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Electron Impact Excitations of $_{119}$Uun, $_{120}$Uun, $_{121}$Uun, $_{122}$Uun, $_{123}$Uun, $_{124}$Uun, $_{125}$Uun and $_{126}$Uun 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 $_{119}$Uun, $_{120}$Uun, $_{121}$Uun, $_{122}$Uun, $_{123}$Uun, $_{124}$Uun, $_{125}$Uun and $_{126}$Uun atoms calculated. By using Lotz' equation in Matlab, ($\sigma^{nrel}{}_N$) and N $\sigma^{nrel}{}_{Ni}$ cross section values obtained for 24 electron impact(E_0) values in the range of $E_{Ni}<E_0\leq 8E_{Ni}$ 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 = 5,2keV, while Z value increases from $_{119}$Uun $\leq Z \leq$ $_{126}$Uun 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 $_{119}$Uun, $_{120}$Uun, $_{121}$Uun, $_{122}$Uun, $_{123}$Uun, $_{124}$Uun, $_{125}$Uun and $_{126}$Uun 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, medical instrumentation, 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 $_{114}$Lv to $_{118}$Uno [21]. In this study, N shell and N_i subshells ionization cross section $\sigma^{nrel}{}_N$ and $\sigma^{nrel}{}_{Ni}$(i= 1,..,7) for $_{119}$Uun, $_{120}$Uun, $_{121}$Uun, $_{122}$Uun, $_{123}$Uun, $_{124}$Uun, $_{125}$Uun and $_{126}$Uun atoms are calculated: For all atoms E_{0i}(i=1,..,24) electron impact values were chosen in the $E_{Ni} < E_{0i} < 8.E_{Ni}$ 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 N_i subshells of that atom. Creation of electron holes in N_i 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 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 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 $\sigma^{nrel}{}_{Ntotal}$ 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

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the i^{th} 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 $_{119}$Uun, $_{120}$Uun, $_{121}$Uun, $_{122}$Uun, $_{123}$Uun, $_{124}$Uun, $_{125}$Uun and $_{126}$Uun atoms are calculated. Calculations done for 24 E_{0i}(i=1, 2,.. 24) values which they chosen in energy range of $E_{N1i} \leq E_{0i} \leq 7{,}39.E_{N1i}$ for each atom. It means that for $_{119}$Uun used over all E_{0i} values fall in 2,3keV<E_0<17keV 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 $\mathbf{q}_{Ni}$ are given in the same order for N_i subshells as: For instance: $\mathbf{a}_{Ni}$ equal to (3, 2, 2, 1,7 1,55, 1,5,1,5.)10^{-14}cm^2(eV)^2; for $\mathbf{b}_{Ni}$ equal to (0.5, 0.92, 0.92, 0,7, 0,6, 0,53, 0,48); for $\mathbf{c}_{Ni}$ equal to (0.6, 0.25, 0.19, 0.18, 0.17, 0,16, 0.15); and for $\mathbf{q}_{Ni}$ equal to (2, 2, 4, 1,6, 1,4, 1,2, 1,16) 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 bigger then N1(2s) subshell binding energies. Impacting electron also lost some parts of its energy as bremsstrahlung while incoming through atom and entering it, then lost some portion of its energy while passing Oi(i=1, 2,..5) subshells.

Table A: Used electron binding energies of E_{Ni}(i=1,,.7) subshells of $_{119}$Uun $_{120}$Uun, $_{121}$Uun, $_{122}$Uun, $_{123}$Uun, $_{124}$Uun $_{125}$Uun and $_{126}$Uun atoms in eV [3,19].

Zatomic Number	E_{N7}(eV)	E_{N6}(eV)	E_{N5}(eV)	E_{N4}(eV)	E_{N3}(eV)	E_{N2}(eV)	E_{N1}(eV)
119Uu0	4982	4635	4352	4127	3 615	2953	2163
120Uun	5292	4926	4637	4328	3860	3165	2373
121Uun	5609	5268	4935	4752	4028	3225	2547
122Uun	5919	5557	5185	4975	4253	3315	2674
123Uun	6229	5879	5569	5305	4383	3435	2894
124Uun	6550	6200	5850	5655	4573	3565	3145
125Uun	7030	6650	6255	6072	4890	3795	3410
126Uun	7495	7045	6698	6415	5175	4105	3625

3. Results

Nonrelativistic cross section calculations for $_{119}$Uun $_{120}$Uun, $_{121}$Uun, $_{122}$Uun, $_{123}$Uun, $_{124}$Uun $_{125}$Uun and $_{126}$Uun atoms carried out for electron impact energies. $\sigma^{nrel}{}_N$ and $\sigma^{nrel}{}_{Ni}$ of Ni shell results for 24 E_{0i} were given in Table.1 to 8 under the name of each atom: $_{119}$Uun $_{120}$Uun, $_{121}$Uun, $_{122}$Uun, $_{123}$Uun, $_{124}$Uun $_{125}$Uun and $_{126}$Uun. This calculations are similar to our earlier study of which were carried out for E_{0i} electron impact energy close to N subshell ionization threshold energy values of $_{114}$Uuq to $_{118}$Uuo [12, 13]. 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; a) For $_{119}$Uun $_{120}$Uun, $_{121}$Uun, $_{122}$Uun atoms $\sigma^{nrel}{}_{N3}$ crosses $\sigma^{nrel}{}_{N1}$ and $\sigma^{nrel}{}_{N2,}$ $\sigma^{nrel}{}_{N4,}$ $\sigma^{nrel}{}_{N5}$ $\sigma^{nrel}{}_{N6}$ and $\sigma^{nrel}{}_{N7}$ other cross sections but for : b) $_{123}$Uun, $_{124}$Uun, $_{125}$Uun, $_{126}$Uun, atoms $\sigma^{nrel}{}_{N3}$ crosses $\sigma^{nrel}{}_{N1}$ and $\sigma^{nrel}{}_{N2,}$ $\sigma^{nrel}{}_{N4,}$ $\sigma^{nrel}{}_{N5}$ $\sigma^{nrel}{}_{N7}$ and $\sigma^{nrel}{}_{N6}$ order. Each $\sigma^{nrel}{}_{Ni}$ increases differently with electron impact energy. Z dependency of ionization cross sections for a fixed E_{0i} = 5,2 keV impact given in Table.9 and Figs.9a. All each $\sigma^{nrel}{}_{Ni}$ decrease with atomic number Z for 119≤ Z ≤126.

Table 1: N_i subshell ionization cross sections σ_{Ni} of $_{119}$Uun in 10^4 b.

E_0(keV)	$\sigma_{N1}.10^4$ b	$\sigma_{N2}.10^4$ b	$\sigma_{N3}10^4$ b	$\sigma_{N4}10^4$ b	$\sigma_{N5}10^4$ b	$\sigma_{N6}10^4$ b	$\sigma_{N7}10^4$ b	$\sigma_{Ntotal}10^4$ b
2,3	-0,4881	-0,3205	-0,6281	-0,0667	-0,0902	-0,0429	0,0102	-1,6263
2,9	-0,2714	-0,1767	-0,3302	-0,0363	-0,0399	-0,0029	0,0457	-0,8117
3,2	-0,2013	-0,1287	-0,231	-0,0252	-0,0213	0,0126	0,0596	-0,5353
3,4	-0,1636	-0,1024	-0,1766	-0,0187	-0,0104	0,0218	0,0679	-0,382
3,6	-0,1314	-0,0797	-0,1297	-0,0129	0,0007	0,0302	0,0755	-0,2473
3,8	-0,1038	-0,0599	-0,0888	-0,0076	0,0082	0,0379	0,0825	-0,1315
4,1	-0,0693	-0,03462	-0,03679	0,00059	0,02005	0,04848	0,09197	0,0204
4,4	-0,0412	-0,0136	0,0064	0,0056	0,0305	0,058	0,1005	0,1462
4,8	-0,0113	0,0093	0,0534	0,0128	0,0428	0,0692	0,1106	0,2868
5,2	0,012	0,0278	0,0912	0,0191	0,0535	0,0791	0,1195	0,4022
5,7	0,0345	0,0462	0,1288	0,0259	0,065	0,0901	0,1292	0,5197
6,6	0,0624	0,0702	0,1776	0,0359	0,082	0,1065	0,1437	0,6783
7,5	0,0801	0,0866	0,2104	0,0439	0,0956	0,1199	0,1553	0,7918
8,4	0,0914	0,098	0,233	0,0504	0,1066	0,1309	0,1645	0,8748
9	0,0967	0,1036	0,244	0,0541	0,1128	0,1372	0,1697	0,9181
9,7	0,1012	0,1088	0,2539	0,0579	0,1192	0,1437	0,175	0,9597
10,5	0,1048	0,1132	0,2622	0,0618	0,1255	0,1501	0,1811	0,9987
11,2	0,1069	0,1161	0,2674	0,0647	0,1304	0,155	0,1838	1,0243
12,3	0,1088	0,1192	0,2728	0,0686	0,1368	0,1617	0,1886	1,0565
13	0,1093	0,1205	0,2747	0,0708	0,1403	0,1653	0,1911	1,072
14	0,1096	0,1217	0,2761	0,0736	0,1446	0,1697	0,1939	1,0892
15	0,1093	0,1222	0,2762	0,0759	0,1482	0,1734	0,1961	1,1013
16	0,1086	0,1222	0,2754	0,0779	0,1513	0,1766	0,1978	1,1098
17	0,1077	0,1218	0,2738	0,0796	0,1538	0,1792	0,199	1,1149

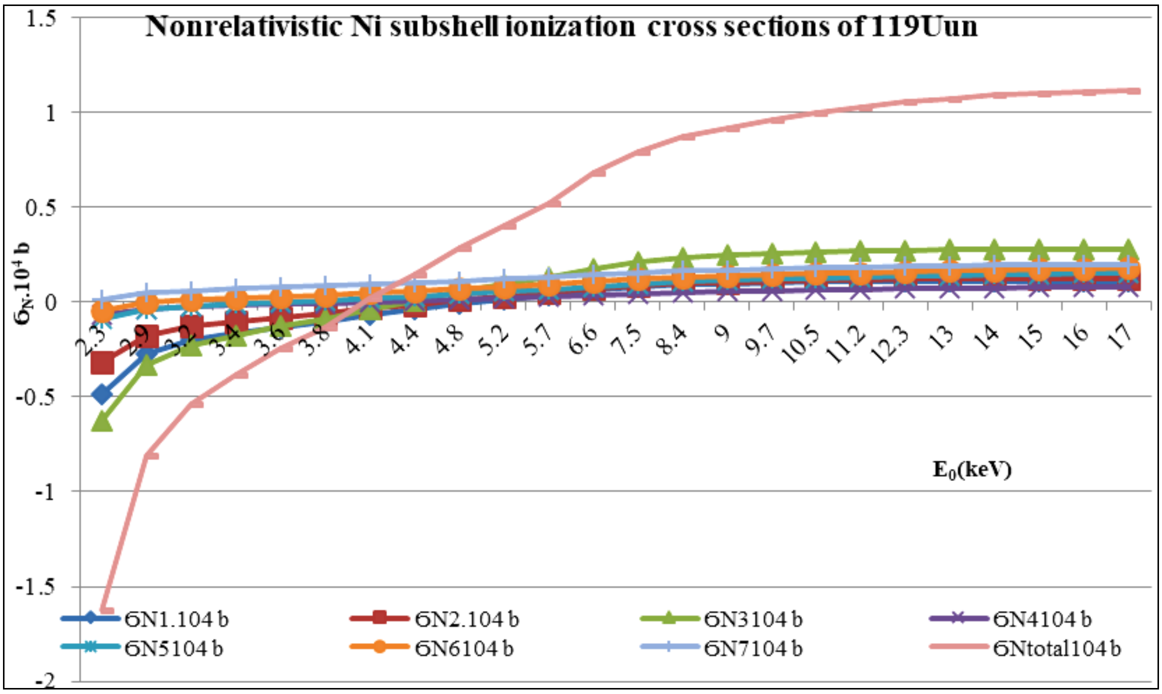

Fig 1a: N_i subshell ionization cross sections σ_{Ni} of $_{119}$Uuo in 10^4 b.

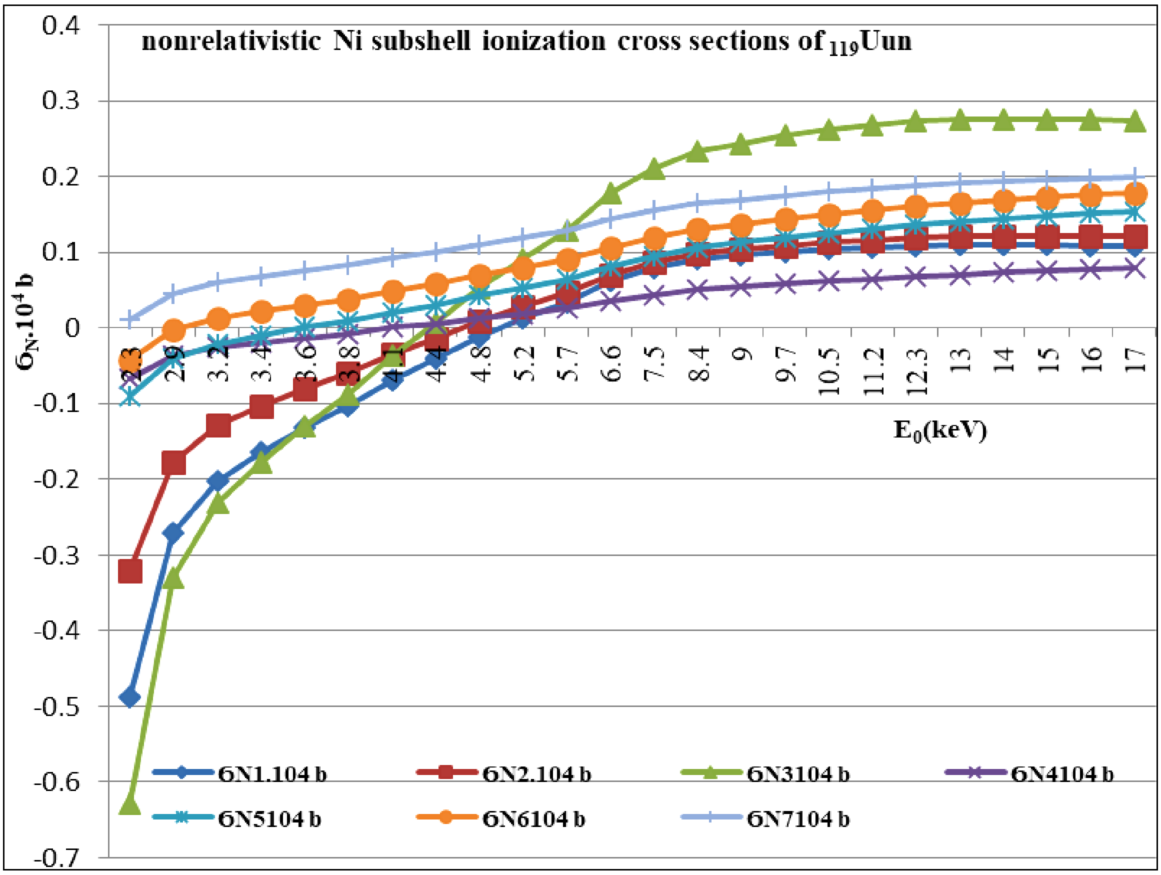

Fig 1b: N_i subshell ionization cross sections σ_{Ni} of $_{119}$Uun in 10^4 b.

Table 2: Ni subshell ionization cross sections σ_{NI} of $_{120}$Uun in 10^4 b.

E_0(keV)	$\sigma_{N1}.10^4$ b	$\sigma_{N2}.10^4$ b	$\sigma_{N3}.10^4$ b	$\sigma_{N4}.10^4$ b	$\sigma_{N5}10^4$ b	$\sigma_{N6}.10^4$ b	$\sigma_{N7}.10^4$ b	$\sigma_{N1total}.10^4$ b
2,5	-0,3886	-0,2697	-0,5416	-0,056	-0,0754	-0,0351	0,0072	-1,3592
3,2	-0,2041	-0,1398	-0,2654	-0,0277	-0,0294	0,0015	0,0387	-0,6262
3,4	-0,1691	-0,1144	-0,2114	-0,0216	-0,0194	0,0098	0,0458	-0,4803
3,6	-0,1391	-0,0924	-0,1647	-0,0161	-0,0105	0,0174	0,0524	-0,353
3,8	-0,1134	-0,0732	-0,1241	-0,0111	-0,0023	0,0243	0,0585	-0,2413
4,1	-0,08104	-0,04873	-0,07223	-0,0045	0,00862	0,03384	0,06674	-0,0973
4,4	-0,05467	-0,02835	-0,02912	0,00134	0,01826	0,04236	0,07415	0,02397
4,8	-0,02652	-0,00607	0,01791	0,00813	0,02951	0,05247	0,08294	0,15837
5,2	0,00441	0,01192	0,05583	0,01403	0,03926	0,06141	0,09072	0,27758
5,7	0,01704	0,02992	0,09366	0,02041	0,04984	0,07126	0,09921	0,38134
6,6	0,0439	0,0536	0,1431	0,0298	0,0654	0,0861	0,1119	0,5338
7,5	0,0611	0,0698	0,1767	0,0373	0,0779	0,0982	0,1221	0,6431
8,4	0,0725	0,0812	0,2001	0,0434	0,088	0,1081	0,1305	0,7238
9	0,0779	0,0869	0,2117	0,0469	0,0937	0,1139	0,1352	0,7662
9,7	0,0826	0,0923	0,2224	0,0505	0,0997	0,1198	0,1399	0,8072
10,5	0,0865	0,0969	0,2315	0,0541	0,1055	0,1258	0,1446	0,8449
11,2	0,0889	0,1002	0,2374	0,0569	0,1011	0,1303	0,1481	0,8716
12,3	0,0913	0,1035	0,2439	0,0606	0,1161	0,1365	0,1527	0,9046
13	0,0922	0,105	0,2465	0,0627	0,1194	0,1399	0,1552	0,9209
14	0,09301	0,1065	0,2489	0,0653	0,1235	0,1441	0,1581	0,93941
15	0,0931	0,1074	0,2501	0,0676	0,127	0,1477	0,1604	0,9532
16	0,0929	0,1078	0,25	0,0695	0,13	0,1508	0,1622	0,9632
17,5	0,0922	0,1077	0,2487	0,0719	0,1336	0,1545	0,1643	0,9729
19	0,091	0,107	0,2462	0,0739	0,1364	0,1574	0,1655	0,9774

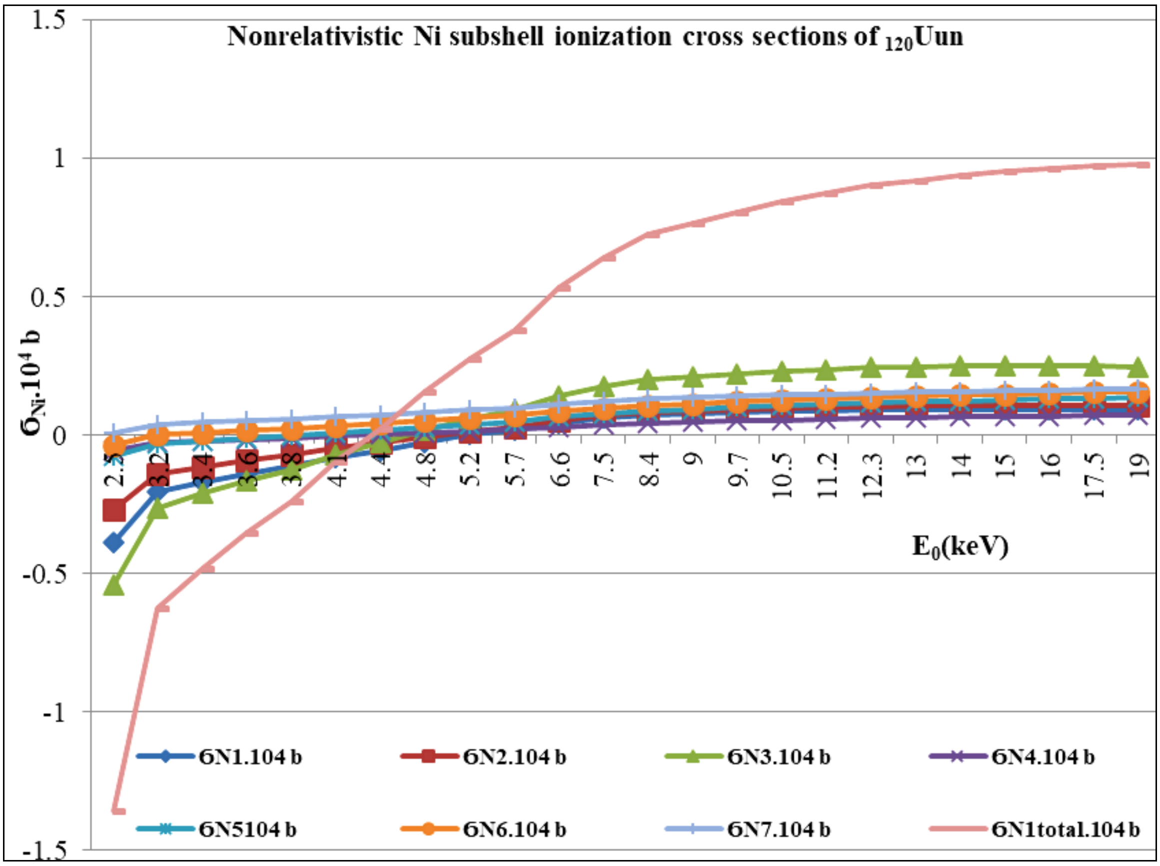

Fig 2a: Ni subshell ionization cross sections σ_{Ni} of $_{120}$Uun in 10^4 b.

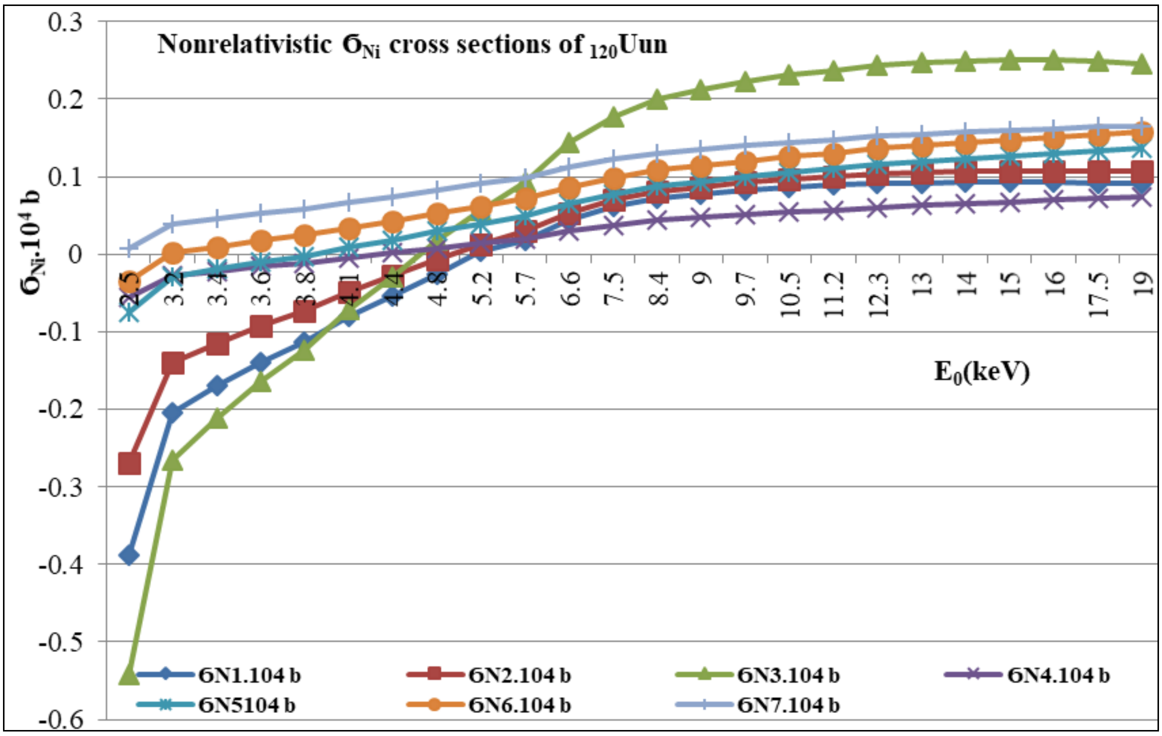

Fig 2b: Ni subshell ionization cross sections σ_{Ni} of $_{120}$Uun in 10^4 b.

Table 3: Ni subshell ionization cross sections σ_{NI} of $_{121}$Uun in 10^4 b.

E_0(keV)	$\sigma_{N1}.10^4$ b	$\sigma_{N2}.10^4$ b	$\sigma_{N3}.10^4$ b	$\sigma_{N4}.10^4$ b	$\sigma_{N5}10^4$ b	$\sigma_{N6}.10^4$ b	$\sigma_{N7}.10^4$ b	$\sigma_{N1total}10^4$ b
2,8	-0,3034	-0,2114	-0,4194	-0,0444	-0,0563	-0,0197	0,0112	-1,0434
3,2	-0,2147	-0,1493	-0,2872	-0,0313	-0,0337	-0,001	0,0261	-0,6911
3,4	-0,1804	-0,1248	-0,2351	-0,0258	-0,0242	0,007	0,0325	-0,5508
3,6	-0,1511	-0,1035	-0,1901	-0,0209	-0,0157	0,0144	0,0384	-0,4285
3,8	-0,1257	-0,0851	-0,1508	-0,0165	-0,0081	0,0211	0,0439	-0,2513
4,1	-0,0938	-0,0614	-0,1007	-0,0106	0,0024	0,0304	0,0513	-0,1824
4,4	-0,06778	-0,04168	-0,05892	-0,00536	0,01148	0,03864	0,05792	-0,0657
4,8	-0,03991	-0,02011	-0,01331	0,00068	0,02211	0,04847	0,06581	0,06374
5,2	-0,01793	-0,00264	0,02356	0,00591	0,03134	0,05716	0,07279	0,17283
5,7	0,00348	0,01489	0,06044	0,01154	0,04133	0,06673	0,08046	0,27887
6,6	0,0305	0,0381	0,1089	0,0198	0,0561	0,0812	0,0921	0,4267
7,5	0,0481	0,0541	0,1421	0,0264	0,0678	0,0929	0,1012	0,5326
8,4	0,0597	0,0653	0,1655	0,0318	0,0774	0,1026	0,1088	0,6111
9	0,0654	0,0711	0,1773	0,0349	0,0828	0,1082	0,1131	0,6528
9,7	0,0704	0,0765	0,1882	0,0381	0,0885	0,1176	0,1141	0,6934
10,5	0,0746	0,0813	0,1977	0,0413	0,0941	0,1198	0,1219	0,7307
11,2	0,0772	0,0846	0,2041	0,0438	0,0983	0,1243	0,1252	0,7575
12,3	0,0801	0,0884	0,2113	0,0472	0,1041	0,1303	0,1296	0,791
13	0,0813	0,0902	0,2144	0,0491	0,1073	0,1337	0,1321	0,8081
14	0,0823	0,0921	0,2175	0,0514	0,1113	0,1378	0,1348	0,8272
15	0,0828	0,0932	0,2194	0,0535	0,1147	0,1414	0,1371	0,8421
16,5	0,0828	0,0941	0,2203	0,0561	0,1189	0,1457	0,1399	0,8578
18	0,0823	0,0943	0,2196	0,0582	0,1222	0,1491	0,1418	0,8675
19,5	0,0815	0,0939	0,2179	0,0601	0,1248	0,1518	0,1432	0,8732

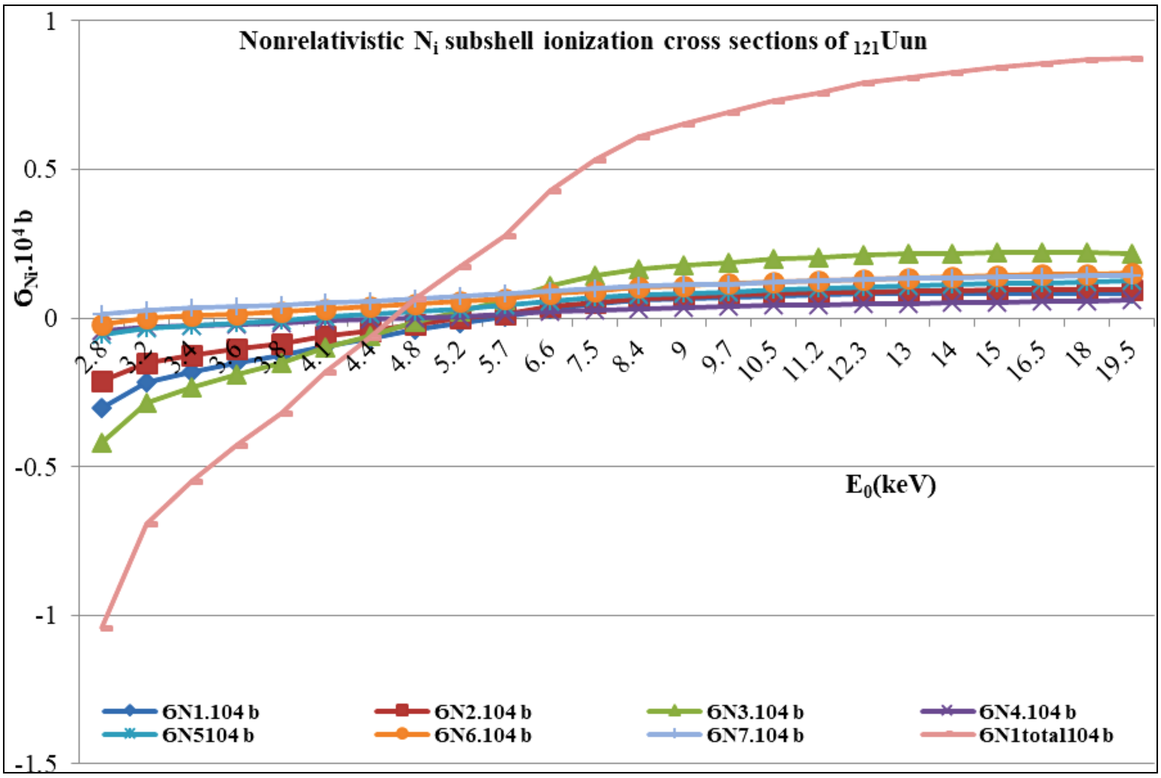

Fig 3a: N_i subshell ionization cross sections σ_{NI} of $_{121}$Uun in 10^4 b.

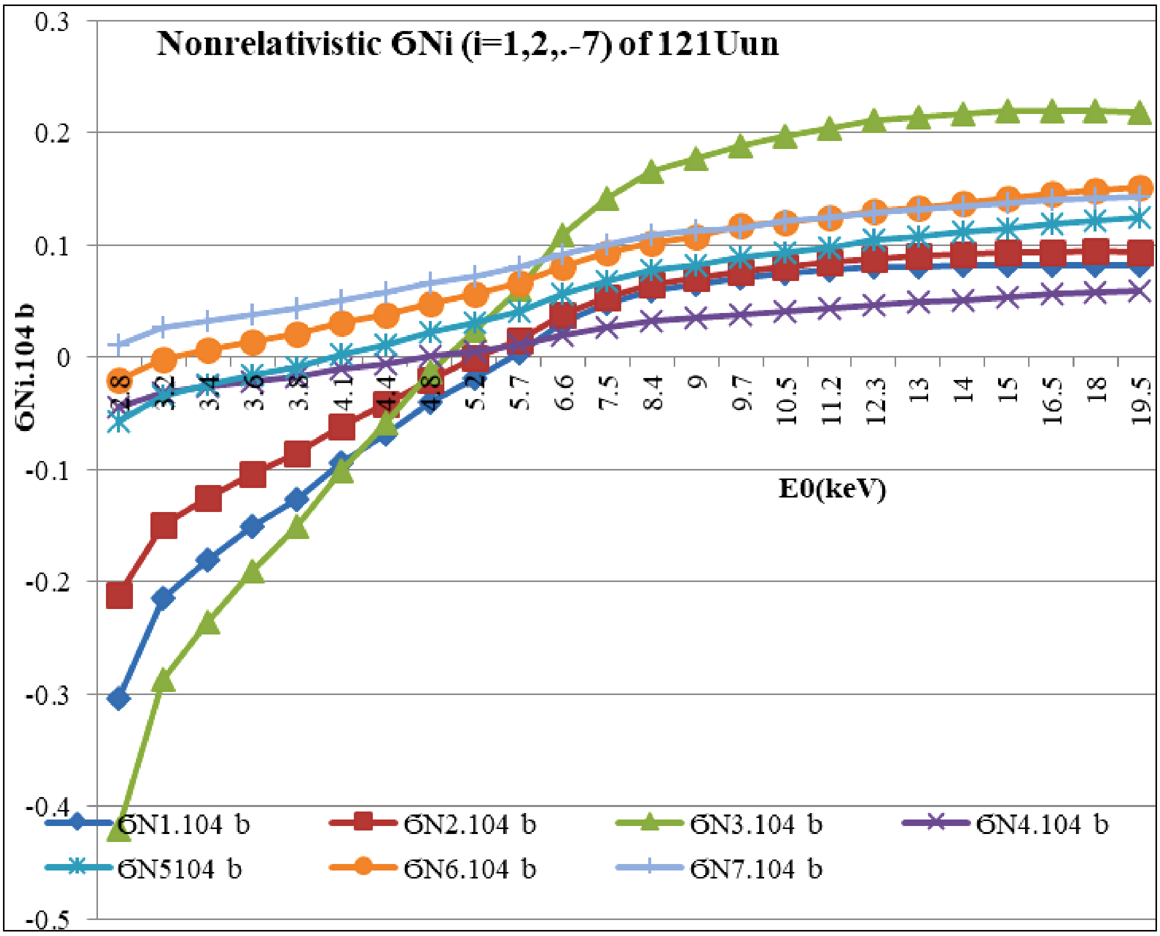

Fig 3b: Ni subshell ionization cross sections σ_{Ni} of $_{121}$Uun in 10^4 b.

Table 4: Ni subshell ionization cross sections σ_{Ni} of $_{122}$Uun in 10^4 b.

E_0(keV)	$\sigma_{N1}.10^4$ b	$\sigma_{N2}.10^4$ b	$\sigma_{N3}.10^4$ b	$\sigma_{N4}.10^4$ b	$\sigma_{N5}10^4$ b	$\sigma_{N6}.10^4$ b	$\sigma_{N7}.10^4$ b	$\sigma_{N1total}10^4$ b
2,7	-0,3366	-0,2339	-0,4698	-0,0486	-0,0656	-0,0285	0,0011	-1,1819
3,3	-0,2053	-0,1429	-0,2756	-0,0298	-0,0336	-0,002	0,0219	-0,6673
3,6	-0,1603	-0,1108	-0,2073	-0,0226	-0,0214	0,0087	0,0303	-0,4834
3,8	-0,1355	-0,0928	-0,1691	-0,0184	-0,0141	0,01515	0,03545	-0,3793
4,1	-0,1041	-0,0699	-0,1201	-0,01282	-0,004511	0,02381	0,04221	-0,245411
4,4	-0,07841	-0,05068	-0,07941	-0,00794	0,00404	0,03161	0,04841	-0,13238
4,8	-0,05084	-0,02966	-0,03484	0,00224	0,01395	0,04087	0,05574	-0,00254
5,2	-0,02904	-0,01263	0,00123	0,00269	0,02254	0,04906	0,06222	0,09607
5,7	-0,00772	0,0045	0,03738	0,0081	0,0318	0,0581	0,0694	0,20156
6,6	0,01931	0,02716	0,08504	0,01581	0,04555	0,07171	0,08006	0,34464
7,5	0,0371	0,0429	0,1179	0,0220	0,0565	0,0828	0,0887	0,4479
8,4	0,0491	0,0542	0,1413	0,0271	0,0654	0,0921	0,0958	0,525
9	0,0548	0,0601	0,1531	0,0301	0,0705	0,0973	0,0999	0,5658
9,7	0,0601	0,0654	0,1642	0,0331	0,0757	0,1028	0,1041	0,6054
10,5	0,0645	0,0703	0,1739	0,0361	0,081	0,1083	0,1082	0,6423
11,2	0,0674	0,0736	0,1806	0,0384	0,085	0,1126	0,1114	0,669
12,3	0,0706	0,0776	0,1882	0,0416	0,0905	0,1184	0,1156	0,7025
13	0,0719	0,0795	0,1917	0,0433	0,0935	0,1216	0,1179	0,7194
14	0,0733	0,0815	0,1953	0,0456	0,0972	0,1256	0,1206	0,7391
16,5	0,0741	0,0829	0,1976	0,0476	0,1005	0,1291	0,1231	0,7549
17	0,0744	0,0842	0,1993	0,0501	0,1046	0,1333	0,1257	0,7716
18,5	0,0741	0,0847	0,1992	0,0527	0,1087	0,1377	0,1283	0,7854
21	0,0729	0,0843	0,1968	0,0552	0,1125	0,1415	0,1302	0,7934

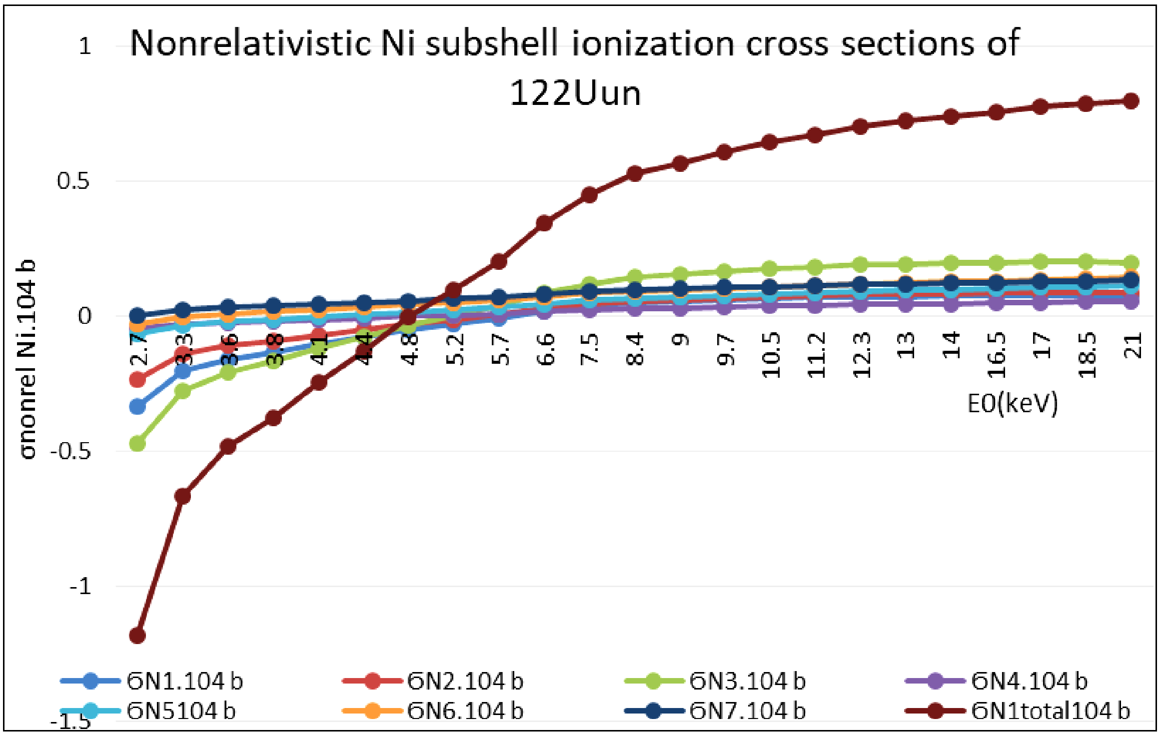

Fig 4: Ni subshell ionization cross sections $Ϭ_{N1}$ of $_{122}$Uun in 10^4 b.

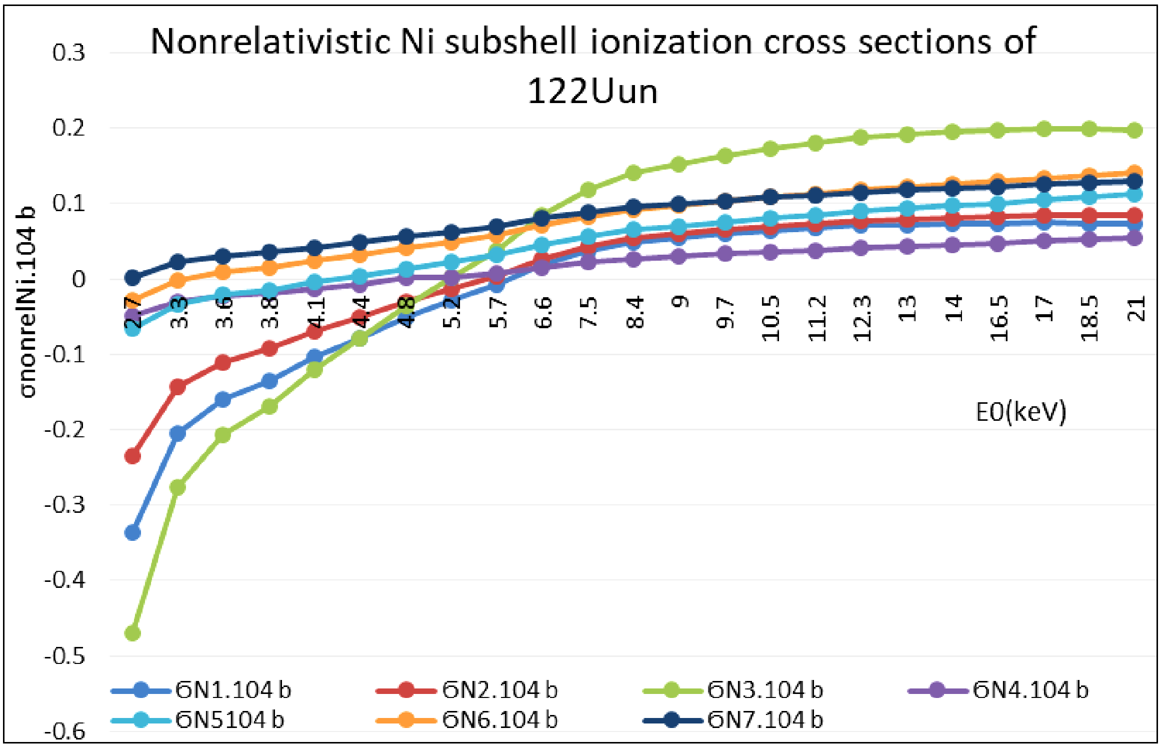

Fig 4b: Ni subshell ionization cross sections $Ϭ_{N1}$ of $_{122}$Uun in 10^4 b.

Table 5: Ni subshell ionization cross sections σ_{N1} of $_{123}$Uun in 10^4 b.

E0(keV)	$\sigma_{N1}.10^4$ b	$\sigma_{N2}.10^4$ b	$\sigma_{N3}.10^4$ b	$\sigma_{N4}.10^4$ b	$\sigma_{N5}10^4$ b	$\sigma_{N6}.10^4$ b	$\sigma_{N7}.10^4$ b	$\sigma_{Ntotal}10^4$
2,9	-0,2901	-0,202	-0,4072	-0,0421	-0,0551	-0,0157	0,0002	-1,012
3,4	-0,1962	-0,1371	-0,2699	-0,0288	-0,0317	0,0057	0,0145	-0,6435
4	-0,1222	-0,0844	-0,1586	-0,0171	-0,0107	0,0258	0,028	-0,3392
4,6	-0,07285	-0,04804	-0,08189	-0,00816	0,00538	0,04188	0,03877	-0,12491
5,2	-0,03844	-0,0218	-0,02665	-0,00109	0,01823	0,05514	0,04766	0,03305
5,8	-0,01364	-0,0022	0,01451	0,00469	0,0288	0,06632	0,05515	0,15363
6,6	0,00974	0,01705	0,05484	0,01098	0,04034	0,0788	0,06351	0,27526
7,4	0,02592	0,03104	0,08402	0,01611	0,04976	0,0892	0,07045	0,3665
8,4	0,0397	0,0437	0,1102	0,0213	0,0594	0,101	0,0776	0,4519
9	0,0457	0,0494	0,1221	0,0241	0,0643	0,1055	0,0813	0,4924
9,7	0,0511	0,0549	0,1332	0,0268	0,0693	0,1112	0,0851	0,5316
10,5	0,0558	0,0598	0,1432	0,0296	0,0744	0,117	0,0889	0,5687
11,2	0,0588	0,0632	0,1501	0,0317	0,0783	0,1214	0,0918	0,5953
12	0,0615	0,0663	0,1563	0,0339	0,0822	0,1259	0,0947	0,6208
13	0,0638	0,0693	0,1622	0,0363	0,0865	0,1307	0,0978	0,6466
14	0,0654	0,0715	0,1663	0,0384	0,0901	0,1348	0,1004	0,6669
15	0,0664	0,0731	0,1692	0,0402	0,0933	0,1383	0,1027	0,6832
16	0,0669	0,0742	0,1712	0,0418	0,0961	0,1413	0,1046	0,6961
17	0,0672	0,0751	0,1723	0,0433	0,0984	0,1439	0,1062	0,7064
18	0,0672	0,0754	0,1729	0,0445	0,1005	0,1461	0,1075	0,7141
19	0,0671	0,0757	0,1729	0,0456	0,1023	0,1479	0,1086	0,7201
20	0,0668	0,0757	0,1726	0,0466	0,1038	0,1495	0,1095	0,7245
21,5	0,0661	0,0755	0,1716	0,0479	0,1057	0,1513	0,1105	0,7286
22,5	0,0656	0,0752	0,1706	0,0487	0,1068	0,1523	0,1121	0,7313

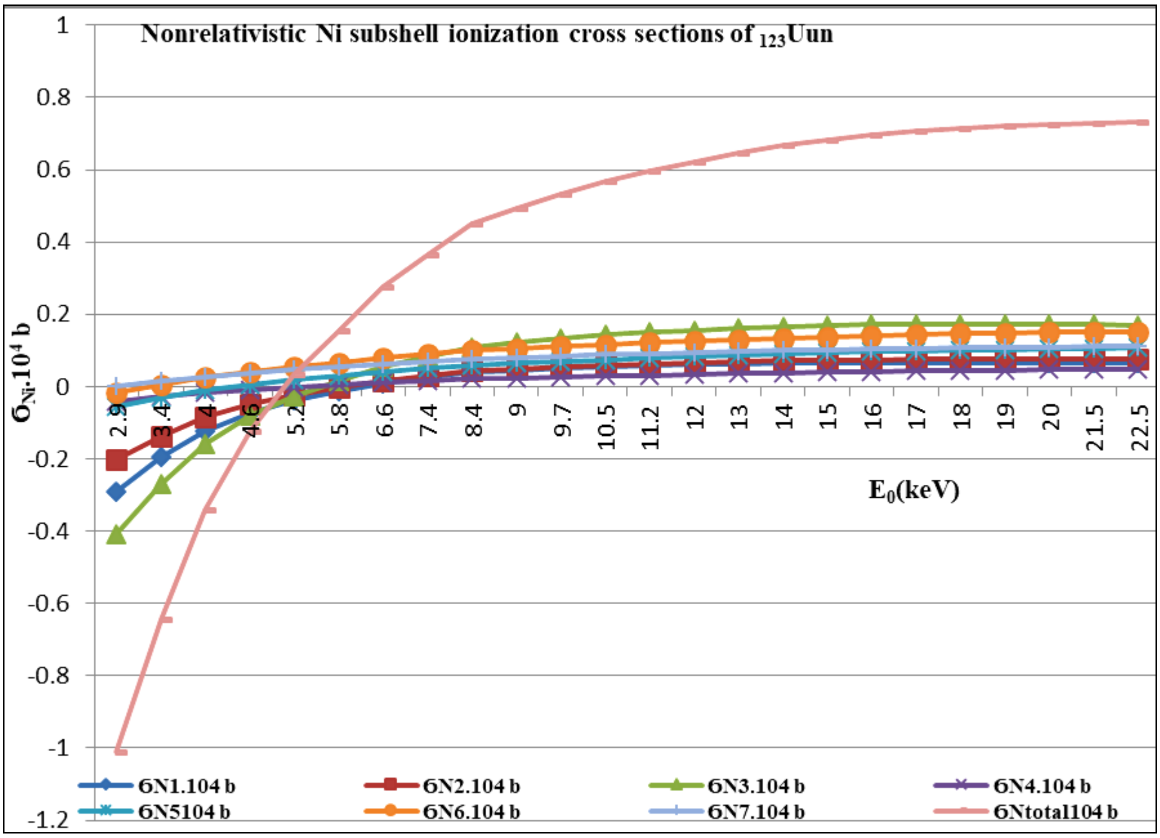

Fig 5a: Ni subshell ionization cross sections σ_{N1} of $_{123}$Uun in 10^4 b.

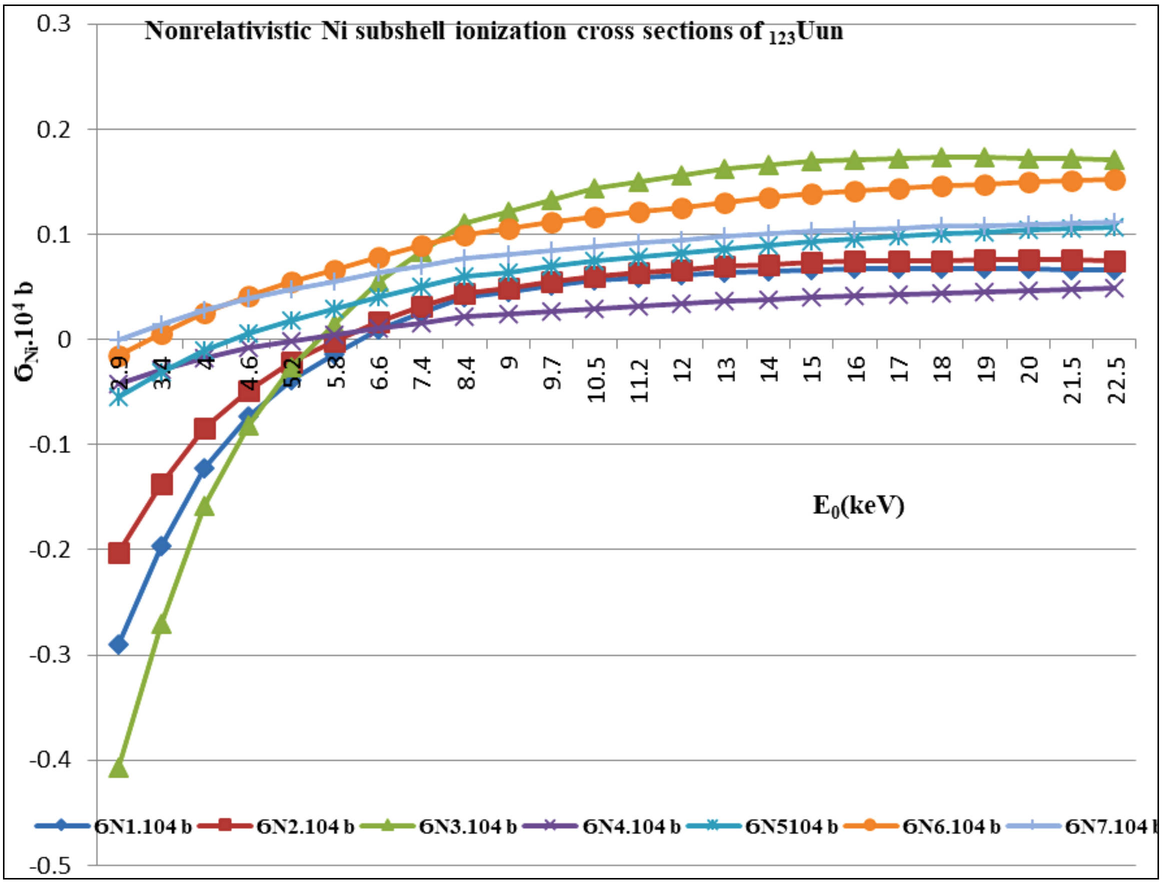

Fig 5b: Ni subshell ionization cross sections $σ_{Ni}$ of $_{123}$Uun in 10^4 b.

Table 6: Ni subshell ionization cross sections $σ_{Ni}$ of $_{124}$Uun in 10^4 b.

E$_0$(keV)	$σ_{N1}.10^4$ b	$σ_{N2}.10^4$ b	$σ_{N3}.10^4$ b	$σ_{N4}.10^4$ b	$σ_{N5}10^4$ b	$σ_{N6}.10^4$ b	$σ_{N7}.10^4$ b	$σ_{Ntotal}10^4$ b
3,35	-0,2101	-0,1464	-0,2925	-0,0308	-0,0374	-0,002	0,0085	-0,7107
4	-0,1298	-0,0898	-0,1734	-0,0187	-0,0161	0,0186	0,0223	-0,3869
4,6	-0,08127	-0,05444	-0,09895	-0,01034	-0,00099	0,03364	0,03242	-0,17993
5,2	-0,04729	-0,02885	-0,04521	-0,00373	0,01094	0,04602	0,04073	-0,02739
5,8	-0,02271	-0,00971	-0,00508	0,00167	0,02072	0,05645	0,04774	0,08908
6,6	0,00061	0,00914	0,03436	0,00753	0,03141	0,06812	0,05556	0,20673
7,4	0,01683	0,02288	0,06302	0,01231	0,04013	0,07784	0,06207	0,29508
8,4	0,0308	0,03534	0,08889	0,01717	0,04904	0,08794	0,06881	0,37799
9	0,0369	0,0411	0,1007	0,0197	0,0536	0,0931	0,0723	0,4174
9,7	0,0425	0,0465	0,1118	0,0222	0,0583	0,0985	0,0758	0,4556
10,5	0,0473	0,0514	0,1219	0,0248	0,063	0,1039	0,0794	0,4917
11,2	0,0505	0,0549	0,1291	0,0268	0,0666	0,1081	0,0822	0,5182
12	0,0534	0,0581	0,1354	0,0289	0,0703	0,1124	0,0851	0,5436
13	0,0559	0,0611	0,1415	0,0311	0,0743	0,117	0,0882	0,5691
14	0,0577	0,0635	0,1461	0,0331	0,0777	0,1209	0,0905	0,5895
15	0,0589	0,0652	0,1493	0,0348	0,0807	0,1243	0,0927	0,6059
16	0,0597	0,0664	0,1516	0,0363	0,0833	0,1273	0,0945	0,6191
17	0,0601	0,0673	0,1532	0,0376	0,0856	0,1298	0,0961	0,6297
18	0,0603	0,0679	0,1541	0,0388	0,0876	0,1319	0,0975	0,6381
19	0,0603	0,0683	0,1546	0,0399	0,0894	0,1338	0,0986	0,6449
20	0,0602	0,0685	0,1547	0,0409	0,0909	0,1354	0,0995	0,6501
21	0,0599	0,0685	0,1544	0,0417	0,0922	0,1367	0,1003	0,6537
22,5	0,0594	0,0683	0,1536	0,0428	0,0939	0,1383	0,1012	0,6575
23,5	0,0591	0,0681	0,1528	0,0435	0,0948	0,1392	0,1016	0,6591

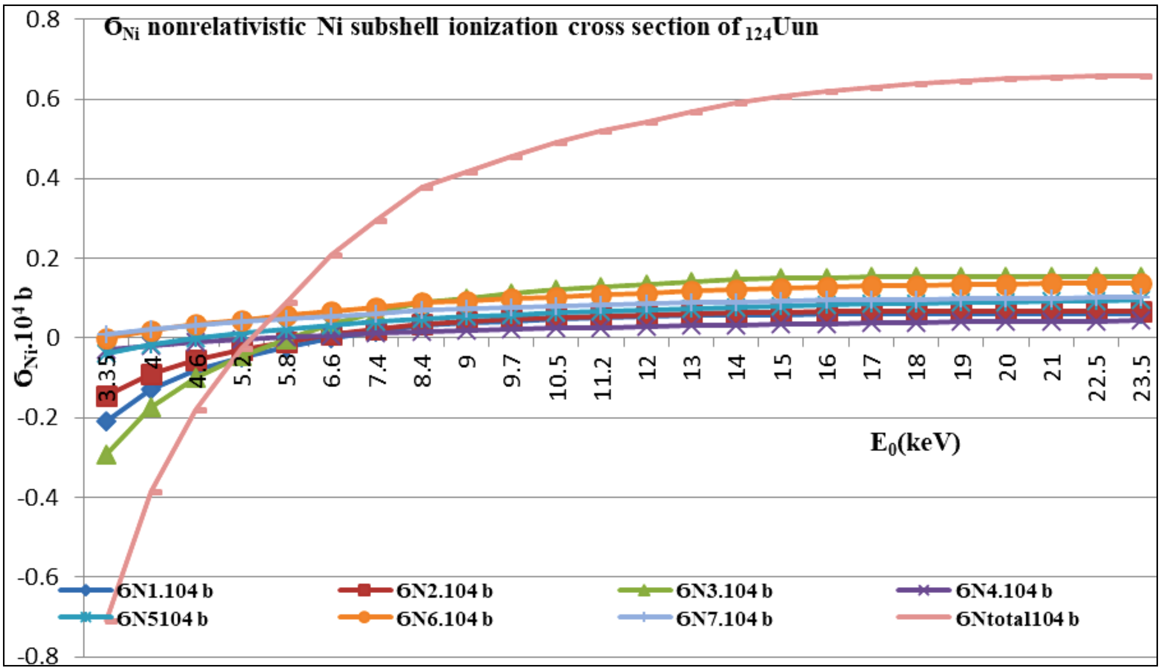

Fig 6a: Ni subshell ionization cross sections σ_{NI} of $_{124}$Uun in 10^4 b.

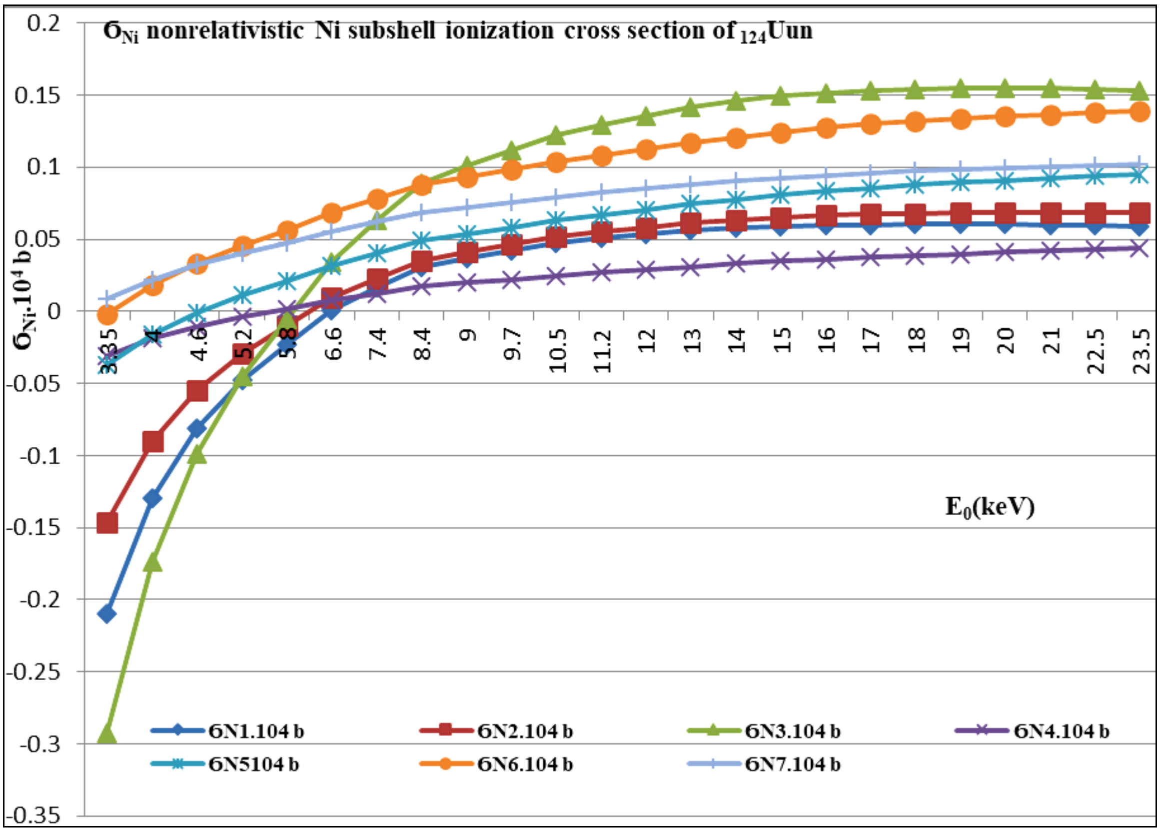

Fig 6b: Ni subshell ionization cross sections σ_{NI} of $_{124}$Uun in 10^4 b.

Table 7: Ni subshell ionization cross sections σ_{N1} of ${}_{125}$Uun in 10^4 b.

E0(keV)	$\sigma_{N1}.10^4$ b	$\sigma_{N2}.10^4$ b	$\sigma_{N3}.10^4$ b	$\sigma_{N4}.10^4$ b	$\sigma_{N5}10^4$ b	$\sigma_{N6}.10^4$ b	$\sigma_{N7}.10^4$ b	$\sigma_{N1total}10^4$ b
3,5	-0,1939	-0,1343	-0,2709	-0,0284	-0,0351	-0,0046	0,0048	-0,6624
4	-0,137	-0,0942	-0,1871	-0,0201	-0,0403	0,0092	0,01391	-0,45559
4,6	-0,0894	-0,0597	-0,1151	-0,0122	-0,0063	0,0227	0,0229	-0,2371
5,2	-0,05595	-0,03474	-0,06299	-0,00608	0,00478	0,03381	0,03024	-0,09093
5,8	-0,03164	-0,01604	-0,02403	-0,00108	0,01385	0,04317	0,03645	0,02068
6,6	-0,00851	0,00242	0,01437	0,00435	0,02373	0,05365	0,04339	0,1334
7,4	0,00773	0,01591	0,04239	0,00876	0,03181	0,06239	0,04918	0,21817
8,4	0,02181	0,02819	0,06781	0,01326	0,04005	0,07151	0,05521	0,29784
9	0,02801	0,03383	0,07947	0,01556	0,04425	0,07621	0,05831	0,33564
9,7	0,03371	0,03922	0,09057	0,01794	0,04859	0,08109	0,06151	0,37263
10,5	0,0387	0,0442	0,1007	0,0203	0,0531	0,086	0,0648	0,4078
11,2	0,0421	0,0476	0,1078	0,0222	0,0563	0,0899	0,0673	0,4332
12	0,0451	0,0509	0,1144	0,0241	0,0597	0,0937	0,0698	0,4577
13	0,0479	0,0541	0,1207	0,0261	0,0635	0,0982	0,0726	0,4831
14	0,0499	0,0564	0,1256	0,0281	0,0667	0,1017	0,0749	0,5033
15	0,0513	0,0582	0,1292	0,0296	0,0696	0,1049	0,0771	0,5199
16	0,0523	0,0596	0,1318	0,031	0,072	0,1076	0,0788	0,5331
17	0,0529	0,0606	0,1337	0,0323	0,0742	0,1101	0,0803	0,5441
18	0,0532	0,0614	0,1352	0,0334	0,0761	0,1122	0,0816	0,5531
19	0,0534	0,0619	0,1359	0,0344	0,0778	0,1141	0,0827	0,5602
20	0,0535	0,0622	0,1364	0,0353	0,0793	0,1155	0,0837	0,5659
21,5	0,0533	0,0623	0,1365	0,0365	0,0812	0,1175	0,0849	0,5722
22,5	0,0531	0,0623	0,1362	0,0372	0,0823	0,1186	0,0855	0,5752
24,5	0,0525	0,0621	0,1352	0,0384	0,084	0,1203	0,0864	0,5789

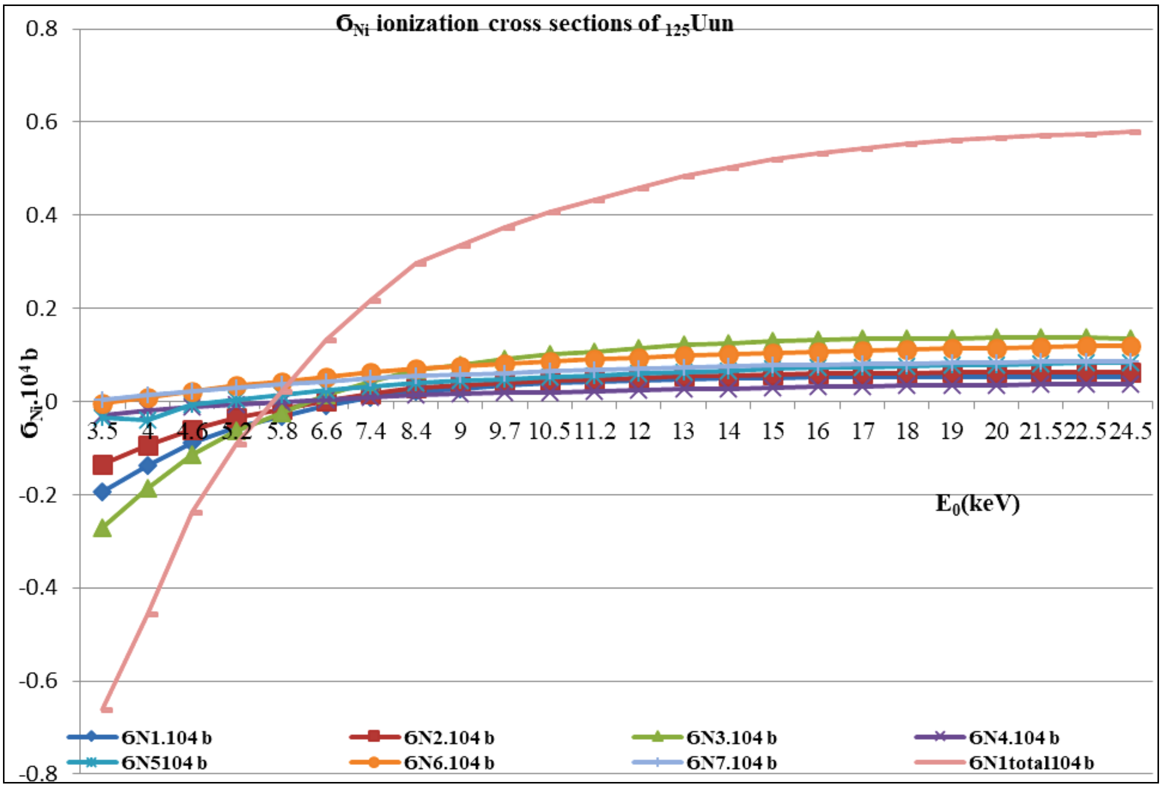

Fig 7a: N_i subshell ionization cross sections σ_{N1} of ${}_{125}$Uun in 10^4 b.

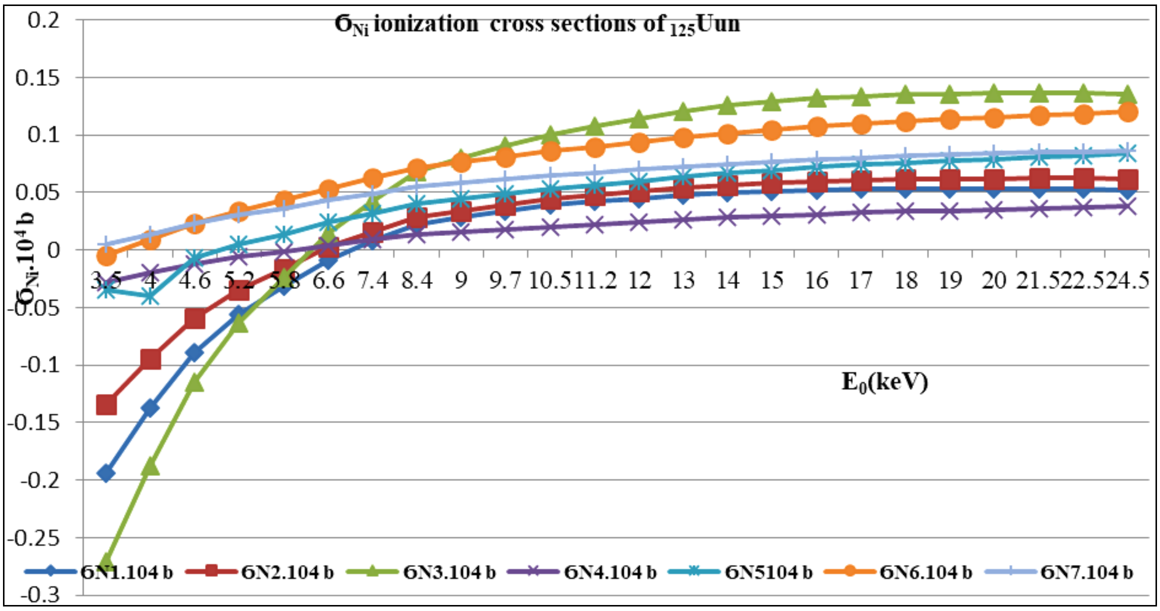

Fig 7b: Ni subshell ionization cross sections σ_{N1} of $_{125}$Uun in 10^4 b.

Table 8: Ni subshell ionization cross sections σ_{N1} of $_{126}$Uun in 10^4 b.

E_0(keV)	$\sigma_{N1}.10^4$ b	$\sigma_{N2}.10^4$ b	$\sigma_{N3}.10^4$ b	$\sigma_{N4}.10^4$ b	$\sigma_{N5}10^4$ b	$\sigma_{N6}.10^4$ b	$\sigma_{N7}.10^4$ b	$\sigma_{N1tota}.0^4$ b
3,5	-0,1981	-0,1371	-0,2773	-0,0288	-0,0376	-0,0113	-0,0013	-0,6915
4	-0,1426	-0,0981	-0,1957	-0,0211	-0,0238	0,0011	0,0067	-0,4735
4,6	-0,0959	-0,0645	-0,1256	-0,0137	-0,0111	0,0131	0,0146	-0,2831
5,2	-0,06302	-0,04021	-0,07482	-0,00794	-0,00768	0,02283	0,02101	-0,14983
5,8	-0,03903	-0,02198	-0,03677	-0,00328	0,00759	0,03113	0,02643	-0,03591
6,6	0,001608	-0,00394	0,0008	0,00176	0,01668	0,04042	0,0325	0,089828
7,4	0,009	0,00927	0,02829	0,00585	0,02409	0,04818	0,03757	0,16225
8,4	0,01421	0,02133	0,05332	0,01002	0,03166	0,05628	0,04286	0,22968
9	0,02047	0,0269	0,06485	0,01214	0,03552	0,06047	0,0456	0,26595
9,7	0,02628	0,03224	0,07586	0,01434	0,03951	0,06485	0,04845	0,30153
10,5	0,03142	0,03714	0,08596	0,01655	0,04352	0,06928	0,05132	0,33519
11,2	0,03493	0,04062	0,09309	0,01827	0,04663	0,07272	0,05356	0,35982
12	0,03808	0,04387	0,09973	0,02002	0,04979	0,07624	0,05584	0,38357
13	0,0411	0,0471	0,1062	0,0221	0,0533	0,0801	0,0583	0,4082
14	0,0432	0,0496	0,1112	0,0236	0,0563	0,0835	0,0605	0,4279
15	0,0448	0,0515	0,115	0,0251	0,0589	0,0864	0,0624	0,4441
16	0,0459	0,0529	0,1179	0,0265	0,0612	0,0891	0,0641	0,4576
17	0,0467	0,0541	0,1201	0,0276	0,0633	0,0913	0,0655	0,4686
18	0,0472	0,0549	0,1216	0,0287	0,0651	0,0933	0,0667	0,4775
19	0,0475	0,0555	0,1227	0,0297	0,0667	0,095	0,0678	0,4849
21	0,0477	0,0562	0,1238	0,0313	0,0694	0,0979	0,0696	0,4959
22,4	0,0476	0,0563	0,1239	0,0323	0,0709	0,0995	0,0706	0,5011
22,5	0,0476	0,0563	0,1239	0,0323	0,071	0,0996	0,0707	0,5014
26	0,0468	0,0561	0,1226	0,0342	0,0739	0,1024	0,0723	0,5083

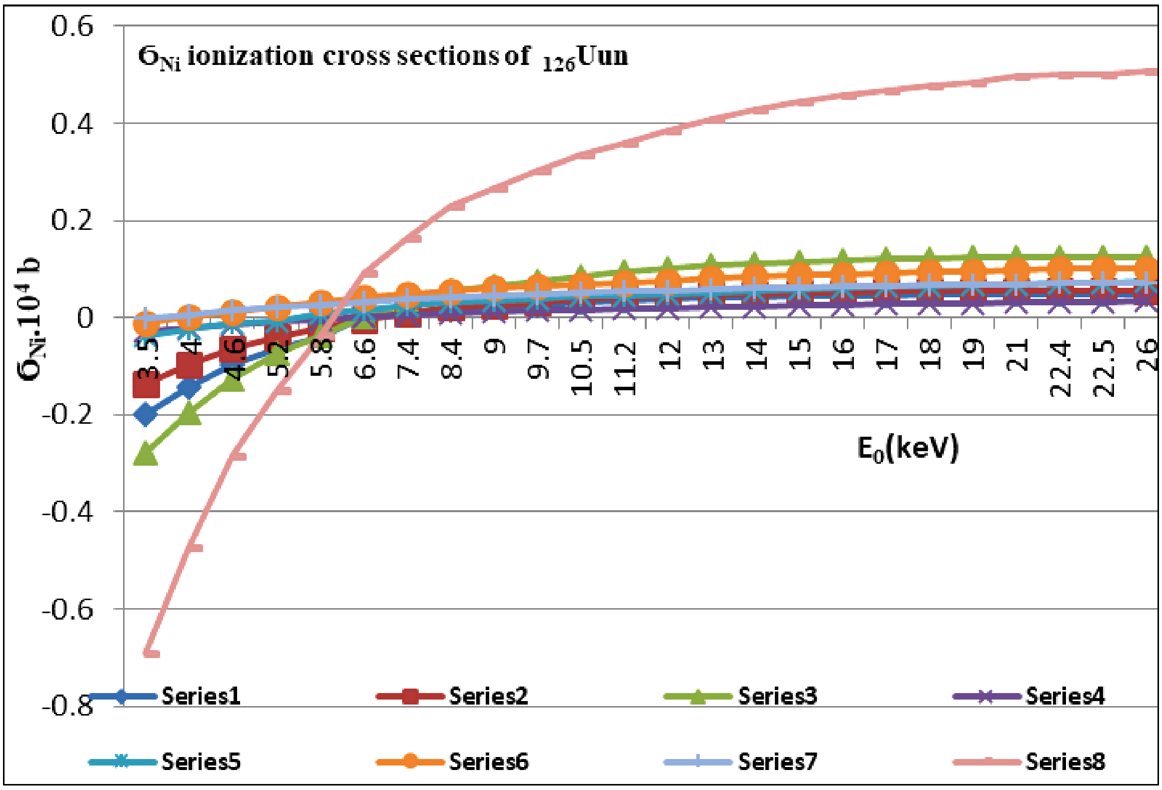

Fig 8a: Ni subshell ionization cross sections $Ϭ_{N1}$ of $_{126}$Uun in 10^4 b.

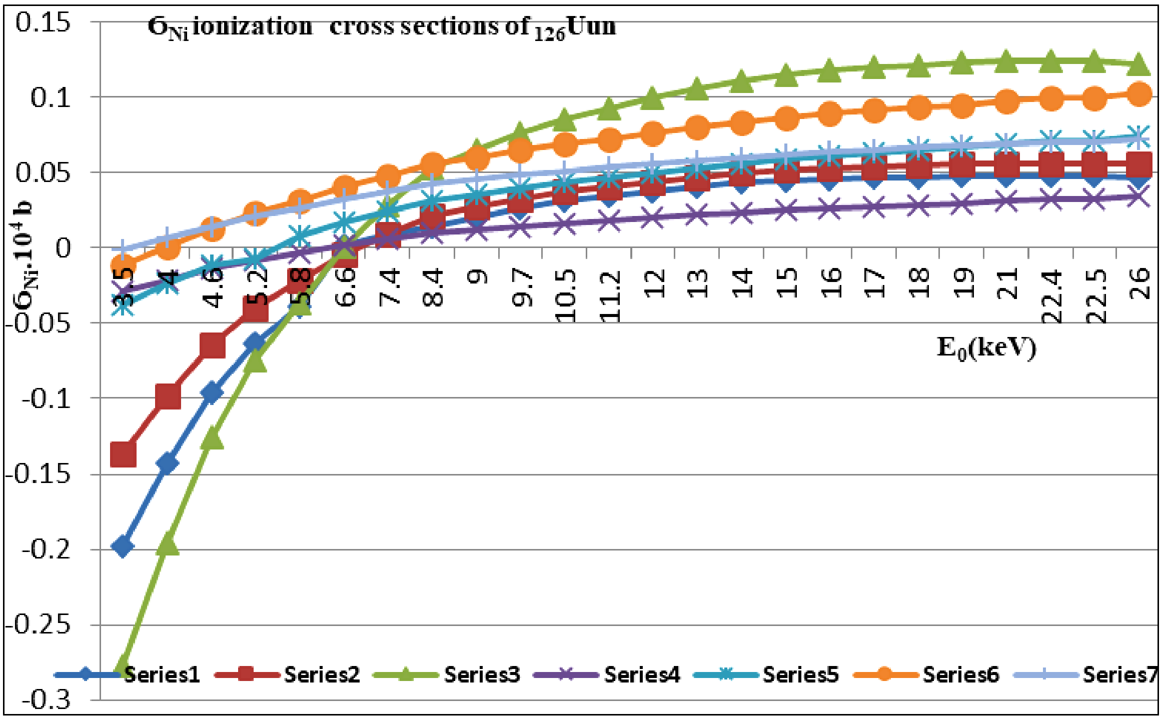

Fig 8b: Ni subshell ionization cross sections $Ϭ_{N1}$ of $_{126}$Uun in 10^4 b.

Table 9: For fixed electron impact E_0 =5,4keV Z dependency of N subshells $Ϭ_{Ni}$ of 119≤Z≤126 atoms in b.

Atomic Z	E_0(keV)	$Ϭ_{N1}.10^4$ b	$Ϭ_{N2}.10^4$ b	$Ϭ_{N3}.10^4$ b	$Ϭ_{N4}.10^4$ b	$Ϭ_{N5}10^4$ b	$Ϭ_{N6}.10^4$ b	$Ϭ_{N7}.10^4$ b	$Ϭ_{Ntot}.10^4$ b
119	5,2	0,012	0,0278	0,0912	0,0191	0,0535	0,0791	0,1195	0,4022
120	5,2	0,00441	0,01192	0,05583	0,01403	0,03926	0,06141	0,09072	0,27758
121	5,2	-0,01793	-0,00264	0,02356	0,00591	0,03134	0,05716	0,07279	0,17283
122	5,2	-0,0291	-0,0126	0,00123	0,00269	0,02254	0,04906	0,06222	0,09607
123	5,2	-0,03844	-0,0218	-0,02665	-0,00109	0,01823	0,05514	0,04766	0,03305
124	5,2	-0,04729	-0,02885	-0,04521	-0,00373	0,01094	0,04602	0,04073	-0,02739
125	5,2	-0,05595	-0,03474	-0,06299	-0,00608	0,00478	0,03381	0,03024	-0,09093
126	5,2	-0,06302	-0,04021	-0,07482	-0,00794	-0,00768	0,02283	0,02101	-0,14983

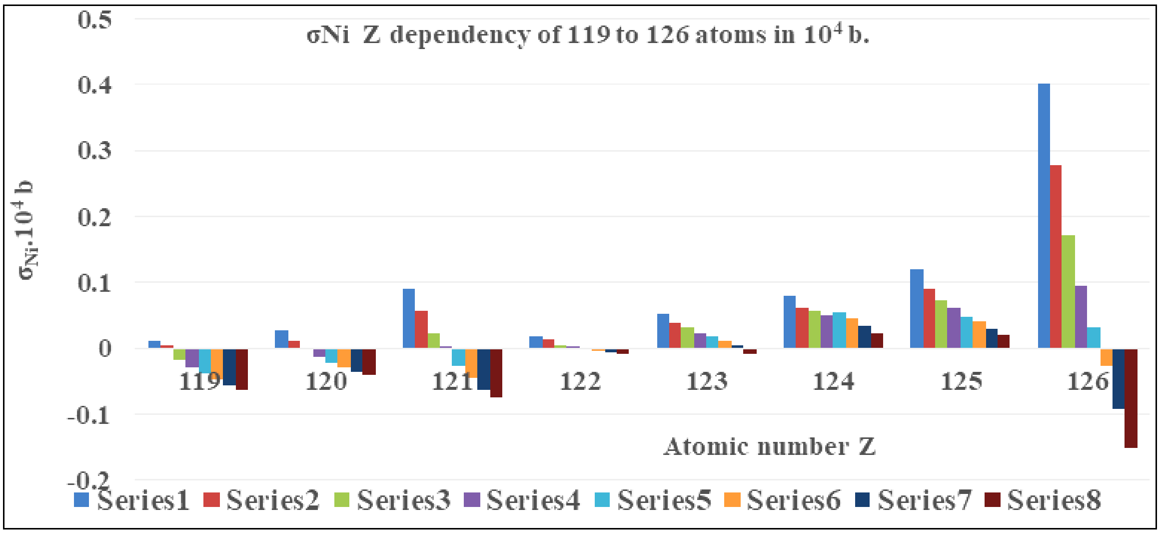

Fig 9: Z dependency of 119 to126 atoms σ_{Ni} in 10^4 b.

4. Conclusions

Nonrelativistic cross section calculations for $_{119}$Uun $_{120}$Uun, $_{121}$Uun, $_{122}$Uun, $_{123}$Uun, $_{124}$Uun $_{125}$Uun and $_{126}$Uun atoms carried out for electron impact energies. σ^{nrel}_{N} and σ^{nrel}_{Ni} of Ni shell results for 24 E_{0i} were given in Table.1 to 8 and Figs. 1a, 1b to Figs.8a, 8b. under the name of each atom: which were carried out for E_{0i} electron impact energy close to N subshell ionization threshold energy values of above atoms. These graphs helps to compare how each subshells σ^{nrel}_{Ni} depends at any value of E_{0i} energy. Nonrelativistic N shell σ^{nrel}_{Ntotal} and N_i subshells σ^{nrel}_{Ni} calculations for each atom has some common characteristics: For each atom very close to threshold region; σ^{nrel}_{N1} crosses σ^{nrel}_{N2} and σ^{nrel}_{N3} and crosses only σ^{nrel}_{N3} other cross sections at higher energies region, namely through end region of graphs. Each σ^{nrel}_{Ni} increases differently with electron impact energy. a) For $_{119}$Uun $_{120}$Uun, $_{121}$Uun, $_{122}$Uun atoms σ^{nrel}_{N3} crosses σ^{nrel}_{N1} and $\sigma^{nrel}_{N2,}$ $\sigma^{nrel}_{N4,}$ σ^{nrel}_{N5} σ^{nrel}_{N6} and σ^{nrel}_{N7} other cross sections but for : b) $_{123}$Uun, $_{124}$Uun, $_{125}$Uun, $_{126}$Uun, atoms σ^{nrel}_{N3} crosses σ^{nrel}_{N1} and $\sigma^{nrel}_{N2,}$ $\sigma^{nrel}_{N4,}$ σ^{nrel}_{N5} σ^{nrel}_{N7} and σ^{nrel}_{N6} order. Z dependency of ionization cross sections for a fixed E_{0i} = 5,2 keV impact given in Table.9a and Figs.9a. All each σ^{nrel}_{Ni} decrease with atomic number Z for 119≤ Z ≤126.

Z dependency of ionization cross sections for a fixed E_{0i} = 5,2 keV impact given in Table.9 and Figs.9. All each σ^{nrel}_{Ni} decrease with atomic number Z for 119≤ Z ≤126 [19, 21].

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