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Electron Impact Excitations of $_{98}$Cf, $_{99}$Es, $_{100}$Fm $_{101}$Md, $_{102}$Nb, $_{103}$Lr Atoms N_i Subshell İonization Cross Sections by Using Lotz's Equation

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Abstract

NonrelativisticN shell ($\sigma^{nrel}{}_N$) and $\sigma^{nrel}{}_{Ni}$ (i =1,.,7) subshells ionization cross sections by electron impact on $_{98}$Cf, $_{99}$Es, $_{100}$Fm $_{101}$Md, $_{102}$No, $_{103}$Lr *calculated. By using Lotz' equation in Matlab, ($\sigma^{nrel}{}_N$) and N $\sigma^{nrel}{}_{Ni}$ cross section values obtained for 14 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), $\sigma^{nrel}{}_N$ and $\sigma^{nrel}{}_N$ are increasing rapidly with E_0. For a fixed E_0 = 3,5keV, while Z value increases from $_{92}U \leq Z \leq {}_{103}Lr$ atoms; $\sigma^{rel}{}_N$ and $\sigma^{rel}{}_{Ni}$ 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 $\sigma^{nrel}{}_N$, subshells $\sigma^{nrel}{}_{Ni}$ studies for single atoms.*

Keywords: *Nonrelativistic $\sigma^{nrel}{}_N$, subshells $\sigma^{nrel}{}_{Ni}$ subshells ionization cross sections calculations for* $_{92}$U, $_{93}$Np, $_{94}$Pu, $_{95}$Am, $_{96}$Cm, $_{97}$Bk *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, 13-14, 16-23]. 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 considered to be supplementray part of Ni subshells ionization cross sections of 92U to 97Bk [23]. In this study, N shell and Ni subshells ionization cross section $\sigma^{nrel}{}_N$ and $\sigma^{nrel}{}_{Ni}$(i= 1,..,7) for $_{98}$Cf, $_{99}$Es, $_{100}$Fm $_{101}$Md, $_{102}$No, $_{103}$Lr 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). 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 $\sigma^{nrel}{}_{Ntotal}$ and for $\sigma^{nrel}{}_{Ni}$ 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 $\sigma^{nrel}{}_{Ntotal}$ and for $\sigma^{nrel}{}_{Ni}$ 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

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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 $_{98}$Cf, $_{99}$Es, $_{100}$Fm $_{101}$Md, $_{102}$No, $_{103}$Lr atoms are calculated. Calculations done for 14 E_{0i}(i=1,2..,14) 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 $_{98}$Cf used over all E_{0i} values fall in 1keV<E_0<5,9keV 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 for $_{99}$Es, $_{100}$Fm $_{101}$Md, $_{102}$No, $_{103}$Lr 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(i=1, 2,..5) subshells.

Table A: Used electron binding energies of E_{Ni}(i=1,to,.7) subshells of $_{98}$Cf, $_{99}$Es, $_{100}$Fm $_{101}$Md, $_{102}$No, $_{103}$Lr in eV [3,19].

Atom Z	E_{N7}	E_{N6}	E_{N5}	E_{N4}	E_{N3}	E_{N2}	E_{N1}
98Cf	1801	1392	1360	955	970	533	515
99Es	1870	1442	1415	989	965	560	545
100Md	1941	1496	1460	1029	1110	590	575
101Fm	2011	1546	1510	1073	1049	627	605
102No	2083	1597	1530	1100	1070	641	625
103Lr	2159	1650	1500	1144	1115	675	655

3. Results

Nonrelativistic cross section calculations for $\sigma^{nrel}{}_{N}$ and $\sigma^{nrel}{}_{Ni}$ $_{98}$Cf, $_{99}$Es, $_{100}$Fm $_{101}$Md, $_{102}$No, $_{103}$Lr atoms carried out for 14 electron impact energies. $\sigma^{nrel}{}_{N}$ and $\sigma^{nrel}{}_{Ni}$ of Ni shell results for 14 E_{0i} were given in Table.1 to 6 under the name of each atom. These are nonrelativistic data similar to our earlier study which were carried out for E_{0i} electron impact energy close to N subshell ionization threshold energy values of $_{98}$Pt to $_{97}$Bk atoms [13,14]. Each table includes nonrelativistic results for each atom. 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 1-7 and in Figs.1-7. There are some common characteristics of $\sigma^{nrel}{}_{Ni}$: For each atom very close to threshold region; $\sigma^{nrel}{}_{N1}$ crosses $\sigma^{nrel}{}_{N2}$ and $\sigma^{nrel}{}_{N3}$ and crosses only $\sigma^{nrel}{}_{N3}$ at higher energies 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} = 3,45 keV impact given in Table.7a,7b and Figs.7a, b. All each $\sigma^{nrel}{}_{Ni}$ decrease with atomic number 98≤ Z ≤103.

Table 1: Nonelativistic $\sigma^{nrel}{}_{Ni}$ subshell ionization cross section of of $_{98}$Cf in 10^5 b

E_0(keV)	σ_{N1}	σ_{N2}	σ_{N3}	σ_{N4}	σ_{N5}	σ_{N6}	σ_{N7}	σ_{Ntotal}
1	-0,1951	-0,1237	-0,2365	0,0076	0,0073	0,1867	0,1403	-0,2134
1,3	-0,0845	-0,0208	-0,0282	0,0464	0,0644	0,2492	0,1844	0,4109
1,6	-0,0253	0,0259	0,0863	0,0726	0,1029	0,2927	0,215	0,7701
1,9	0,0098	0,0703	0,1556	0,0918	0,1311	0,3244	0,2372	1,0202
2,2	0,0321	0,0924	0,1999	0,1063	0,1525	0,3482	0,2537	1,1851
2,5	0,0467	0,1072	0,2294	0,1178	0,1693	0,3662	0,2661	1,3027
2,8	0,0568	0,1172	0,2492	0,1269	0,1828	0,3799	0,2755	1,3883
3,1	0,0639	0,1241	0,2627	0,1344	0,1938	0,3903	0,2825	1,4517
3,4	0,0689	0,1287	0,2716	0,1405	0,2028	0,3981	0,2877	1,4983
3,8	0,0734	0,1325	0,2788	0,1469	0,2124	0,4053	0,2923	1,5416
4,2	0,0762	0,1344	0,2821	0,1518	0,2197	0,4096	0,2949	1,5687
4,6	0,0779	0,1351	0,2829	0,1556	0,2254	0,4118	0,2961	1,5848
5,1	0,0791	0,1346	0,2815	0,1591	0,2306	0,4122	0,2957	1,5928
5,6	0,0794	0,1333	0,2784	0,1614	0,2342	0,4105	0,2941	1,5913

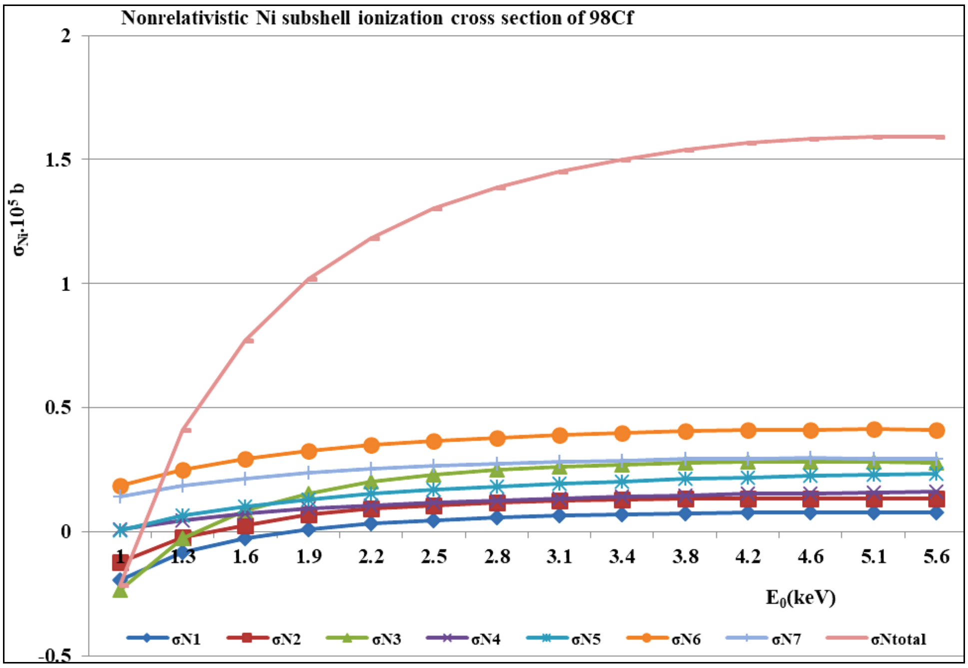

Fig 1a: Nonelativistic subshell σ^{nrel} Ni ionization cross section of of $_{98}$Cf in 10^5 b

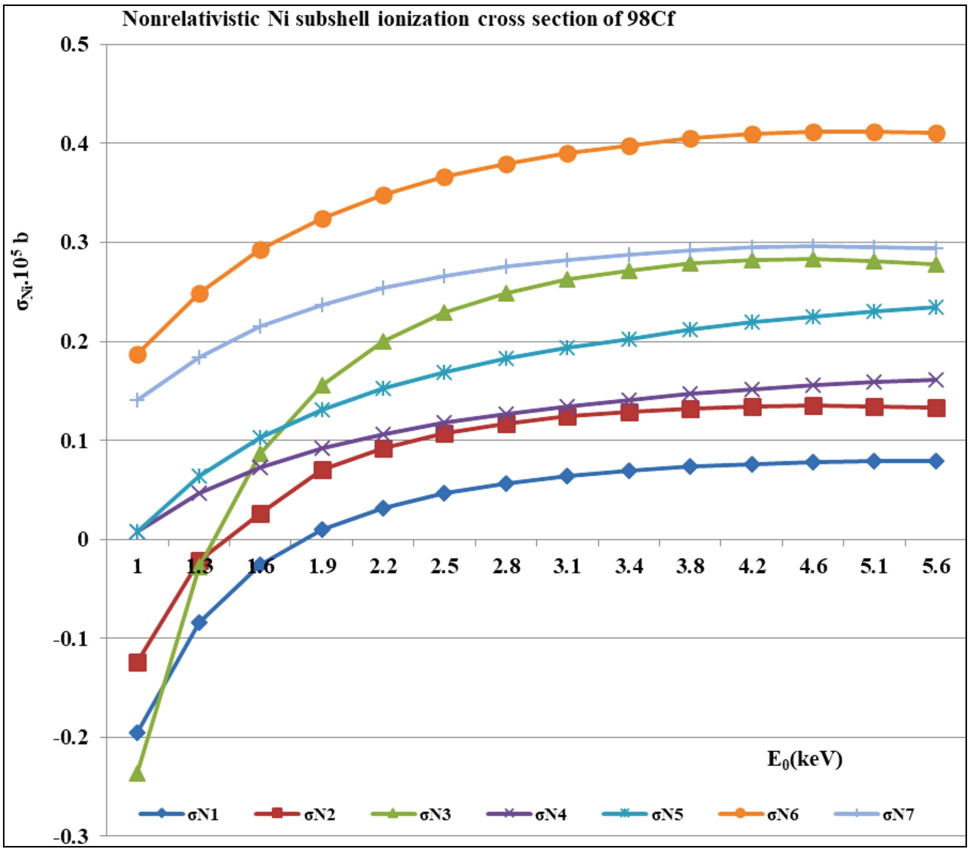

Fig 1b: Nonelativistic subshell σ^{nrel} Ni ionization cross section of of $_{98}$Cf in 10^5 b

Table 2: Nonelativistic subshell σ^{nrel} Ni ionization cross section of of $_{99}$Es in 10^5 b

E_0(keV)	σ_{N1}	σ_{N2}	σ_{N3}	σ_{N4}	σ_{N5}	σ_{N6}	σ_{N7}	σ_{Ntotal}
1	-0,1994	-0,1313	-0,2547	0,0016	0,0087	0,1576	0,1172	-0,3003
1,3	-0,0905	-0,0301	-0,0504	0,0387	0,0661	0,2081	0,1582	0,2972
1,6	-0,0032	0,0257	0,0622	0,0637	0,1049	0,2562	0,1867	0,6674
2	0,0112	0,0681	0,1474	0,087	0,1411	0,2942	0,2133	0,9623
2,4	0,0354	0,0921	0,1956	0,1035	0,1665	0,3205	0,2316	1,1452
2,8	0,0499	0,1066	0,2244	0,1157	0,1853	0,339	0,2444	1,2653
3,2	0,0589	0,1154	0,2418	0,1249	0,1996	0,3521	0,2534	1,3461
3,6	0,0647	0,1208	0,2522	0,1321	0,2105	0,3612	0,2595	1,401
4	0,0685	0,1238	0,2581	0,1376	0,2189	0,3673	0,2634	1,4376
4,4	0,0709	0,1254	0,2608	0,1419	0,2254	0,3711	0,2658	1,4613
4,8	0,0723	0,1258	0,2614	0,1452	0,2303	0,373	0,2669	1,4749
5, 2	0,0732	0,1256	0,2605	0,1477	0,2341	0,3735	0,2669	1,4815
5,6	0,0736	0,1248	0,2586	0,1496	0,2368	0,3729	0,2662	1,4825
5,9	0,0736	0,1239	0,2566	0,1507	0,2382	0,3718	0,2653	1,4801

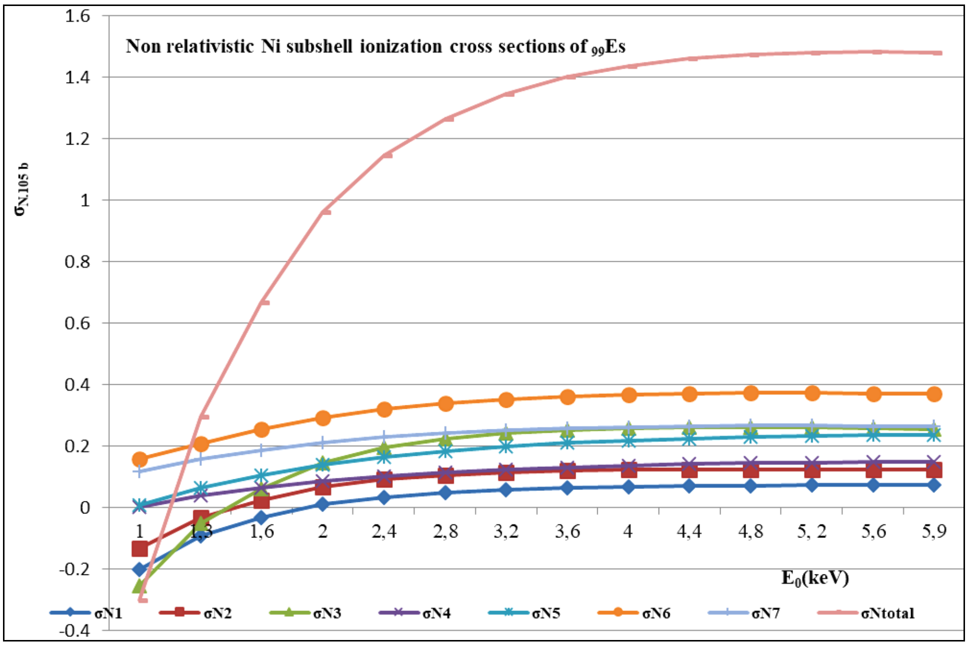

Fig 2a: Nonelativistic subshell σ^{nrel} Ni ionization cross section of of $_{99}$Es in 10^5 b

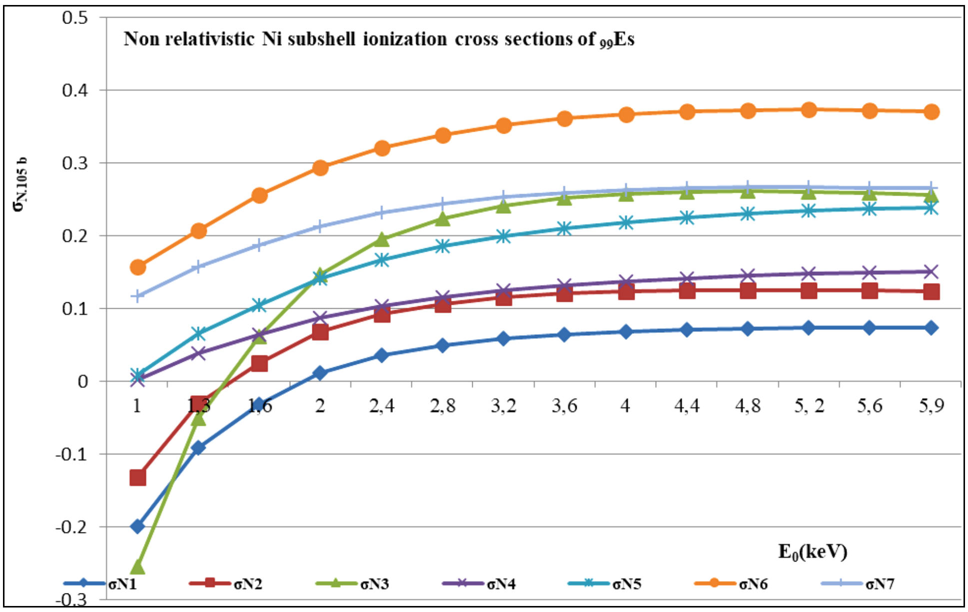

Fig 2b: Nonelativistic subshell σ^{nrel} Ni ionization cross section of of $_{99}$Es in 10^5 b

Table 3: Nonelativistic subshell σ^{nrel} Ni ionization cross section of of $_{100}$Fm 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
1	-0,2031	-0,1383	-0,2675	-0,0042	-0,0202	0,1308	0,0975	-0,5358
1,4	-0,0729	-0,0174	-0,0227	0,0399	0,0398	0,1984	0,1452	0,3103
1,8	-0,0134	0,0399	0,0931	0,0669	0,0764	0,2415	0,1755	0,6799
2,2	0,0185	0,0713	0,1562	0,0854	0,1015	0,271	0,1962	0,9001
2,6	0,0371	0,0898	0,1933	0,0988	0,1198	0,2921	0,2108	1,0417
3	0,0485	0,1013	0,2161	0,1091	0,1337	0,307	0,2212	1,1369
3,4	0,0559	0,1084	0,2298	0,1168	0,1446	0,3178	0,2286	1,2019
3,8	0,0607	0,1128	0,2383	0,1229	0,1532	0,3255	0,2337	1,2471
4,2	0,0639	0,1153	0,243	0,1277	0,1601	0,3307	0,2372	1,2779
4,6	0,0659	0,1165	0,2451	0,1314	0,1654	0,334	0,2393	1,2976
5	0,0672	0,1169	0,2455	0,1343	0,1698	0,3358	0,2403	1,3098
5,4	0,0679	0,1167	0,2446	0,1366	0,1732	0,3365	0,2405	1,316
5,8	0,0683	0,1159	0,2428	0,1382	0,1759	0,3361	0,2401	1,3172
6,1	0,0683	0,1152	0,241	0,1392	0,1775	0,3354	0,2393	1,3159

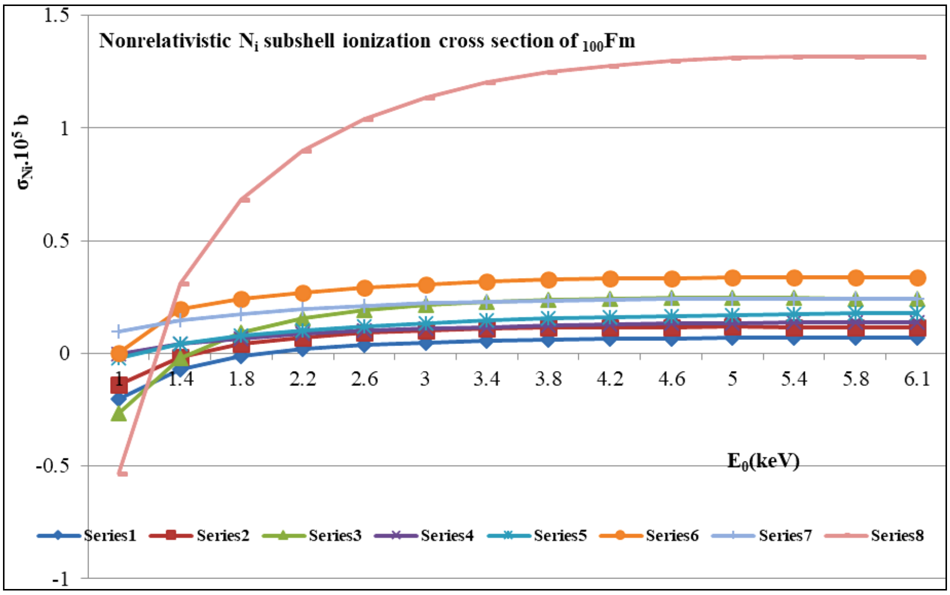

Fig 3a: Nonelativistic subshell σ^{nrel} Ni ionization cross section of of $_{100}$Fm in 10^5 b.

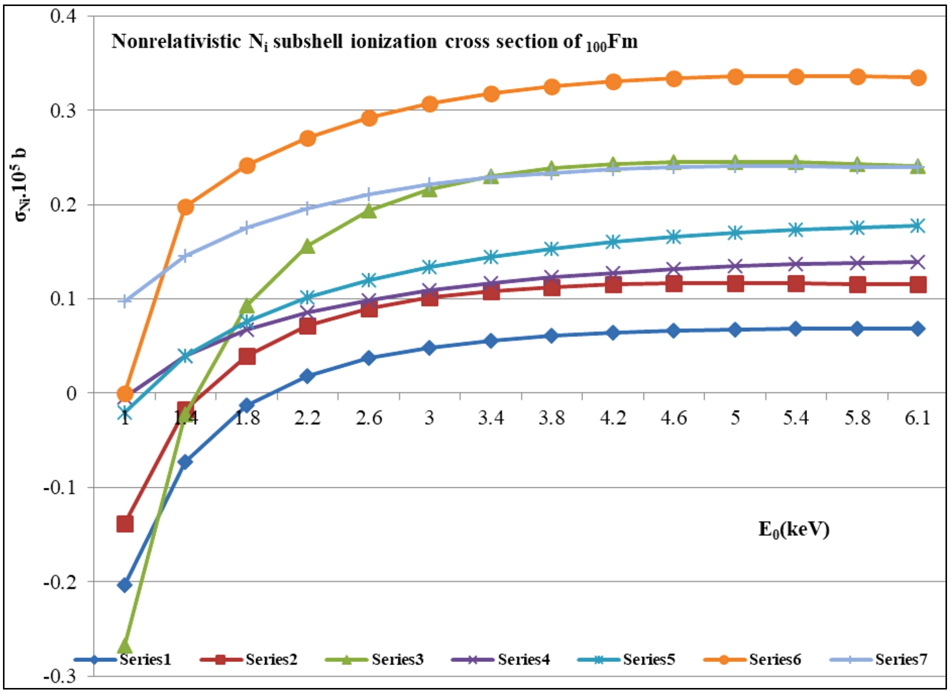

Fig 3b: Nonelativistic subshell σ^{nrel} $_{Ni}$ ionization cross section of of $_{100}$Fm in 10^5 b.

Table 4: Nonelativistic subshell $\sigma^{nrel}{}_{Ni}$ ionization cross section of of $_{101}$Md in 10^5 b.

E₀(keV)	σN1	σN2	σN3	σN4	σN5	σN6	σN7	σNtotal
1	-0,2031	-0,1383	-0,2675	-0,0042	-0,0202	0,1308	0,0975	-0,405
1,4	-0,0729	-0,0174	-0,0227	0,0399	0,0398	0,1984	0,1452	0,3103
1,8	-0,0133	0,0399	0,0931	0,0669	0,0763	0,2415	0,1755	0,6799
2,2	0,0185	0,0713	0,1562	0,0853	0,1014	0,271	0,1962	0,8999
2,6	0,037	0,0898	0,1933	0,0988	0,1198	0,292	0,2108	1,0415
3	0,0485	0,1013	0,216	0,109	0,1337	0,307	0,2212	1,1367
3,4	0,0559	0,1084	0,2299	0,1168	0,1446	0,3178	0,2286	1,202
3,8	0,0607	0,1128	0,2383	0,1229	0,1532	0,3255	0,2337	1,2471
4,2	0,0639	0,1153	0,243	0,1277	0,16	0,3307	0,2372	1,2778
4,6	0,0659	0,1165	0,2451	0,1314	0,1654	0,334	0,2393	1,2976
5	0,0672	0,1169	0,2455	0,1343	0,1698	0,3358	0,2403	1,3098
5,4	0,0679	0,1167	0,2446	0,1365	0,1732	0,3365	0,2405	1,3159
5,8	0,0683	0,1159	0,2428	0,1382	0,1759	0,3361	0,241	1,3182
6,1	0,0683	0,1152	0,241	0,1392	0,1775	0,3354	0,2393	1,3159

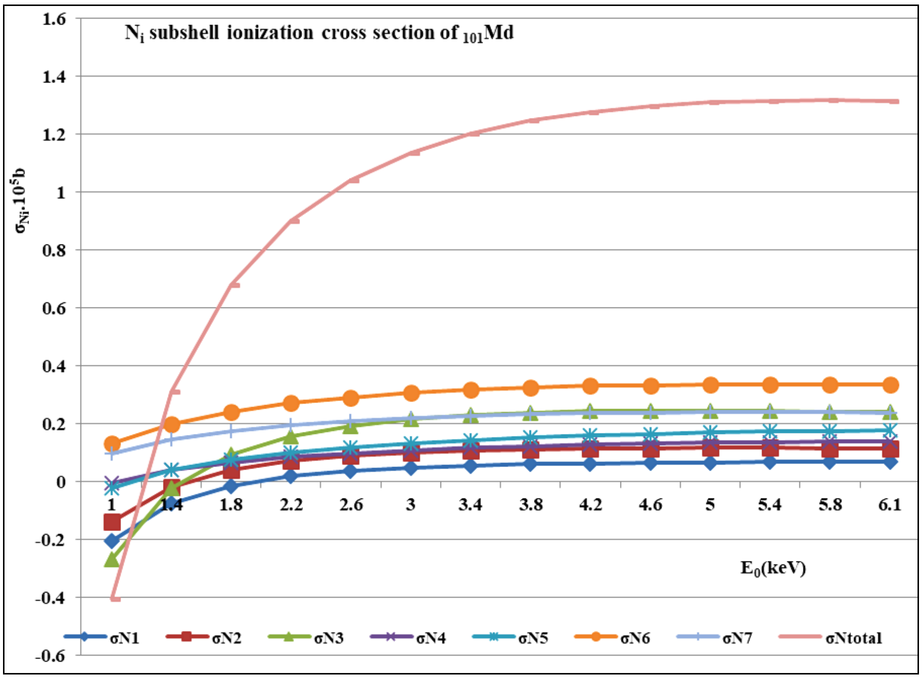

Fig 4a: Nonelativistic subshell $\sigma^{nrel}{}_{Ni}$ ionization cross section of of $_{101}$Md in 10^5 b.

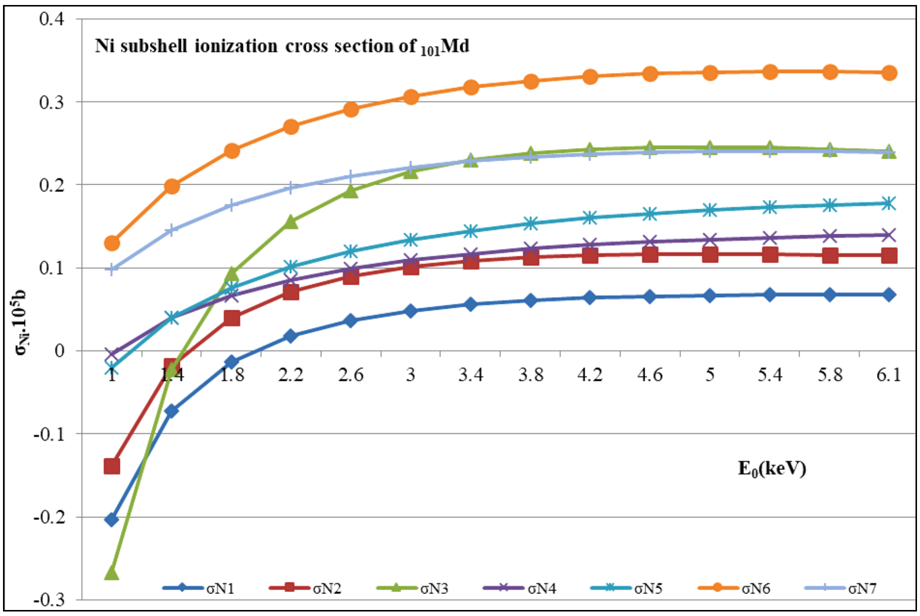

Fig 4b: Nonelativistic subshell $\sigma^{nrel}{}_{Ni}$ ionization cross section of of $_{101}$Md in 10^5 b.

Table 5: Nonelativistic subshell $\sigma^{nrel}{}_{Ni}$ ionization cross section of $_{102}$No in 10^5 b.

E_0(keV)	σN1	σN2	σN3	σN4	σN5	σN6	σN7	σNtotal
1,15	-0,148	-0,0931	-0,1705	0,0055	0,0141	0,1211	0,0924	-0,1785
1,6	-0,0482	0,0004	0,0206	0,0416	0,0702	0,1759	0,1321	0,3926
2	-0,0061	0,0413	0,1036	0,0618	0,1017	0,2076	0,1551	0,665
2,4	0,0179	0,065	0,1514	0,0762	0,124	0,2301	0,1713	0,8359
2,8	0,0324	0,0796	0,1805	0,087	0,1407	0,2465	0,1831	0,9498
3,2	0,0418	0,0888	0,1988	0,0952	0,1535	0,2586	0,1917	1,0284
3,6	0,0479	0,0948	0,2102	0,1017	0,1635	0,2676	0,1981	1,0838
4	0,0521	0,0986	0,2173	0,1068	0,1713	0,2741	0,2026	1,1228
4,4	0,0549	0,1008	0,2213	0,1109	0,1776	0,2787	0,2057	1,1499
4,8	0,0568	0,1021	0,2231	0,1142	0,1825	0,2819	0,2078	1,1684
5,2	0,0581	0,1026	0,2235	0,1168	0,1864	0,2838	0,2091	1,1803
5,6	0,0587	0,1025	0,2229	0,1188	0,1894	0,2848	0,2096	1,1867
6	0,0592	0,1021	0,2214	0,1203	0,1916	0,285	0,2096	1,1892
6,3	0,0593	0,1015	0,2199	0,1213	0,1929	0,2848	0,2092	1,1889

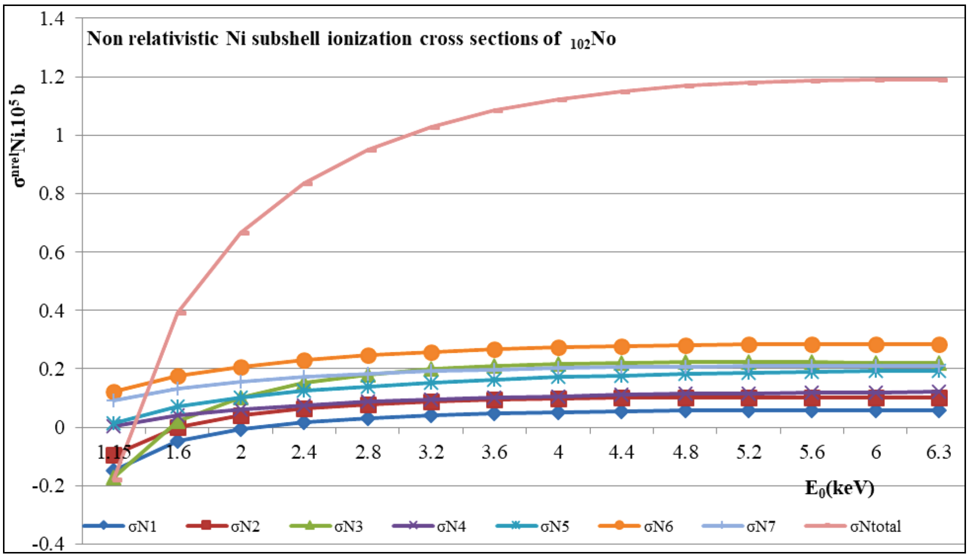

Fig 5a: Seven $\sigma^{nrel}{}_{Ni}$ For 1,2keV to about 3 keV threshold impact of $_{102}$No; $\sigma^{nrel}{}_{Ni}$ in 10^5b: $\sigma^{nrel}{}_{N3}$ crosses the other cross sections in the following order: $\sigma^{nrel}{}_{N1}$ $\sigma^{nrel}{}_{N2}$ $\sigma^{nrel}{}_{N4}$ $\sigma^{nrel}{}_{N5}$ and $\sigma^{nrel}{}_{N7}$.Can not cross the $\sigma^{nrel}{}_{N6}$.

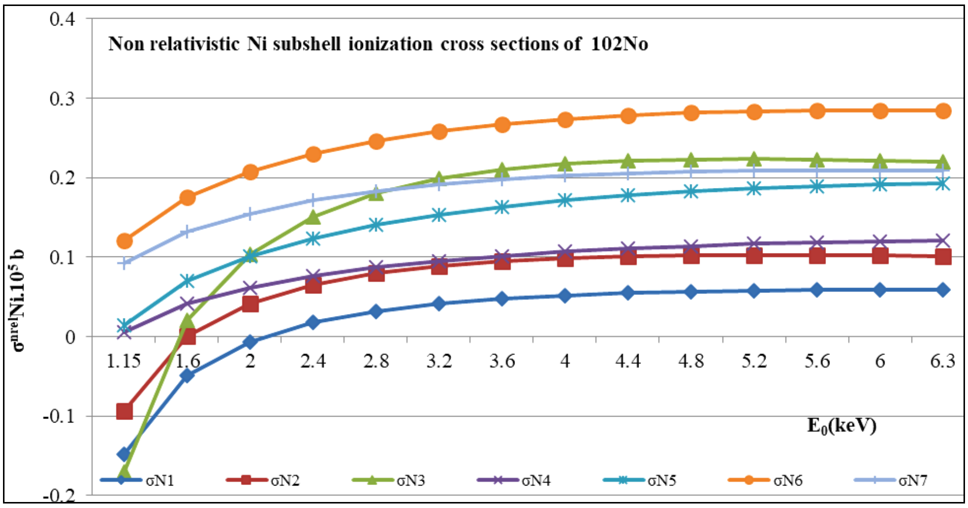

Fig 5b: Seven $\sigma^{nrel}{}_{Ni}$ For 1,2keV to 3 keV threshold impact of $_{102}$No, Nonelativistic subshell $\sigma^{nrel}{}_{Ni}$ in 10^5 b. $\sigma^{nrel}{}_{N3}$ crosses the other cross sections in the following order: $\sigma^{nrel}{}_{N1}$ $\sigma^{nrel}{}_{N2}$ $\sigma^{nrel}{}_{N4}$ $\sigma^{nrel}{}_{N5}$ and $\sigma^{nrel}{}_{N7}$. Can not cross the σ^{nrel} $\sigma^{nre}{}_{N6}$.

Table 6: Nonelativistic subshell $\sigma^{nrel}{}_{Ni}$ ionization cross section of $_{103}$Lr in 10^5 b.

E0(keV)	σN1	σN2	σN3	σN4	σN5	σN6	σN7	σN8
1,2	-0,1353	-0,0839	-0,1319	0,0055	0,0132	0,1078	0,0858	-0,1388
1,6	-0,0527	-0,0065	0,0304	0,0349	0,0588	0,1514	0,1186	0,3349
2	-0,011	0,0339	0,114	0,0541	0,0886	0,1809	0,1407	0,6232
2,4	0,0128	0,0574	0,162	0,0677	0,1098	0,202	0,1564	0,7681
2,8	0,0274	0,072	0,191	0,078	0,1257	0,2176	0,1679	0,8796
3,2	0,0368	0,0813	0,2091	0,0859	0,1379	0,2292	0,1765	0,9567
3,6	0,0431	0,0874	0,2203	0,0921	0,1475	0,2379	0,1828	1,0111
4	0,0473	0,0914	0,2271	0,0971	0,1551	0,2444	0,1875	1,0499
4,4	0,0502	0,0938	0,2308	0,1011	0,1611	0,2492	0,1909	1,0771
4,8	0,0522	0,0953	0,2324	0,1043	0,166	0,2526	0,1933	1,0961
5,2	0,0535	0,096	0,2325	0,1068	0,1699	0,2549	0,1948	1,1084
5,6	0,0544	0,0961	0,2315	0,1089	0,1729	0,2563	0,1956	1,1157
6	0,0549	0,0959	0,2298	0,1105	0,1753	0,257	0,1959	1,1193
6,4	0,0552	0,0953	0,2275	0,1117	0,1771	0,257	0,1957	1,1195

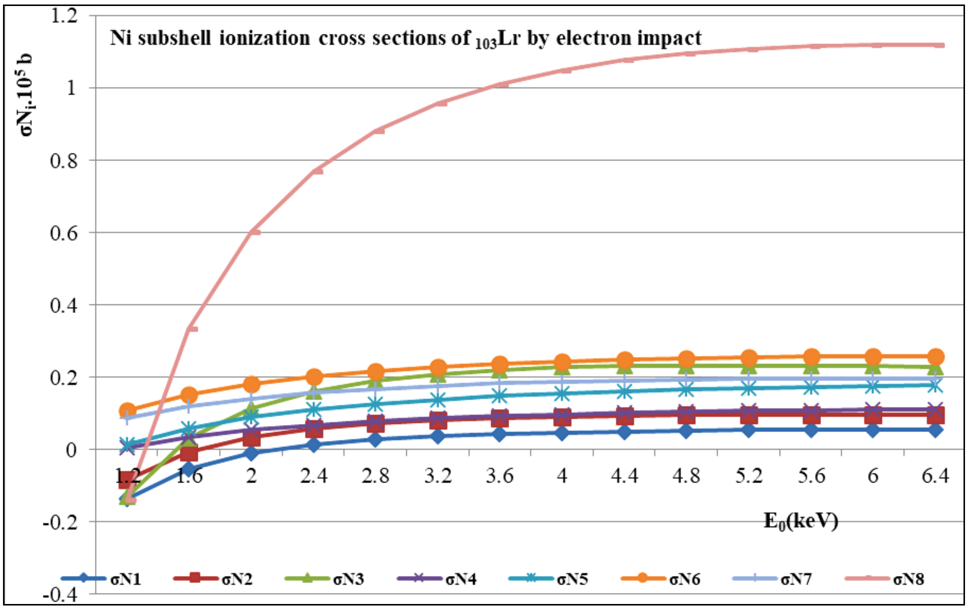

Fig 6a: Nonelativistic subshell $\sigma^{nrel}{}_{Ni}$ ionization cross section of $_{103}$Lr in 10^5 b.

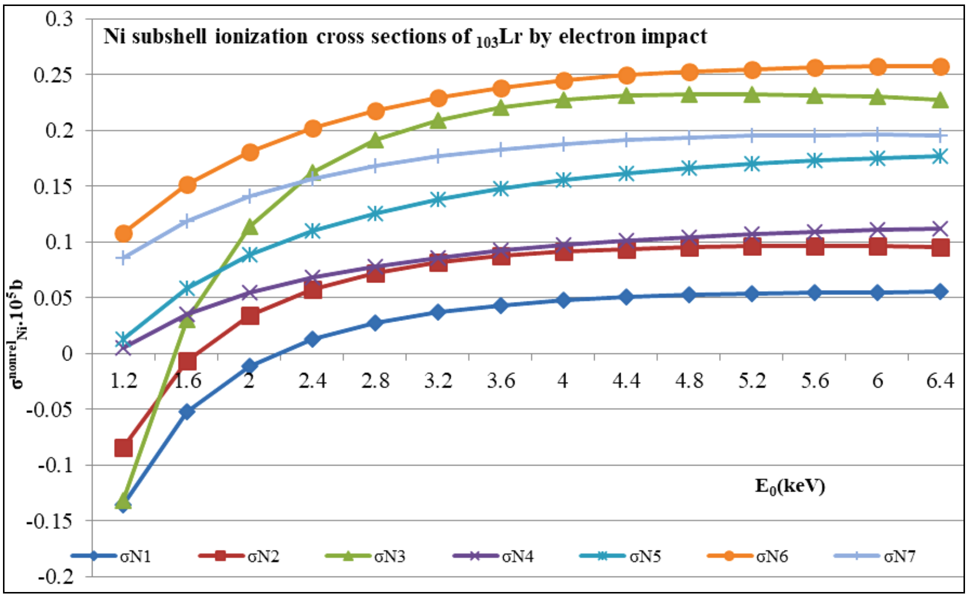

Fig 6b: Nonelativistic subshell $\sigma^{nrel}{}_{Ni}$ ionization cross section of $_{103}$Lr in 10^5 b:. $\sigma^{nrel}{}_{N3}$ crosses the other cross sections in the following order: $\sigma^{nrel}{}_{N1}$ $\sigma^{nrel}{}_{N2}$ $\sigma^{nrel}{}_{N4}$ $\sigma^{nrel}{}_{N5}$ and $\sigma^{nrel}{}_{N7}$.

Table 7: For about 3,33 to 3,45keV electron impact Z dependency of Ni subshell σ^{nrel}_{Ni} of $_{95}$Am to $_{107}$Bh near to N_{1i} thresholds.

E_0(keV)	Atom Z	$\sigma_{N1}10^5b$	$\sigma_{N2}10^5b$	$\sigma_{N3}10^5b$	$\sigma_{N4}10^5b$	$\sigma_{N5}10^5b$	$\sigma_{N6}10^5b$	$\sigma_{N7}10^5b$	$\sigma_{Ntotal}10^5b$
3,45	95Am	0,10821	0,14348	0,33073	0,18572	0,33703	0,34256	0,29739	1,74512
3,5	9Cm	0,09961	0,13452	0,30746	0,16617	0,30444	0,30347	0,26381	1,57948
3,4	97Bk	0,09007	0,13944	0,30096	0,15283	0,24322	0,26872	0,23574	1,43098
3,4	98Cf	0,08302	0,12866	0,27073	0,13358	0,21068	0,24281	0,21233	1,28181
3,5	99Es	0,07662	0,11967	0,25634	0,12255	0,19544	0,21743	0,19158	1,17963
3,38	100Fm	0,06723	0,10787	0,23259	0,10912	0,17434	0,19245	0,16905	1,05265
3,45	101Md	0,06199	0,10051	0,23469	0,0946	0,15871	0,17374	0,14825	0,97249
3,3	101Md	0,05967	0,09851	0,23092	0,09476	0,15511	0,17159	0,14651	0,95707
3,45	102No	0,05595	0,09275	0,21639	0,0896	0,14938	0,16361	0,14112	0,90885
3,3	102No	0,05354	0,09065	0,21244	0,08738	0,14584	0,16198	0,13942	0,89125
3,5	103Lr	0,05081	0,08582	0,20078	0,08087	0,13577	0,14351	0,12569	0,82325
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

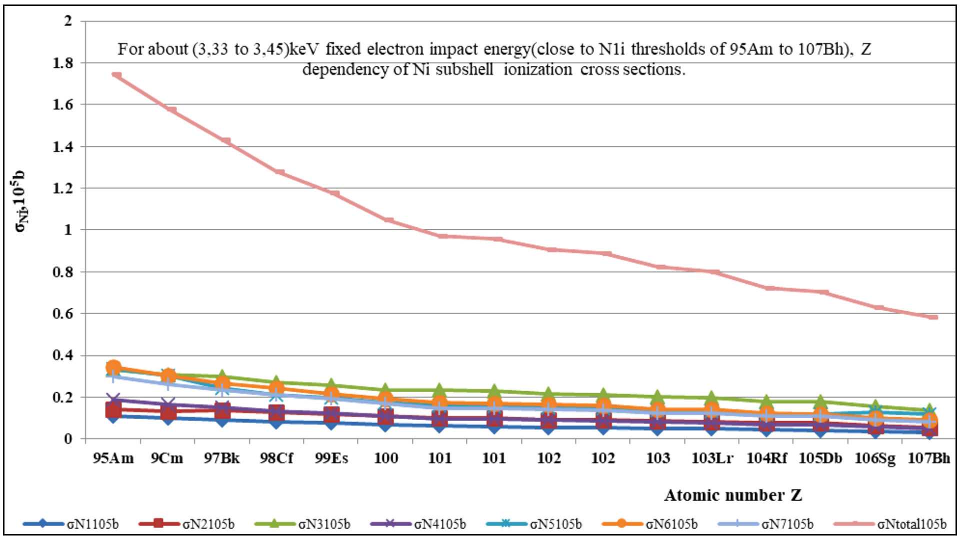

Fig 7a: For fixed energy (3,33 to 3,45keV); Nonrelativistic σ^{nrel}_{Ni} N_i(1,...7) subshell ionization cross section of $_{92}$U to $_{107}$Bh in 10^5 b[23].

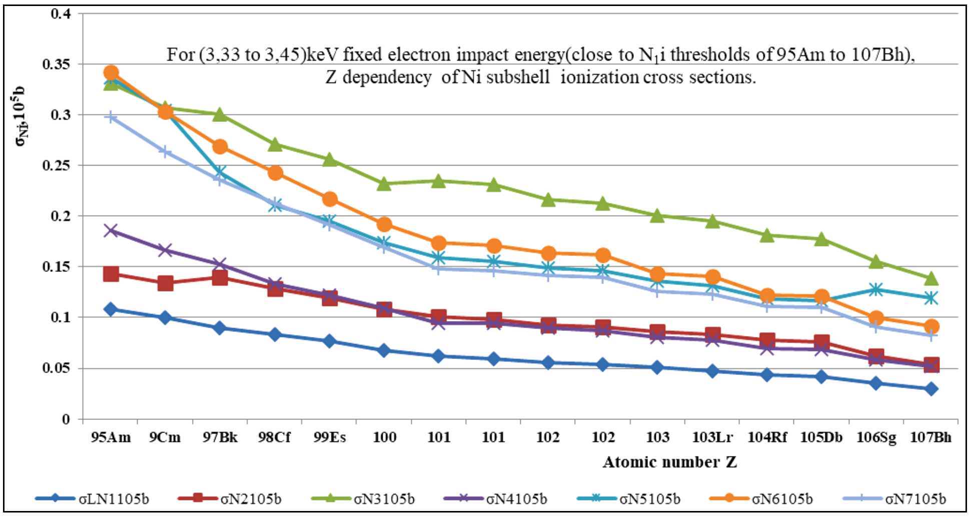

Fig 7b: For fixed energy about (3,33 to 3,45keV); Nonrelativistic σ^{nrel}_{Ni} N_i(1,..7) subshell ionization cross section of $_{92}$U to $_{107}$Bh in 10^5 b [23].

4. Conclusions

Nonrelativistic N shell σ^{nrel}_{Ntotal} and N_i subshells σ^{nrel}_{Ni} for $_{98}$Cf, $_{99}$Es, $_{100}$Fm, $_{101}$Md, $_{102}$No, $_{103}$Lr atoms results given in tables.1,-7 and figures 1,-7 under the name of each atom separately. Following each table, for the same atomic results also given as colored graphs in 2 figs. These graphs helps to compare how each subshells σ^{nrel}_{Ni} and total $\sigma^{nrel}_{Ntotall}$ depends at any value of E_{0i} electron impact energy. σ^{nrel}_{N} values are given in (b) in Tables 1-7 and in Figs.1-7. 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 $_{102}$No as seeing at Figs.5a, and 5b, 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} σ^{nrel}_{N5} and σ^{nrel}_{N7}. But can not cross the $\sigma^{nrel}N_6$. As seeing at Figs.6a and 6b for $_{103}$Lr atom: σ^{nrel}_{N3}; σ^{nrel}_{N1} and σ^{nrel}_{N2} and σ^{nrel}_{N4}, and $_{N4}$ σ^{nrel}_{N5} and σ^{nrel}_{N7} crosses the other cross sections in the this order for impact energy range of 1, 2 to 2, 4keV. For higher energies namely through end region of graphs.. each σ^{nrel}_{Ni} increases differently E_0 impact energy. How much effects Auger and Coster-Cronig transitions to these σ^{nrel}_{Ni} ? For a fixed about E_{oi}=(3,3 to 3,45)keV, while Z value changes from $_{95}U \leq Z \leq {}_{103}Lr$ σ^{nrel}_{Ni} decrease with atomic number Z [14, 15]. Nonrelativistic σ^{nrel}Ni of $_{92}$U to $_{97}$Bk results and also relativistic σ^{rel} results for $_{92}$U to $_{97}$Bk published in [23]. 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, ... 18, 23].

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