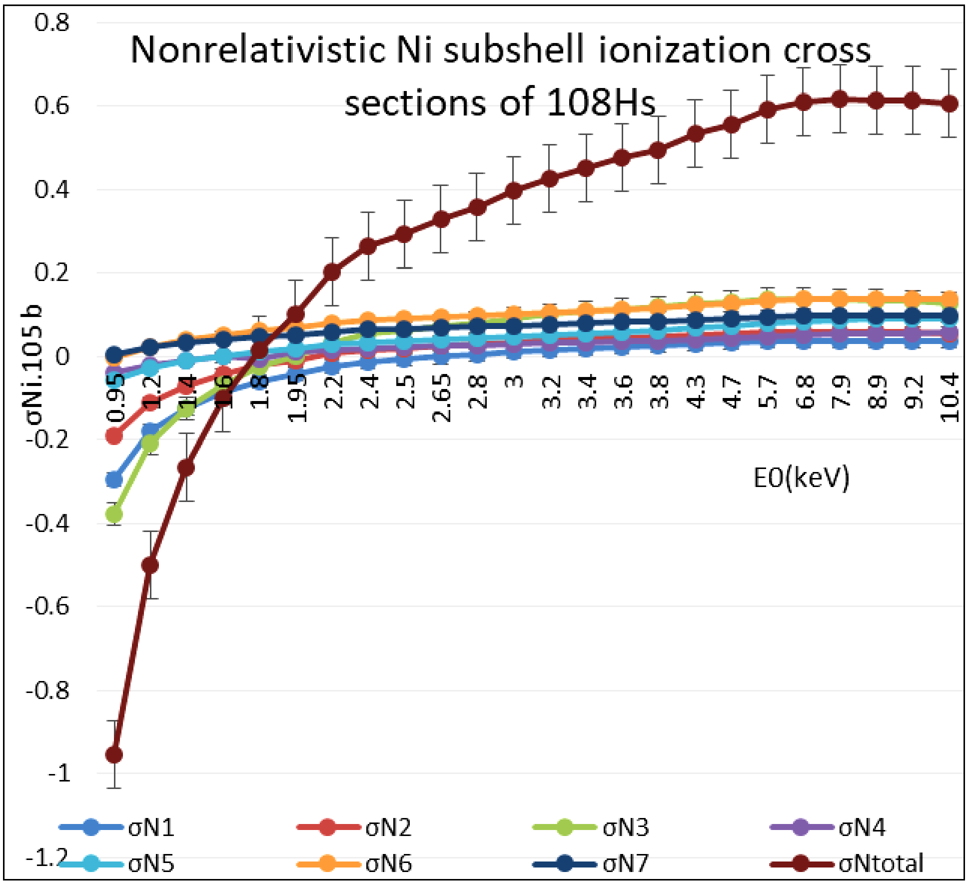

Fig 5a: Nonrelativistic Ni subshell ionization cross section of $_{108}$Hs 10^5 b.

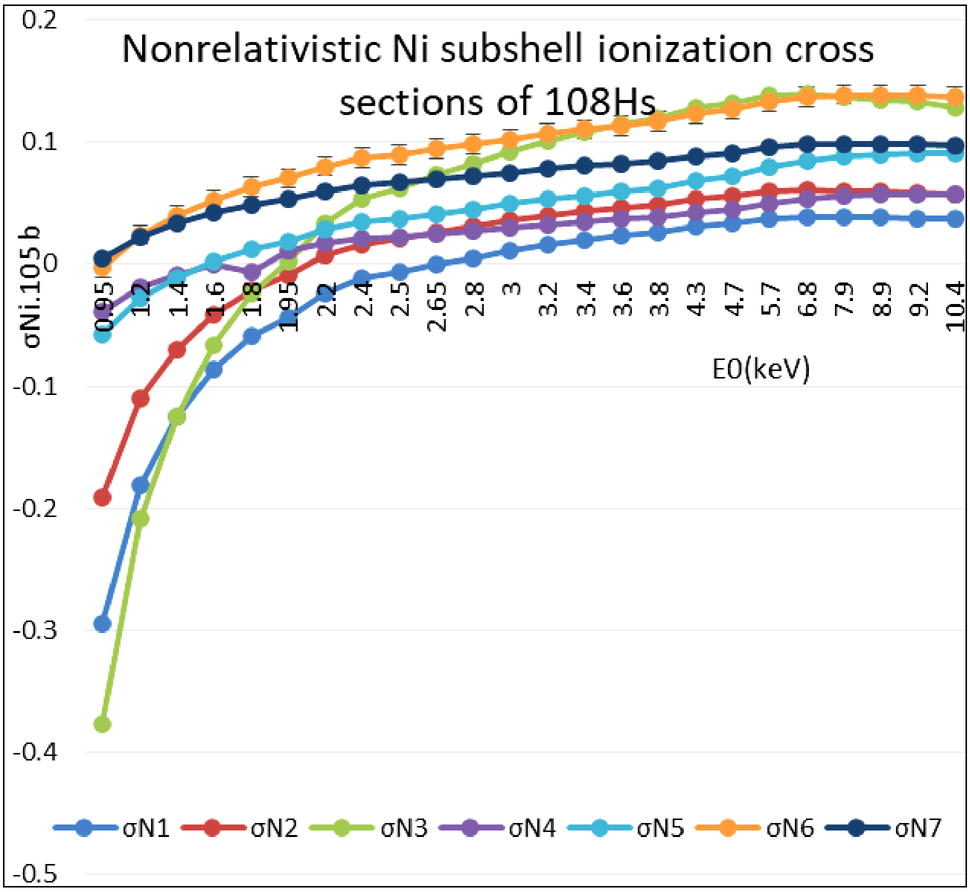

Fig 5b: Nonrelativistic Ni subshell ionization cross section of $_{108}$Hs in 10^5 b.

Table 6: For about 3,33 to 3,45keV electron impact Z dependency of $\sigma^{nrel}{}_{Ni}$ of $_{103}$Lr to $_{107}$Hs. Each color belongs to one atom data.

E_0(keV)	AtomicZ	$\sigma_{N1}10^5$b	$\sigma_{N2}10^5$b	$\sigma_{N3}10^5$b	$\sigma_{N4}10^5$b	$\sigma_{N5}10^5$b	$\sigma_{N6}10^5$b	$\sigma_{N7}10^5$b	$\sigma_{Ntotal}10^5$b
3,3	103Lr	0,04766	0,08308	0,19561	0,07806	0,13136	0,14086	0,12353	0,80016
3,4	104Rf	0,04351	0,07765	0,18107	0,06987	0,11885	0,12255	0,11087	0,72437
3,3	105Db	0,04168	0,07603	0,17794	0,06842	0,11657	0,12115	0,10971	0,70286
3,5	106Sg	0,03562	0,06176	0,15533	0,05834	0,12813	0,09994	0,09041	0,63042
3,45	107Bh	0,02999	0,05348	0,13882	0,05151	0,11973	0,09142	0,08241	0,58533
3,4	108Hs	0,01992	0,04331	0,10822	0,03481	0,05631	0,11032	0,08032	0,45312

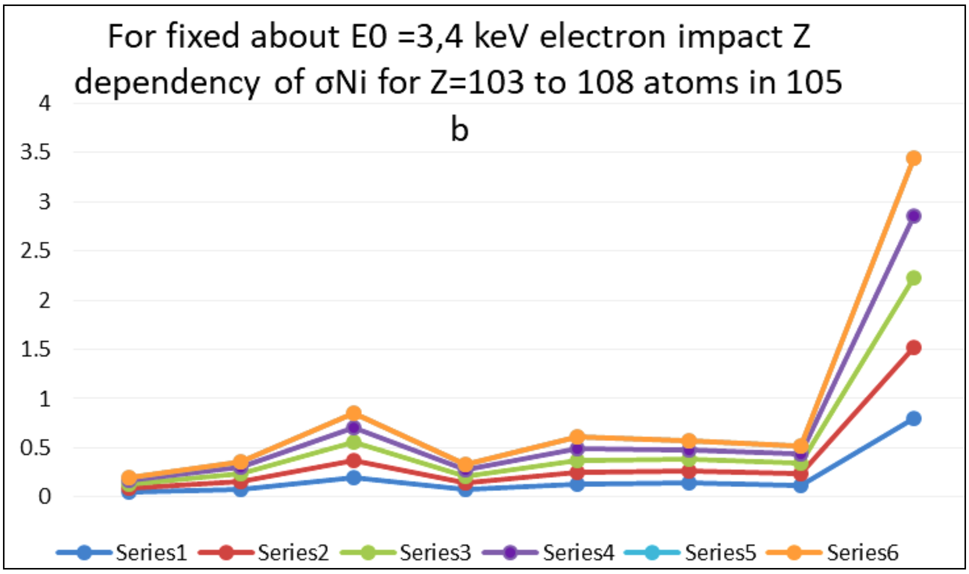

Fig 6: Z dependency of $\sigma^{nrel}{}_{Ni}$ of $_{103}$Lr to $_{108}$Hs for about 3,33 to 3,4keV electron impact ionization.

4. Conclusions

Nonrelativistic N shell σ^{nrel}_{Ntotal} and N_i subshells σ^{nrel}_{Ni} for $_{104}$Rf, $_{105}$Db, $_{106}$Sg, $_{107}$Bh and $_{108}$Hs atoms results given in under the name of each atom separately. These graphs helps to compare how each subshells σ^{nrel}_{Ni} and total σ^{nrel}_{Ntotal} depends at any value of E_{0i} electron impact energy. There are some common charcteristics of σ^{nrel}_{Ni}. For each atom very close to threshold region; Seven σ^{nrel}_{Ni} For 1,2 keV to about 3 keV threshold impact of $_{104}$Rf as seeing at Figs.1a, and 1b, σ^{nrel}_{Ni}: σ^{nrel} N_3 crosses the other cross sections in the following order: σ^{nrel}_{N1} σ^{nrel}_{N2} σ^{nrel}_{N4} $\sigma^{nrel}_{N5,}$ $\sigma^{nrel}_{N6,}$ and $\sigma^{nrel}_{N7.}$ As seeing at Figs.2a and 2b; and up to Figs.3a and 3b; up toFigs.5a and 5b for $_{105}$Db to $_{108}$Hs atom: σ^{nrel}_{N3}; always crosses others in the following order:σ^{nrel}_{N1} and σ^{nrel}_{N2} and $\sigma^{nrel}_{N4,}$ σ^{nrel}_{N5}, σ^{nrel}_{N6} and σ^{nrel}_{N7} cross sections in the this order(for impact energy range of 1,2 to 3keV. For higher energies namely through end region of graphs each σ^{nrel}_{Ni} increases differently by E_0 impact energy. For a fixed about E_{oi} = (3,3 to 3,4) keV, while Z value changes from $_{104}$Rf≤ Z≤ $_{108}$Hs σ^{nrel}_{Ni} decrease with Z. Nonrelativistic σ^{nrel}_{Ni} and relativistic σ^{rel} results for $_{92Bk}$≤ Z≤$_{103Lr}$ published in [12, 13, 21]. It will be better if results compared with single electron impact on single free atom experimental measurements and with other calculations such as Distorted wave Born approximation (DWBA) and Modified Relativistic Bethe Born Approximation (MRBEB) [5-16, ...8, 21].

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