K. K. Sirma et al. International Journal of Recent Research Aspects ISSN: 2349-7688, Vol. 7, Issue 2, June 2020, pp. 24-50

Calculation of Charge Radius of Nuclei using The Modified Coulomb Energy Formula for Nuclei

K. K. Sirma[1] and K. M. Khanna[2]

[1]Department of Renewable energy and Technology, Turkana University College, P.O. Box 69-30500, Lodwar – Kenya.
[2]Department of Physics, University of Eldoret, P.O. Box 1125-30100, Eldoret – Kenya.
1,2E-mail address: sirmaken@yahoo.com , khannak700@gmail.com
Author for correspondence: khannak700@gmail.com

Abstract: **Nuclear charge radius is an important macroscopic variable that determines the magnitude and extent of the Coulomb potential within the boundaries of the atomic nucleus. An expression for the modified Coulomb potential valid for the atomic nucleus has been used to obtain an expression for the nuclear charge radius. The calculated values for the nuclear charge radius have been compared with the experimentally observed values for the nuclear charge radius. Excellent agreement between the calculated nuclear charge radius and the experimentally observed nuclear charge radius leads to a modified Coulomb potential relation that can be used to calculate more accurately the binding energy for the nucleus. The average deviation of nuclear charge radius is calculated for 957 nuclei to establish the better agreement between the calculated nuclear charge radius and the experimentally observed nuclear charge radius and the value of the average deviation is 0.30297fm, which is small.**

Keywords- Nuclear charge radius, Coulomb Energy, Core radius, Super Heavy Nuclei.

I. INTRODUCTION

Among all the bulk properties of atomic nuclei, nuclear charge radius is the most fundamental. It has been investigated thoroughly by many experimental methods and techniques [1-7]. The charge radius of the nucleus is due to the presence of positively charged protons inside the nucleus which are assumed to interact with each other via the Coulomb interactions in addition to the nuclear interaction. Coulomb interaction is basically a long range interaction law, whereas inside the nucleus, the protons whose size is very small are confined in a nucleus whose size is also small, of the order of 1fm to 5-9fm since the size of the nucleus increases as the mass number A and proton number Z of the nucleus increase. The purpose of this study is to use a modified Coulomb law for the Coulomb interaction between the protons such that the range of the Coulomb force, and the Coulomb energy are confined to within the boundary of the atomic nucleus [8]. From this modified Coulomb law, charge radius of the atomic nuclei has been calculated.

A number of scientists have proposed modified versions of the Coulomb's law [9-14]. A modified Coulomb law has also been proposed by us according to which we consider a liquid drop in which the charge distribution in the interior of the nucleus is assumed to be uniform, and a correction term is a multiplier to the usual Coulomb law [15,16]. A further modification was the assumption that a nucleus with neutron number N>Z is assumed to be composed of a core of radius say R_o and the core is composed of equal number of protons and neutrons, and the excess neutrons are in the neutron skin or surface region of the nucleus [8]. The modified formula for E_c (Coulomb energy) is written in terms of R, R_o, Z etc. Since the protons reside in the core region of radius R_o, the quantity R_o should be treated as the maximum charge radius of the nucleus. For different nuclei as Z varies, R_o can be calculated. The effective charge radius of the nucleus is then calculated from the modified formula for the Coulomb law. However, this effective charge radius could be considered as the 'Nuclear Charge radius'.

It will be interesting to understand the phenomenological macroscopic formula for the nuclear radius and nuclear charge radius proposed by Bozena Nerlo-Pomorska and Krzysztof Pomorski, Theoretical Physics Department, The Maria -Curie Sklodowska University, Lublin, Poland [17]. In this study the nuclear charge radius R_o, depends on r_o and the neutron excess parameter ($\frac{N-Z}{A}$). The formula is more successful for the elements for which Z>38, and is not successful for elements 8<Z<38. Different parametric formulas are proposed for different types of nuclei; for instance, for even-even nuclei, for Z>38 nuclei and so on.

II. DERIVATIONS

The modified Coulomb energy E_c equation for a nucleus of radius R and core radius R_o when the core is assumed to be composed of equal number of protons and neutrons (2Z) and the neutron skin or surface region of the nucleus is composed of unpaired neutrons equal to (N-Z), is given by [8],

$$E_C = \frac{3}{5}\frac{Z_1 Z_2 e^2}{4\pi\varepsilon_o R_o A^{\frac{1}{3}}} e^{\frac{R_o^n}{nR^n}} \quad (1)$$

Where

$$R = r_o A^{\frac{1}{3}}$$

$$R_o = r_o (2Z)^{\frac{1}{3}}$$

$$r_o = 1.2\,fm - 1.5\,fm$$

Our modified Coulomb energy model is infact, a finite-range Coulomb interaction model. If r is the effective charge radius of the nucleus, then we can write E_c as,

$$E_C = \frac{3}{5}\frac{Z_1 Z_2 e^2}{4\pi\varepsilon_o r A^{\frac{1}{3}}} \quad (2)$$

Equating Eq.1 and Eq. 2, we can get the values of r,

$$\frac{1}{r} = \frac{1}{R_o} e^{\frac{R_o^n}{nR^n}} \quad (3)$$

Or

$$r = R_o e^{-\left(\frac{R_o^n}{nR^n}\right)} \quad (4)$$

Using extreme values for n, i.e, n=1 and n=infinity, we get,

$$r_1(n=1) = R_o e^{-\left(\frac{R_o}{R}\right)} \quad (5)$$

$$r_2(n=\infty) = R_o \quad (6)$$

Equation 6 gives the core radius and will correspond to spherical nuclei [18]. Now r_1 and r_2 can be calculated for different nuclei and the results compared with the experimental and theoretical values known so far. Equation 5 and Eq. 6 contain R_o which is proportional to $(Z)^{1/3}$ and this is what was proposed by Zhang [18].

In our case, in Eq. 5 and Eq. 6, the dependence of the nuclear charge radius as proportional to $Z^{1/3}$ appears as a part of our formulation. Thus the charge radius of the nucleus may be more directly related to its charge number Z, rather than the mass number A. This means that compared to the $A^{1/3}$ law, a $Z^{1/3}$ dependence for nuclear charge radii may be physically more reasonable.

In Eq. 4, n can be varied from n=1 to $n=\infty$. Thus r will depend on the value of n. The values of r obtained for different values of n can be compared with the known experimental and or theoretical values. This will lead to a Coulomb energy, E_c formula that will be more acceptable to study the binding energy of nuclei, and also the conditions for stability of nuclei.

We did a large number of calculations for n=2, 3, 4, 5. It was found out that the values of r for n=5 for different nuclei compare very well with the experimental values in "[19]". We calculated the average deviation, $\langle\sigma\rangle$, of our r values from the R_{av}(fm) given in "[19]", and obtained a value of 0.30297fm which is shown in Eq. (7). This deviation is quite small, and when combined with our values of r(n=5) can lead to very close agreement between our values of r(n=5) with the experimental values of R_{av}(fm) [19]. For comparison the calculated and experimental values are given in Table 1.

III. RESULTS

Calculations using Eq. 4 for n=5 are presented in Table 1.

Table 1. Comparison of r (n=5) and R_{av}(fm)

Elem.	Z	A	N	$r(n=\infty)$	$r(n=1)$	$r(n=5)$	R_{av}(fm)
n	0	1	1	0	0	0	-0.114
H	1	1	0	1.51190526	0.428891874	0.801243964	0.878
	1	2	1	1.51190526	0.556198862	1.237843332	2.142
	1	3	2	1.51190526	0.631151186	1.365632249	1.759
He	2	3	1	1.904881262	0.633672678	1.379024019	1.966
	2	4	2	1.904881262	0.700766654	1.559584817	1.675
	2	6	4	1.904881262	0.795200665	1.720590077	2.066
	2	8	6	1.904881262	0.861327178	1.788582899	1.923
Li	3	6	3	2.180544711	0.802177577	1.785279014	2.589
	3	7	4	2.180544711	0.843378409	1.868037399	2.444
	3	8	5	2.180544711	0.878986638	1.926591619	2.339
	3	9	6	2.180544711	0.910277527	1.969583967	2.245
	3	11	8	2.180544711	0.963210573	2.027386252	2.482
Be	4	7	3	2.4	0.843625014	1.869398088	2.646

	4	9	5	2.4	0.917565808	2.036263346	2.519
	4	10	6	2.4	0.948523201	2.090879764	2.355
	4	11	7	2.4	0.976461566	2.133655557	2.463
	4	12	8	2.4	1.001890057	2.167807656	
B	5	10	5	2.585321628	0.951086676	2.116682323	2.427
	5	11	6	2.585321628	0.981297714	2.179782516	2.406
C	6	12	6	2.747314182	1.010680406	2.249310609	2.470
	6	13	7	2.747314182	1.037643094	2.306200968	2.461
	6	14	8	2.747314182	1.06259021	2.35357963	2.502
N	7	14	7	2.892170717	1.063970147	2.367909109	2.558
	7	15	8	2.892170717	1.088436788	2.419913962	2.605
O	8	16	8	3.02381052	1.112397724	2.475686664	2.699
	8	17	9	3.02381052	1.134875766	2.523731625	2.693
	8	18	10	3.02381052	1.156060476	2.565531053	2.772
F	9	19	10	3.144889673	1.17778998	2.619577512	2.897
Ne	10	17	7	3.257301144	1.133411135	2.505978808	3.041
	10	18	8	3.257301144	1.156218554	2.566406164	2.971
	10	19	9	3.257301144	1.177806974	2.619671964	3.008
	10	20	10	3.257301144	1.198294123	2.666852615	3.005
	10	21	11	3.257301144	1.21778159	2.708835099	2.969
Elem.	**Z**	**A**	**N**	$r\,(n=\infty)$	$r\,(n=1)$	$r\,(n=5)$	R_{av}**(fm)**
	10	22	12	3.257301144	1.236357646	2.746353876	2.952
	10	23	13	3.257301144	1.254099474	2.780020265	2.910
	10	24	14	3.257301144	1.271074941	2.810345736	2.900
	10	25	15	3.257301144	1.287344043	2.837760433	2.931
	10	26	16	3.257301144	1.302960072	2.862627932	2.925
	10	28	18	3.257301144	1.332418146	2.90591132	2.964
Na	11	20	9	3.362447197	1.197683082	2.659761745	2.971
	11	21	10	3.362447197	1.217794599	2.708907413	3.013
	11	22	11	3.362447197	1.236975196	2.752938926	2.985
	11	23	12	3.362447197	1.255303103	2.792537624	2.993
	11	24	13	3.362447197	1.272847174	2.828277483	2.973
	11	25	14	3.362447197	1.289668321	2.860644083	2.976
	11	26	15	3.362447197	1.305820691	2.890049999	2.992
	11	27	16	3.362447197	1.321352629	2.916847272	3.013
	11	28	17	3.362447197	1.336307478	2.941337561	3.04
	11	29	18	3.362447197	1.350724242	2.963780408	3.092
	11	30	19	3.362447197	1.364638145	2.984400009	3.118
	11	31	20	3.362447197	1.378081106	3.003390771	3.170
Mg	12	21	9	3.461398969	1.216717813	2.696138595	
	12	22	10	3.461398969	1.236449956	2.746865753	

	12	23	11	3.461398969	1.255313308	2.792594356	
	12	24	12	3.461398969	1.273377518	2.833953784	3.057
	12	25	13	3.461398969	1.290704255	2.871480034	3.0284
	12	26	14	3.461398969	1.307348376	2.905631145	3.0337
	12	27	15	3.461398969	1.323358892	2.936799936	
	12	28	16	3.461398969	1.338779773	2.965324518	
	12	29	17	3.461398969	1.35365061	2.991496956	
	12	30	18	3.461398969	1.368007179	3.015570441	
	12	31	19	3.461398969	1.381881915	3.037765221	
	12	32	20	3.461398969	1.395304313	3.058273563	
Al	13	27	14	3.554995282	1.324261634	2.946288858	3.061
Si	14	28	14	3.643906766	1.340518385	2.983378537	3.1224
	14	29	15	3.643906766	1.356198215	3.017467841	3.1176
	14	30	16	3.643906766	1.371344421	3.048900539	3.1336
P	15	31	16	3.728679007	1.386696699	3.085428872	3.1889
S	16	32	16	3.809762525	1.401533309	3.119169741	3.2611
	16	34	18	3.809762525	1.429853866	3.179702598	3.2847
	16	36	20	3.809762525	1.456544929	3.232366578	3.2985
Cl	17	35	18	3.887534162	1.443962463	3.213008999	3.3654
	17	37	20	3.887534162	1.47044834	3.267629721	3.384
Elem.	**Z**	**A**	**N**	$r\,(n=\infty)$	$r\,(n=1)$	$r\,(n=5)$	**R_{av}(fm)**
Ar	18	32	14	3.962312699	1.400439279	3.106349538	3.3468
	18	33	15	3.962312699	1.415381875	3.144376349	3.3438
	18	34	16	3.962312699	1.429882684	3.179862713	3.3654
	18	35	17	3.962312699	1.443965792	3.213027511	3.3636
	18	36	18	3.962312699	1.457653381	3.24406726	3.3905
	18	37	19	3.962312699	1.470965932	3.273158662	3.3908
	18	38	20	3.962312699	1.483922388	3.300460849	3.4028
	18	39	21	3.962312699	1.496540306	3.326117355	3.4093
	18	40	22	3.962312699	1.508835988	3.350257854	3.4274
	18	41	23	3.962312699	1.520824601	3.372999689	3.4251
	18	42	24	3.962312699	1.532520274	3.394449211	3.4414
	18	43	25	3.962312699	1.543936195	3.414702962	3.4354
	18	44	26	3.962312699	1.555084691	3.433848725	3.4454
	18	46	28	3.962312699	1.576624843	3.469128989	3.4377
K	19	37	18	4.034370488	1.470968802	3.273174624	
	19	38	19	4.034370488	1.484161961	3.303063188	3.4264
	19	39	20	4.034370488	1.49701241	3.331171434	3.4349
	19	40	21	4.034370488	1.509536582	3.357637481	3.4381
	19	41	22	4.034370488	1.521749764	3.382586583	3.4518
	19	42	23	4.034370488	1.533666208	3.406132484	3.4517

	19	43	24	4.034370488	1.545299214	3.428378632	3.4556
	19	44	25	4.034370488	1.55666122	3.44941924	3.4563
	19	45	26	4.034370488	1.56776387	3.469340239	3.4605
	19	46	27	4.034370488	1.578618083	3.488220112	3.4558
	19	47	28	4.034370488	1.589234109	3.506130644	3.4534
	19	48	29	4.034370488	1.599621587	3.523137583	
	19	49	30	4.034370488	1.609789585	3.539301227	
	19	50	31	4.034370488	1.619746652	3.554676951	
	19	51	32	4.034370488	1.629500853	3.569315678	
Ca	20	39	19	4.103942272	1.497014904	3.331185305	3.4595
	20	40	20	4.103942272	1.50975599	3.360023747	3.4776
	20	41	21	4.103942272	1.522182456	3.387227852	3.478
	20	42	22	4.103942272	1.534308659	3.412918362	3.5081
	20	43	23	4.103942272	1.546148003	3.437205303	3.4954
	20	44	24	4.103942272	1.557713024	3.460189059	3.5179
	20	45	25	4.103942272	1.569015461	3.481961343	3.4944
	20	46	26	4.103942272	1.580066325	3.502606051	3.4953
	20	47	27	4.103942272	1.590875956	3.522200027	3.4783
	20	48	28	4.103942272	1.601454074	3.540813759	3.4771
	20	50	30	4.103942272	1.621951858	3.575354104	3.5168
Elem.	**Z**	**A**	**N**	$r\,(n=\infty)$	$r\,(n=1)$	$r\,(n=5)$	R_{av}(fm)
Sc	21	42	21	4.171231974	1.534510488	3.415115895	3.5702
	21	43	22	4.171231974	1.546546296	3.441485187	3.5575
	21	44	23	4.171231974	1.558304688	3.466454102	3.5432
	21	45	24	4.171231974	1.56979749	3.490119871	3.5459
	21	46	25	4.171231974	1.581035793	3.512571584	3.5243
Ti	22	44	22	4.236418002	1.558491087	3.468485701	3.6115
	22	45	23	4.236418002	1.57016556	3.49408138	3.5939
	22	46	24	4.236418002	1.581582804	3.518376936	3.607
	22	47	25	4.236418002	1.59275331	3.541458765	3.5962
	22	48	26	4.236418002	1.603686948	3.563406336	3.5921
	22	49	27	4.236418002	1.614393012	3.584292827	3.5733
	22	50	28	4.236418002	1.624880265	3.604185697	3.5704
V	23	51	28	4.299657445	1.636149025	3.633277366	3.6002
Cr	24	50	26	4.361089423	1.626185461	3.61783814	3.6588
	24	52	28	4.361089423	1.647155738	3.660865842	3.6452
	24	53	29	4.361089423	1.657337918	3.680942535	3.6511
	24	54	30	4.361089423	1.667327725	3.700136059	3.6885
Mn	25	50	25	4.420837798	1.626335339	3.619475866	3.712
	25	51	26	4.420837798	1.637070498	3.643054072	3.7026
	25	52	27	4.420837798	1.647596746	3.665572971	3.6706

	25	53	28	4.420837798	1.657921624	3.68709494	3.6662
	25	54	29	4.420837798	1.668052279	3.70767788	3.6834
	25	55	30	4.420837798	1.677995488	3.72737567	3.7057
	25	56	31	4.420837798	1.687757682	3.74623840	3.7146
Fe	26	54	28	4.479013388	1.668465108	3.71209135	3.6933
	26	56	30	4.479013388	1.68843631	3.75332013	3.7377
	26	57	31	4.479013388	1.698154029	3.77265505	3.7532
	26	58	32	4.479013388	1.707701056	3.79119901	3.7745
Co	27	59	32	4.53571578	1.717842786	3.816851146	3.7875
Ni	28	57	29	4.591034839	1.698911824	3.7807376*	3.7757
	28	59	31	4.591034839	1.718325518	3.82196879*	3.8118
	28	60	32	4.591034839	1.727785702	3.84137396*	3.8225
	28	61	33	4.591034839	1.737088339	3.86002767	3.8399
	28	63	35	4.591034839	1.755240247	3.895231652	3.8572
Cu	29	63	34	4.645051969	1.755914928	3.902242458	3.8823
	29	65	36	4.645051969	1.773707044	3.93690691*	3.9022
Zn	30	64	34	4.697841169	1.765415668	3.92552187*	3.9283
	30	66	36	4.697841169	1.783136284	3.960927698	3.9491
	30	67	37	4.697841169	1.791794262	3.977691046	3.953
	30	68	38	4.697841169	1.800322437	3.993867081	3.9658
Elem.	**Z**	**A**	**N**	**$r\,(n=\infty)$**	**$r\,(n=1)$**	**$r\,(n=5)$**	**R_{av}(fm)**
	30	70	40	4.697841169	1.8170037	4.024564555	3.9845
Ga	31	63	32	4.749469932	1.756551071	3.909056261	
	31	64	33	4.749469932	1.765722784	3.928826566	
	31	66	35	4.749469932	1.783642252	3.966262088	
	31	68	37	4.749469932	1.801023127	4.001106669	
	31	69	38	4.749469932	1.809520977	4.01763148*	3.9973
	31	70	39	4.749469932	1.817895135	4.033594197	
	31	71	40	4.749469932	1.82614895	4.04902010*	4.0118
	31	72	41	4.749469932	1.834285635	4.063933116	
	31	73	42	4.749469932	1.842308282	4.078355817	
	31	74	43	4.749469932	1.85021986	4.092309593	
	31	75	44	4.749469932	1.858023226	4.105814683	
	31	76	45	4.749469932	1.86572113	4.118890255	
	31	77	46	4.749469932	1.873316219	4.131554472	
	31	78	47	4.749469932	1.880811044	4.143824552	
	31	79	48	4.749469932	1.888208062	4.155716828	
	31	80	49	4.749469932	1.895509643	4.167246828	
	31	81	50	4.749469932	1.902718073	4.178429186	
	31	82	51	4.749469932	1.909835555	4.189277963	
Ge	32	70	38	4.8	1.818559886	4.04047804*	4.0414

	32	72	40	4.8	1.835131616	4.07252669	4.0576
	32	73	41	4.8	1.843243544	4.087766739	4.0632
	32	74	42	4.8	1.851243536	4.102514074	4.0742
	32	76	44	4.8	1.86691909	4.130613946	4.0811
As	33	75	42	4.849488025	1.860023582	4.125762	4.0968
Se	34	74	40	4.897986122	1.852648816	4.116955469	4.07
	34	76	42	4.897986122	1.868657889	4.148163746	4.1395
	34	77	43	4.897986122	1.876503305	4.163044572	4.1395
	34	78	44	4.897986122	1.884246127	4.17746952	4.1406
	34	80	46	4.897986122	1.899433888	4.205024904	4.14
	34	82	48	4.897986122	1.914240103	4.230967269	4.14
Br	35	79	44	4.94554236	1.89269594	4.199646091	4.1629
	35	81	46	4.94554236	1.907843274	4.227761116	4.1599
Kr	36	72	36	4.992201175	1.836528179	4.087268628	4.1635
	36	74	38	4.992201175	1.853300942	4.123921498	4.187
	36	75	39	4.992201175	1.861517658	4.141390846	4.2097
	36	76	40	4.992201175	1.869625053	4.158320098	4.202
	36	77	41	4.992201175	1.877625841	4.174731266	4.2082
	36	78	42	4.992201175	1.885522634	4.190645271	4.2038
	36	79	43	4.992201175	1.893317951	4.206082007	4.2034
Elem.	**Z**	**A**	**N**	$r\,(n=\infty)$	$r\,(n=1)$	$r\,(n=5)$	R_{av}(fm)
	36	80	44	4.992201175	1.901014223	4.221060393	4.197
	36	81	45	4.992201175	1.908613794	4.235598446	4.1952
	36	82	46	4.992201175	1.916118928	4.249713309	4.1919
	36	83	47	4.992201175	1.92353181	4.263421311	4.1871
	36	84	48	4.992201175	1.930854552	4.276738012	4.1884
	36	85	49	4.992201175	1.938089195	4.289678242	4.1846
	36	86	50	4.992201175	1.945237712	4.302256141	4.1835
	36	87	51	4.992201175	1.95230201	4.3144852	4.1984
	36	88	52	4.992201175	1.959283937	4.326378291	4.2171
	36	89	53	4.992201175	1.966185279	4.337947703	4.2286
	36	90	54	4.992201175	1.973007766	4.349205173	4.2423
	36	91	55	4.992201175	1.979753074	4.360161913	4.2543
	36	92	56	4.992201175	1.986422827	4.370828638	4.2724
	36	93	57	4.992201175	1.993018598	4.381215593	4.2794
	36	94	58	4.992201175	1.999541913	4.391332578	4.3002
	36	95	59	4.992201175	2.00599425	4.401188961	4.3067
	36	96	60	4.992201175	2.012377046	4.410793733	4.3267
Rb	37	76	39	5.038003745	1.869853233	4.160788823	4.2273
	37	77	40	5.038003745	1.87792857	4.177978562	4.2356
	37	78	41	5.038003745	1.885899253	4.194650566	4.2385

	37	79	42	5.038003745	1.893767811	4.21082539	4.2284
	37	80	43	5.038003745	1.901536685	4.22652261	4.2271
	37	81	44	5.038003745	1.90920823	4.24176085	4.2213
	37	82	45	5.038003745	1.916784717	4.25655786	4.216
	37	83	46	5.038003745	1.924268343	4.27093054	4.2058
	37	84	47	5.038003745	1.931661229	4.28489501	4.1999
	37	85	48	5.038003745	1.938965424	4.29846665	4.2036
	37	86	49	5.038003745	1.946182911	4.31166011	4.2025
	37	87	50	5.038003745	1.953315605	4.32448939	4.1989
	37	88	51	5.038003745	1.960365364	4.33696783	4.217
	37	89	52	5.038003745	1.967333981	4.34910821	4.2391
	37	90	53	5.038003745	1.974223195	4.36092270	4.2554
	37	91	54	5.038003745	1.98103469	4.37242296	4.2723
	37	92	55	5.038003745	1.987770098	4.38362011	4.2903
	37	93	56	5.038003745	1.994431	4.39452480	4.3048
	37	94	57	5.038003745	2.001018929	4.40514723	4.3184
	37	95	58	5.038003745	2.007535372	4.41549714	4.3391
	37	96	59	5.038003745	2.013981772	4.42558388	4.3501
	37	97	60	5.038003745	2.020359528	4.43541637	4.4231
	37	98	61	5.038003745	2.026669999	4.44500319	4.4336
Elem.	**Z**	**A**	**N**	**r** $(n=\infty)$	**r** $(n=1)$	**r** $(n=5)$	**R_{av}(fm)**
Sr	38	77	39	5.082988301	1.878074816	4.17957502	4.2569
	38	78	40	5.082988301	1.886117447	4.19701301	4.2561
	38	79	41	5.082988301	1.894057331	4.21393983	4.2586
	38	80	42	5.082988301	1.901896915	4.2303581	4.2562
	38	81	43	5.082988301	1.909638564	4.24630471	4.2547
	38	82	44	5.082988301	1.917284561	4.26179203	4.2478
	38	83	45	5.082988301	1.924837109	4.27683758	4.2455
	38	84	46	5.082988301	1.932298339	4.29145801	4.2394
	38	85	47	5.082988301	1.939670308	4.30566923	4.2304
	38	86	48	5.082988301	1.946955008	4.31948640	4.2307
	38	87	49	5.082988301	1.954154364	4.3329240	4.2249
	38	88	50	5.082988301	1.961270238	4.34599591	4.224
	38	89	51	5.082988301	1.968304435	4.35871529	4.2407
	38	90	52	5.082988301	1.975258701	4.37109479	4.2611
	38	91	53	5.082988301	1.982134727	4.38314649	4.274
	38	92	54	5.082988301	1.988934152	4.39488194	4.2924
	38	93	55	5.082988301	1.995658566	4.40631218	4.3026
	38	94	56	5.082988301	2.002309508	4.41744780	4.3191
	38	95	57	5.082988301	2.008888472	4.42829890	4.3305
	38	96	58	5.082988301	2.015396909	4.43887520	4.3522

	38	97	59	5.082988301	2.021836224	4.449185972	4.3625
	38	98	60	5.082988301	2.028207784	4.459240117	4.4377
	38	99	61	5.082988301	2.034512914	4.469046172	4.4495
	38	100	62	5.082988301	2.040752903	4.478612317	4.464
Y	39	86	47	5.127190418	1.947565366	4.325785938	4.2513
	39	87	48	5.127190418	1.954829721	4.339839507	4.2498
	39	88	49	5.127190418	1.96201007	4.353512438	4.2441
	39	89	50	5.127190418	1.969108224	4.366818395	4.243
	39	90	51	5.127190418	1.976125937	4.379770458	4.2573
	39	92	53	5.127190418	1.989926782	4.404662321	4.2887
	39	93	54	5.127190418	1.996713156	4.416625526	4.3052
	39	94	55	5.127190418	2.003425578	4.428281683	4.3142
	39	95	56	5.127190418	2.010065547	4.439641285	4.3284
	39	96	57	5.127190418	2.016634523	4.450714381	4.3402
	39	97	58	5.127190418	2.023133912	4.461510604	4.358
	39	98	59	5.127190418	2.029565093	4.472039187	4.3711
	39	99	60	5.127190418	2.035929395	4.482308987	4.4658
	39	100	61	5.127190418	2.042228113	4.492328487	4.4705
	39	101	62	5.127190418	2.048462505	4.502105847	4.4863
	39	102	63	5.127190418	2.054633792	4.511648877	4.4911
Elem.	**Z**	**A**	**N**	$r\,(n=\infty)$	$r\,(n=1)$	$r\,(n=5)$	R_{av}(fm)
Zr	40	87	47	5.170643256	1.955352178	4.345283947	4.2789
	40	88	48	5.170643256	1.962595429	4.359565033	4.2787
	40	89	49	5.170643256	1.969755985	4.373464682	4.2706
	40	90	50	5.170643256	1.976835607	4.386996391	4.2694
	40	91	51	5.170643256	1.983836003	4.400173075	4.2845
	40	92	52	5.170643256	1.990758824	4.413007093	4.3057
	40	94	54	5.170643256	2.004378104	4.437693956	4.332
	40	96	56	5.170643256	2.017705698	4.461145777	4.3512
	40	97	57	5.170643256	2.024263742	4.472434293	4.3792
	40	98	58	5.170643256	2.030753136	4.483444095	4.4012
	40	99	59	5.170643256	2.037175218	4.494184367	4.4156
	40	100	60	5.170643256	2.043531288	4.504663897	4.4891
	40	101	61	5.170643256	2.049822609	4.514891134	4.5119
	40	102	62	5.170643256	2.056050409	4.524874188	4.5292
Nb	41	90	49	5.213377783	1.977397567	4.392817182	4.2891
	41	91	50	5.213377783	1.984457929	4.406566541	4.2878
	41	92	51	5.213377783	1.991440255	4.419960004	4.3026
	41	93	52	5.213377783	1.998346153	4.433009786	4.324
	41	99	58	5.213377783	2.038260769	4.504713593	4.4062
	41	101	60	5.213377783	2.051019811	4.526342953	4.4861

	41	103	62	5.213377783	2.063523122	4.546955605	4.5097
Mo	42	90	48	5.255422968	1.977820901	4.397275493	4.3265
	42	91	49	5.255422968	1.98493983	4.411603745	4.3182
	42	92	50	5.255422968	1.991980277	4.425562878	4.3151
	42	94	52	5.255422968	2.005832132	4.452423621	4.3529
	42	95	53	5.255422968	2.012646627	4.465348862	4.3628
	42	96	54	5.255422968	2.019388814	4.477952295	4.3847
	42	97	55	5.255422968	2.026060124	4.49024456	4.388
	42	98	56	5.255422968	2.032661947	4.502235865	4.4091
	42	100	58	5.255422968	2.045662491	4.525354391	4.4468
	42	102	60	5.255422968	2.058400789	4.547381662	4.4914
	42	103	61	5.255422968	2.064674671	4.558007563	4.5145
	42	104	62	5.255422968	2.070886614	4.568385765	4.5249
	42	105	63	5.255422968	2.077037756	4.578523973	4.5389
	42	106	64	5.255422968	2.083129207	4.588429595	4.549
	42	108	66	5.255422968	2.09513732	4.607571318	4.5602
Ru	44	96	52	5.337552217	2.020518943	4.489610652	4.3908
	44	98	54	5.337552217	2.034007738	4.515925982	4.4229
	44	99	55	5.337552217	2.040648089	4.528609141	4.4338
	44	100	56	5.337552217	2.047220849	4.540989427	4.4531
Elem.	**Z**	**A**	**N**	$r\,(n=\infty)$	$r\,(n=1)$	$r\,(n=5)$	R_{av}(fm)
	44	101	57	5.337552217	2.053727304	4.553076442	4.4606
	44	102	58	5.337552217	2.0601687	4.564879417	4.4809
	44	104	60	5.337552217	2.072861138	4.587668408	4.5098
Rh	45	103	58	5.377685696	2.067282454	4.583823124	4.4945
Pd	46	102	56	5.417228923	2.061418598	4.577642634	4.4827
	46	104	58	5.417228923	2.074308911	4.602257425	4.5078
	46	105	59	5.417228923	2.080660205	4.614145068	4.515
	46	106	60	5.417228923	2.086950437	4.625764153	4.5318
	46	108	62	5.417228923	2.099352063	4.648228619	4.5563
	46	110	64	5.417228923	2.111522217	4.669711864	4.5782
Ag	47	97	50	5.456203133	2.028244367	4.512971379	
	47	98	51	5.456203133	2.035106225	4.527512329	
	47	99	52	5.456203133	2.041898099	4.541707906	
	47	100	53	5.456203133	2.048621324	4.555568949	
	47	101	54	5.456203133	2.055277198	4.569105881	4.4799
	47	103	56	5.456203133	2.068391901	4.595247153	4.5036
	47	104	57	5.456203133	2.074853149	4.60787043	4.5119
	47	105	58	5.456203133	2.081251887	4.620207507	4.5269
	47	107	60	5.456203133	2.093866319	4.644057184	4.5454
	47	109	62	5.456203133	2.106243881	4.666861349	4.5638

Cd	48	102	54	5.494628364	2.062206124	4.585924706	4.481
	48	103	55	5.494628364	2.068778149	4.599315641	4.4951
	48	104	56	5.494628364	2.075286187	4.612401936	4.5122
	48	105	57	5.494628364	2.081731403	4.625192771	4.5216
	48	106	58	5.494628364	2.088114929	4.637696983	4.5383
	48	107	59	5.494628364	2.094437869	4.649923093	4.5466
	48	108	60	5.494628364	2.100701298	4.661879308	4.5577
	48	109	61	5.494628364	2.106906261	4.673573541	4.5601
	48	110	62	5.494628364	2.113053778	4.685013416	4.5765
	48	111	63	5.494628364	2.119144842	4.696206291	4.5845
	48	112	64	5.494628364	2.12518042	4.707159261	4.5944
	48	113	65	5.494628364	2.131161457	4.717879166	4.6012
	48	114	66	5.494628364	2.137088872	4.728372615	4.6087
	48	115	67	5.494628364	2.142963562	4.73864598	4.6114
	48	116	68	5.494628364	2.148786402	4.748705415	4.6203
	48	117	69	5.494628364	2.154558246	4.758556862	4.6136
	48	118	70	5.494628364	2.160279928	4.76820606	4.6246
	48	120	72	5.494628364	2.171576035	4.786919691	4.63
In	49	104	55	5.532523555	2.075613911	4.615880215	4.5184
	49	105	56	5.532523555	2.082104672	4.629128871	4.5311
Elem.	**Z**	**A**	**N**	$r\,(n=\infty)$	$r\,(n=1)$	$r\,(n=5)$	**R_{av}(fm)**
	49	106	57	5.532523555	2.088533445	4.642081897	4.5375
	49	107	58	5.532523555	2.094901335	4.654748014	4.5494
	49	108	59	5.532523555	2.101209422	4.667135648	4.5571
	49	109	60	5.532523555	2.107458754	4.679252921	4.5685
	49	110	61	5.532523555	2.113650354	4.691107666	4.5742
	49	111	62	5.532523555	2.119785219	4.702707422	4.5856
	49	112	63	5.532523555	2.12586432	4.714059493	4.5907
	49	113	64	5.532523555	2.131888602	4.725170903	4.601
	49	114	65	5.532523555	2.137858991	4.73604844	4.6056
	49	115	66	5.532523555	2.143776385	4.746698655	4.6156
	49	116	67	5.532523555	2.149641663	4.757127876	4.6211
	49	117	68	5.532523555	2.155455681	4.767342211	4.6292
	49	118	69	5.532523555	2.161219276	4.777347563	4.6335
	49	119	70	5.532523555	2.166933264	4.787149634	4.6407
	49	120	71	5.532523555	2.17259844	4.796753936	4.6443
	49	121	72	5.532523555	2.178215584	4.806165796	4.6505
	49	122	73	5.532523555	2.183785454	4.815390362	4.6534
	49	123	74	5.532523555	2.189308793	4.824432616	4.6594
	49	124	75	5.532523555	2.194786325	4.833297374	4.6625
	49	125	76	5.532523555	2.200218759	4.841989294	4.667

	49	126	77	5.53252355	2.205606786	4.850512886	4.6702
	49	127	78	5.53252355	2.210951084	4.858872511	4.6733
Sn	50	108	58	5.5699066	2.101614179	4.671381415	4.5605
	50	109	59	5.5699066	2.107907013	4.683925595	4.5679
	50	110	60	5.5699066	2.114141837	4.6961990	4.5785
	50	111	61	5.5699066	2.120319652	4.708209588	4.5836
	50	112	62	5.5699066	2.126441431	4.719964626	4.5948
	50	113	63	5.5699066	2.132508124	4.731471401	4.6015
	50	114	64	5.5699066	2.138520657	4.742736871	4.6095
	50	115	65	5.5699066	2.144479935	4.753767784	4.6148
	50	116	66	5.5699066	2.150386836	4.764570617	4.625
	50	117	67	5.5699066	2.156242222	4.775151654	4.6302
	50	118	68	5.5699066	2.162046931	4.785516957	4.6393
	50	119	69	5.5699066	2.167801783	4.795672387	4.6438
	50	120	70	5.5699066	2.173507575	4.8056236	4.6519
	50	121	71	5.5699066	2.179165089	4.815376	4.6566
	50	122	72	5.5699066	2.184775088	4.824935154	4.6634
	50	123	73	5.5699066	2.190338315	4.834305893	4.6665
	50	124	74	5.5699066	2.195855498	4.843493271	4.6735
	50	125	75	5.5699066	2.201327349	4.852502083	4.6765
Elem.	**Z**	**A**	**N**	**$r\,(n=\infty)$**	**$r\,(n=1)$**	**$r\,(n=5)$**	**R_{av}(fm)**
	50	126	76	5.5699066	2.206754562	4.861336966	4.6833
	50	127	77	5.5699066	2.212137814	4.870002412	4.6867
	50	128	78	5.5699066	2.217477771	4.878502767	4.6921
	50	129	79	5.5699066	2.222775082	4.8868422	4.6934
	50	130	80	5.5699066	2.228030382	4.895024908	4.7019
	50	131	81	5.5699066	2.233244291	4.903054719	4.7078
	50	132	82	5.5699066	2.238417418	4.910935498	4.7093
Sb	51	121	70	5.606794474	2.180006156	4.823648607	4.6802
	51	123	72	5.606794474	2.19125791	4.843248493	4.6879
Te	52	116	64	5.643203251	2.151568507	4.776611442	4.6847
	52	118	66	5.643203251	2.163388955	4.799032576	4.6956
	52	120	68	5.643203251	2.175008026	4.8205611	4.7038
	52	122	70	5.643203251	2.186432082	4.841244096	4.7095
	52	123	71	5.643203251	2.192072887	4.851282316	4.7117
	52	124	72	5.643203251	2.197667193	4.861125391	4.7183
	52	125	73	5.643203251	2.203215714	4.87077838	4.7204
	52	126	74	5.643203251	2.208719151	4.880246179	4.7266
	52	128	76	5.643203251	2.219593492	4.8986450	4.7346
	52	130	78	5.643203251	2.230295504	4.916358117	4.7423
	52	132	80	5.643203251	2.240830249	4.9334193	4.75

	52	134	82	5.643203251	2.251202568	4.949860734	4.7569
	52	136	84	5.643203251	2.261417101	4.965712118	4.7815
I	53	127	74	5.679148189	2.215042306	4.897976714	4.75
Xe	54	116	62	5.714643787	2.152371315	4.785008754	4.7211
	54	118	64	5.714643787	2.164346287	4.808931104	4.7387
	54	120	66	5.714643787	2.176118056	4.831907951	4.7509
	54	122	68	5.714643787	2.187693024	4.853988579	4.759
	54	124	70	5.714643787	2.199077298	4.875219147	4.7661
	54	126	72	5.714643787	2.210276706	4.895642914	4.7722
	54	127	73	5.714643787	2.215808837	4.905565026	4.7747
	54	128	74	5.714643787	2.22129682	4.915300453	4.7774
	54	129	75	5.714643787	2.226741314	4.92485388	4.7775
	54	130	76	5.714643787	2.232142962	4.934229844	4.7818
	54	131	77	5.714643787	2.237502395	4.943432745	4.7808
	54	132	78	5.714643787	2.242820228	4.952466848	4.7859
	54	133	79	5.714643787	2.248097063	4.961336289	4.7831
	54	134	80	5.714643787	2.253333492	4.970045079	4.7899
	54	136	82	5.714643787	2.263687424	4.986996144	4.7964
	54	137	83	5.714643787	2.268806047	4.995245856	4.8094
	54	138	84	5.714643787	2.273886502	5.003349793	4.8279
Elem.	**Z**	**A**	**N**	$r\,(n=\infty)$	$r\,(n=1)$	$r\,(n=5)$	R_{av}(fm)
	54	139	85	5.714643787	2.278929318	5.011311405	4.8409
	54	140	86	5.714643787	2.283935016	5.019134039	4.8566
	54	141	87	5.714643787	2.288904106	5.026820946	4.8694
	54	142	88	5.714643787	2.293837086	5.03437528	4.8841
	54	143	89	5.714643787	2.298734447	5.041800108	4.8942
	54	144	90	5.714643787	2.303596666	5.049098407	4.9082
	54	146	92	5.714643787	2.313217554	5.063326904	4.9315
Cs	55	118	63	5.749703828	2.164691972	4.812576375	4.7832
	55	119	64	5.749703828	2.170640114	4.824549684	4.7896
	55	120	65	5.749703828	2.176538052	4.836286466	4.7915
	55	121	66	5.749703828	2.18238658	4.847792918	4.7769
	55	122	67	5.749703828	2.188186471	4.859075038	4.7773
	55	123	68	5.749703828	2.193938483	4.870138635	4.782
	55	124	69	5.749703828	2.199643355	4.880989331	4.7828
	55	125	70	5.749703828	2.205301808	4.891632574	4.788
	55	126	71	5.749703828	2.210914549	4.902073638	4.7872
	55	127	72	5.749703828	2.216482269	4.912317635	4.7936
	55	128	73	5.749703828	2.222005642	4.922369516	4.7921
	55	129	74	5.749703828	2.227485327	4.932234081	4.7981
	55	130	75	5.749703828	2.232921972	4.941915982	4.7992

	55	131	76	5.749703828	2.238316207	4.951419729	4.8026
	55	132	77	5.749703828	2.24366865	4.960749695	4.8002
	55	133	78	5.749703828	2.248979907	4.969910119	4.8041
	55	134	79	5.749703828	2.254250568	4.978905116	4.8031
	55	135	80	5.749703828	2.259481213	4.987738676	4.8067
	55	136	81	5.749703828	2.26467241	4.996414669	4.8059
	55	137	82	5.749703828	2.269824713	5.004936853	4.8128
	55	138	83	5.749703828	2.274938666	5.013308874	4.8255
	55	139	84	5.749703828	2.280014803	5.021534271	4.8422
	55	140	85	5.749703828	2.285053645	5.029616481	4.8554
	55	141	86	5.749703828	2.290055702	5.037558844	4.8689
	55	142	87	5.749703828	2.295021477	5.045364595	4.8825
	55	143	88	5.749703828	2.29995146	5.053036877	4.8965
	55	144	89	5.749703828	2.304846131	5.060578766	4.9055
	55	145	90	5.749703828	2.309705964	5.067993209	4.9188
	55	146	91	5.749703828	2.314531419	5.075283113	4.9281
Ba	56	120	64	5.784341434	2.176873576	4.839827923	4.8092
	56	121	65	5.784341434	2.182758291	4.851694277	4.8176
	56	122	66	5.784341434	2.188594163	4.863330117	4.8153
	56	123	67	5.784341434	2.194381951	4.874741381	4.8135
Elem.	**Z**	**A**	**N**	$r\,(n=\infty)$	$r\,(n=1)$	$r\,(n=5)$	**R_{av}(fm)**
	56	124	68	5.784341434	2.200122395	4.885933823	4.8185
	56	125	69	5.784341434	2.20581622	4.896913013	4.8177
	56	126	70	5.784341434	2.211464134	4.907684352	4.8221
	56	127	71	5.784341434	2.21706683	4.918253069	4.8204
	56	128	72	5.784341434	2.222624984	4.928624234	4.8255
	56	129	73	5.784341434	2.228139258	4.938802761	4.8248
	56	130	74	5.784341434	2.2336103	4.948793414	4.8283
	56	131	75	5.784341434	2.239038744	4.958600811	4.8276
	56	132	76	5.784341434	2.244425208	4.968229433	4.8303
	56	133	77	5.784341434	2.249770301	4.977683625	4.8286
	56	134	78	5.784341434	2.255074615	4.986967676	4.8322
	56	135	79	5.784341434	2.260338731	4.996085449	4.8294
	56	136	80	5.784341434	2.265563219	5.00504114	4.8334
	56	137	81	5.784341434	2.270748635	5.013838525	4.8314
	56	138	82	5.784341434	2.275895525	5.022481343	4.8378
	56	139	83	5.784341434	2.281004424	5.030973222	4.8513
	56	140	84	5.784341434	2.286075855	5.039317689	4.8684
	56	141	85	5.784341434	2.291110331	5.047518165	4.8807
	56	142	86	5.784341434	2.296108354	5.055577976	4.8953
	56	143	87	5.784341434	2.301070417	5.063500351	4.9087

	56	144	88	5.784341434	2.305997002	5.071288428	4.9236
	56	145	89	5.784341434	2.310888583	5.078945258	4.9345
	56	146	90	5.784341434	2.315745624	5.086473802	4.9479
	56	148	92	5.784341434	2.325357896	5.101157482	4.9731
La	57	135	78	5.818569103	2.261106768	5.003654468	4.8488
	57	137	80	5.818569103	2.271581971	5.021967723	4.8496
	57	138	81	5.818569103	2.276761251	5.030883957	4.8473
	57	139	82	5.818569103	2.28190237	5.039644927	4.855
Ce	58	136	78	5.852398753	2.267078639	5.019985144	4.8739
	58	138	80	5.852398753	2.277539786	5.038532917	4.8737
	58	140	82	5.852398753	2.287847608	5.056442165	4.8771
	58	142	84	5.852398753	2.298006275	5.073742066	4.9063
	58	144	86	5.852398753	2.308019795	5.090460161	4.9303
	58	146	88	5.852398753	2.317892014	5.106622466	4.959
	58	148	90	5.852398753	2.327626633	5.122253565	4.9893
Pr	59	141	82	5.885841758	2.29373346	5.072886906	4.8919
Nd	60	132	72	5.918908978	2.246610939	4.990456184	4.9174
	60	134	74	5.918908978	2.257519308	5.011576679	4.9128
	60	135	75	5.918908978	2.262911875	5.021857251	4.9086
	60	136	76	5.918908978	2.268264135	5.031957213	4.9111
Elem.	**Z**	**A**	**N**	$r\,(n=\infty)$	$r\,(n=1)$	$r\,(n=5)$	R_{av}(fm)
	60	137	77	5.918908978	2.273576653	5.041880786	4.908
	60	138	78	5.918908978	2.278849979	5.051632071	4.9123
	60	139	79	5.918908978	2.284084655	5.061215053	4.9076
	60	140	80	5.918908978	2.28928121	5.0706336	4.9101
	60	141	81	5.918908978	2.294440163	5.079891475	4.9057
	60	142	82	5.918908978	2.299562024	5.088992333	4.9123
	60	143	83	5.918908978	2.30464729	5.097939726	4.9254
	60	144	84	5.918908978	2.30969645	5.106737109	4.9421
	60	145	85	5.918908978	2.314709983	5.11538784	4.9535
	60	146	86	5.918908978	2.319688359	5.123895184	4.9696
	60	148	88	5.918908978	2.329541473	5.140492327	4.9999
	60	150	90	5.918908978	2.339259371	5.15655292	5.04
Sm	62	138	76	5.983957143	2.279853569	5.061898473	4.9599
	62	139	77	5.983957143	2.285148171	5.072040845	4.9556
	62	140	78	5.983957143	2.290404348	5.082010236	4.9565
	62	141	79	5.983957143	2.295622621	5.091810571	4.9517
	62	142	80	5.983957143	2.300803502	5.101445667	4.9518
	62	143	81	5.983957143	2.305947493	5.110919233	4.9479
	62	144	82	5.983957143	2.311055084	5.120234878	4.9524
	62	145	83	5.983957143	2.316126757	5.129396111	4.9651

	62	146	84	5.98395714	2.321162985	5.13840634	4.9808
	62	147	85	5.98395714	2.326164231	5.14726889	4.9892
	62	148	86	5.98395714	2.331130948	5.15598699	5.0042
	62	149	87	5.98395714	2.336063583	5.16456379	5.0134
	62	150	88	5.98395714	2.340962573	5.17300234	5.0387
	62	151	89	5.98395714	2.345828347	5.18130562	5.055
	62	152	90	5.98395714	2.350661325	5.18947653	5.0819
	62	153	91	5.98395714	2.35546192	5.19751789	5.0925
	62	154	92	5.98395714	2.360230538	5.20543244	5.1053
Eu	63	137	74	6.01595752	2.274885217	5.0553982	4.9762
	63	138	75	6.01595752	2.280248194	5.06600485	4.9779
	63	139	76	6.01595752	2.285572064	5.0764300	4.976
	63	140	77	6.01595752	2.290857362	5.08667802	4.9695
	63	141	78	6.01595752	2.29610461	5.09675273	4.9697
	63	142	79	6.01595752	2.301314322	5.10665808	4.9607
	63	143	80	6.01595752	2.306487	5.11639786	4.9636
	63	144	81	6.01595752	2.311623137	5.1259757	4.9612
	63	145	82	6.01595752	2.316723215	5.1353953	4.9663
	63	146	83	6.01595752	2.321787708	5.14466015	4.9789
	63	147	84	6.01595752	2.326817081	5.15377351	4.9938
Elem.	**Z**	**A**	**N**	$r\,(n=\infty)$	$r\,(n=1)$	$r\,(n=5)$	**R_{av}(fm)**
	63	148	85	6.01595752	2.331811789	5.16273875	5.0045
	63	149	86	6.01595752	2.336772279	5.17155908	5.0202
	63	150	87	6.01595752	2.341698989	5.18023762	5.0296
	63	151	88	6.01595752	2.346592349	5.18877742	5.0522
	63	152	89	6.01595752	2.351452782	5.19718143	5.1064
	63	153	90	6.01595752	2.3562807	5.20545255	5.1115
	63	154	91	6.01595752	2.361076512	5.21359358	5.1239
	63	155	92	6.01595752	2.365840615	5.22160726	5.1221
	63	156	93	6.01595752	2.370573402	5.22949625	5.1264
	63	157	94	6.01595752	2.375275256	5.23726314	5.1351
	63	158	95	6.01595752	2.379946556	5.24491047	5.1413
	63	159	96	6.01595752	2.384587672	5.25244070	5.1498
Gd	64	145	81	6.04762103	2.317249008	5.1407420	4.9786
	64	146	82	6.04762103	2.322341342	5.15026336	4.9801
	64	148	84	6.04762103	2.332420699	5.16884383	5.008
	64	150	86	6.04762103	2.342362644	5.18683013	5.0342
	64	152	88	6.04762103	2.352170659	5.2042474	5.0774
	64	154	90	6.04762103	2.361848099	5.22111970	5.1223
	64	155	91	6.04762103	2.366638867	5.22935854	5.1319
	64	156	92	6.04762103	2.371398194	5.23746952	5.142

	64	157	93	6.047621039	2.376126465	5.245455292	5.1449
	64	158	94	6.047621039	2.380824058	5.253318435	5.1569
	64	160	96	6.047621039	2.390128694	5.268686855	5.1734
Tb	65	147	82	6.078956423	2.327911047	5.164849241	4.9201
	65	148	83	6.078956423	2.332960489	5.17431457	4.9291
	65	149	84	6.078956423	2.33797545	5.183627762	4.9427
	65	150	85	6.078956423	2.342956371	5.192792073	4.9499
	65	151	86	6.078956423	2.347903683	5.201810676	4.963
	65	152	87	6.078956423	2.352817812	5.210686659	4.9689
	65	153	88	6.078956423	2.357699173	5.219423032	4.995
	65	154	89	6.078956423	2.362548174	5.228022723	5.0333
	65	155	90	6.078956423	2.367365219	5.236488588	5.0391
	65	157	92	6.078956423	2.376905001	5.253029889	5.0489
	65	159	94	6.078956423	2.386321587	5.269068342	5.06
Dy	66	146	80	6.109972044	2.323246362	5.159567483	5.0438
	66	148	82	6.109972044	2.333433834	5.17916293	5.0455
	66	149	83	6.109972044	2.338475432	5.188725317	5.0567
	66	150	84	6.109972044	2.343482864	5.198135272	5.0706
	66	151	85	6.109972044	2.348456562	5.207396031	5.0801
	66	152	86	6.109972044	2.353396953	5.216510746	5.095
Elem.	**Z**	**A**	**N**	$r\,(n=\infty)$	$r\,(n=1)$	$r\,(n=5)$	R_{av}(fm)
	66	153	87	6.109972044	2.358304453	5.225482485	5.1035
	66	154	88	6.109972044	2.363179472	5.234314238	5.1241
	66	155	89	6.109972044	2.368022412	5.243008919	5.1457
	66	156	90	6.109972044	2.372833668	5.251569361	5.1622
	66	157	91	6.109972044	2.377613628	5.259998347	5.1709
	66	158	92	6.109972044	2.382362672	5.268298555	5.1815
	66	159	93	6.109972044	2.387081175	5.276472619	5.1825
	66	160	94	6.109972044	2.391769503	5.284523101	5.1951
	66	161	95	6.109972044	2.396428018	5.292452498	5.1962
	66	162	96	6.109972044	2.401057073	5.300263245	5.2074
	66	163	97	6.109972044	2.405657017	5.307957717	5.2099
	66	164	98	6.109972044	2.410228191	5.315538231	5.2218
Ho	67	151	84	6.140675936	2.348944391	5.212375916	5.0398
	67	152	85	6.140675936	2.353910666	5.221731106	5.0614
	67	153	86	6.140675936	2.358843929	5.230939954	5.076
	67	154	87	6.140675936	2.363744592	5.240005508	5.0856
	67	155	88	6.140675936	2.368613058	5.248930741	5.1076
	67	156	89	6.140675936	2.373449723	5.257718547	5.1156
	67	157	90	6.140675936	2.378254975	5.266371749	5.1535
	67	158	91	6.140675936	2.383029195	5.274893098	5.1571

	67	159	92	6.140675936	2.38777276	5.283285276	5.1675
	67	160	93	6.140675936	2.392486036	5.291550896	5.1662
	67	161	94	6.140675936	2.397169386	5.299692507	5.1785
	67	162	95	6.140675936	2.401823165	5.307712596	5.1817
	67	163	96	6.140675936	2.406447722	5.315613587	5.1907
	67	165	98	6.140675936	2.415610536	5.331067677	5.2022
Er	68	150	82	6.171075818	2.344344281	5.207011231	5.0548
	68	152	84	6.171075818	2.35436141	5.226358822	5.0843
	68	154	86	6.171075818	2.364246014	5.245107488	5.1129
	68	156	88	6.171075818	2.374001359	5.263281783	5.1429
	68	158	90	6.171075818	2.383630589	5.28090503	5.1761
	68	160	92	6.171075818	2.393136738	5.297999392	5.2045
	68	162	94	6.171075818	2.402522734	5.314585942	5.2246
	68	164	96	6.171075818	2.411791401	5.330684724	5.2389
	68	166	98	6.171075818	2.420945466	5.346314808	5.2516
	68	167	99	6.171075818	2.425480351	5.353959797	5.256
	68	168	100	6.171075818	2.429987566	5.361494351	5.2644
	68	170	102	6.171075818	2.438920245	5.376240646	5.2789
Tm	69	153	84	6.201179103	2.359735229	5.24009272	5.0643
	69	154	85	6.201179103	2.364686098	5.249630845	5.0755
Elem.	**Z**	**A**	**N**	$r\,(n=\infty)$	$r\,(n=1)$	$r\,(n=5)$	R_{av}(fm)
	69	156	87	6.201179103	2.374490954	5.268269622	5.0976
	69	157	88	6.201179103	2.379345728	5.277376216	5.114
	69	158	89	6.201179103	2.384169247	5.286344782	5.1235
	69	159	90	6.201179103	2.388961888	5.295178109	5.1392
	69	160	91	6.201179103	2.39372402	5.303878915	5.1504
	69	161	92	6.201179103	2.398456008	5.312449851	5.1616
	69	162	93	6.201179103	2.403158207	5.320893503	5.1713
	69	163	94	6.201179103	2.407830969	5.329212395	5.1849
	69	164	95	6.201179103	2.412474639	5.337408986	5.1906
	69	165	96	6.201179103	2.417089555	5.345485679	5.2004
	69	166	97	6.201179103	2.42167605	5.353444816	5.2046
	69	167	98	6.201179103	2.426234452	5.361288684	5.2129
	69	168	99	6.201179103	2.430765083	5.369019514	5.217
	69	169	100	6.201179103	2.435268258	5.376639486	5.2256
	69	170	101	6.201179103	2.439744289	5.384150725	5.2303
	69	171	102	6.201179103	2.444193481	5.391555309	5.2388
	69	172	103	6.201179103	2.448616136	5.398855263	5.2411
Yb	70	152	82	6.230992922	2.355083254	5.233879208	5.0423
	70	154	84	6.230992922	2.365067095	5.253585969	5.0875
	70	155	85	6.230992922	2.370010005	5.26321266	5.104

	70	156	86	6.230992922	2.374920775	5.272692336	5.1219
	70	157	87	6.230992922	2.379799797	5.282027982	5.1324
	70	158	88	6.230992922	2.384647456	5.291222512	5.1498
	70	159	89	6.230992922	2.389464128	5.300278766	5.1629
	70	160	90	6.230992922	2.394250184	5.309199512	5.1781
	70	161	91	6.230992922	2.399005989	5.317987453	5.1889
	70	162	92	6.230992922	2.403731901	5.326645224	5.2054
	70	163	93	6.230992922	2.408428272	5.335175397	5.2157
	70	164	94	6.230992922	2.413095446	5.343580479	5.2307
	70	165	95	6.230992922	2.417733764	5.351862922	5.2399
	70	166	96	6.230992922	2.42234356	5.360025107	5.2525
	70	167	97	6.230992922	2.426925161	5.368069372	5.2621
	70	168	98	6.230992922	2.43147889	5.375997992	5.2702
	70	169	99	6.230992922	2.436005064	5.383813188	5.2771
	70	170	100	6.230992922	2.440503995	5.391517129	5.2853
	70	171	101	6.230992922	2.44497599	5.399111933	5.2906
	70	172	102	6.230992922	2.44942135	5.406599668	5.2995
	70	173	103	6.230992922	2.453840372	5.413982353	5.3046
	70	174	104	6.230992922	2.458233347	5.421261962	5.3108
	70	175	105	6.230992922	2.462600563	5.428440422	5.3135
Elem.	**Z**	**A**	**N**	$r\,(n=\infty)$	$r\,(n=1)$	$r\,(n=5)$	**R_{av}(fm)**
	70	176	106	6.230992922	2.466942301	5.435519613	5.3215
	70	177	107	6.230992922	2.47125884	5.442501376	
Lu	71	161	90	6.260524136	2.399496724	5.322977411	5.2293
	71	162	91	6.260524136	2.404246027	5.331850791	5.2398
	71	163	92	6.260524136	2.408965687	5.340593731	5.2567
	71	164	93	6.260524136	2.413656048	5.349208789	5.2677
	71	165	94	6.260524136	2.418317453	5.357698457	5.283
	71	166	95	6.260524136	2.422950235	5.366065172	5.2972
	71	167	96	6.260524136	2.427554724	5.374311307	5.3108
	71	168	97	6.260524136	2.432131242	5.382439185	5.3227
	71	169	98	6.260524136	2.436680108	5.390451069	5.329
	71	170	99	6.260524136	2.441201634	5.39834917	5.3364
	71	171	100	6.260524136	2.445696128	5.406135647	5.3436
	71	172	101	6.260524136	2.450163891	5.41381261	5.3486
	71	173	102	6.260524136	2.454605221	5.421382118	5.3577
	71	174	103	6.260524136	2.459020411	5.428846183	5.3634
	71	175	104	6.260524136	2.463409748	5.43620671	5.37
	71	176	105	6.260524136	2.467773515	5.443465798	5.3739
	71	177	106	6.260524136	2.472111991	5.450625145	5.3815
	71	178	107	6.260524136	2.476425449	5.457686642	5.3857

	71	179	108	6.260524136	2.480714159	5.464652082	5.3917
Hf	72	170	98	6.289779346	2.441839374	5.404655914	5.2898
	72	171	99	6.289779346	2.446356069	5.412635476	5.3041
	72	172	100	6.289779346	2.45084594	5.420503074	5.3065
	72	173	101	6.289779346	2.455309286	5.428260806	5.314
	72	174	102	6.289779346	2.459746398	5.435910723	5.3201
	72	175	103	6.289779346	2.464157567	5.443454828	5.3191
	72	176	104	6.289779346	2.468543075	5.450895079	5.3286
	72	177	105	6.289779346	2.472903201	5.458233388	5.3309
	72	178	106	6.289779346	2.477238221	5.465471625	5.3371
	72	179	107	6.289779346	2.481548403	5.472611617	5.3408
	72	180	108	6.289779346	2.485834016	5.479655148	5.347
	72	182	110	6.289779346	2.494332572	5.493459775	5.3516
Ta	73	181	108	6.318764914	2.490911319	5.494404524	5.3507
W	74	180	106	6.347486967	2.48736536	5.494418316	5.3491
	74	182	108	6.347486967	2.495947307	5.508907727	5.3559
	74	183	109	6.347486967	2.500202205	5.516008372	5.3611
	74	184	110	6.347486967	2.504433389	5.523015251	5.3658
	74	186	112	6.347486967	2.5128256	5.536754306	5.3743
Re	75	185	110	6.375951415	2.50942248	5.537427496	5.3596
Elem.	**Z**	**A**	**N**	$r\,(n=\infty)$	$r\,(n=1)$	$r\,(n=5)$	**R_{av}(fm)**
	75	187	112	6.375951415	2.517808583	5.551313122	5.3698
Os	76	184	108	6.404163957	2.505900005	5.537204275	5.3823
	76	186	110	6.404163957	2.514372235	5.55160548	5.3909
	76	187	111	6.404163957	2.518573518	5.558666061	5.3933
	76	188	112	6.404163957	2.522751897	5.565635473	5.3993
	76	189	113	6.404163957	2.526907605	5.572515273	5.4016
	76	190	114	6.404163957	2.531040873	5.57930701	5.4062
	76	192	116	6.404163957	2.539240989	5.592632305	5.4126
Ir	77	182	105	6.432130093	2.497945119	5.528466762	5.3705
	77	183	106	6.432130093	2.502260256	5.536080908	5.378
	77	184	107	6.432130093	2.50655144	5.543595165	5.3805
	77	185	108	6.432130093	2.510818927	5.551011283	5.3854
	77	186	109	6.432130093	2.515062942	5.558330978	5.39
	77	187	110	6.432130093	2.519283746	5.565555924	5.3812
	77	188	111	6.432130093	2.52348157	5.572687764	5.3838
	77	189	112	6.432130093	2.527656648	5.579728103	5.3898
	77	191	114	6.432130093	2.535939484	5.593540529	5.3968
	77	193	116	6.432130093	2.544134059	5.607005379	5.4032
Pt	78	178	100	6.459855135	2.480920901	5.501846423	5.3728
	78	179	101	6.459855135	2.485354316	5.510060444	5.3915

	78	180	102	6.459855135	2.489762665	5.518164994	5.3891
	78	181	103	6.459855135	2.494146212	5.526162027	5.3996
	78	182	104	6.459855135	2.49850522	5.534053424	5.3969
	78	183	105	6.459855135	2.502839945	5.541841069	5.4038
	78	184	106	6.459855135	2.50715064	5.549526776	5.4015
	78	185	107	6.459855135	2.511437555	5.557112329	5.4148
	78	186	108	6.459855135	2.515700936	5.5645994	5.4037
	78	187	109	6.459855135	2.519941024	5.571989906	5.4063
	78	188	110	6.459855135	2.524158057	5.579285308	5.4053
	78	189	111	6.459855135	2.52835227	5.586487309	5.406
	78	190	112	6.459855135	2.532523894	5.593597508	5.4108
	78	191	113	6.459855135	2.536673157	5.600617473	5.4102
	78	192	114	6.459855135	2.540800283	5.607548736	5.4169
	78	193	115	6.459855135	2.544905492	5.614392796	5.4191
	78	194	116	6.459855135	2.548989002	5.621151124	5.4236
	78	195	117	6.459855135	2.553051029	5.627825158	5.427
	78	196	118	6.459855135	2.557091782	5.634416307	5.4307
	78	198	120	6.459855135	2.565110301	5.64735544	5.4383
Au	79	183	104	6.487344211	2.503369304	5.547147975	5.4247
	79	184	105	6.487344211	2.507699275	5.555006242	5.4306
Elem.	**Z**	**A**	**N**	$r\,(n=\infty)$	$r\,(n=1)$	$r\,(n=5)$	**R_{av}(fm)**
	79	185	106	6.487344211	2.51200539	5.562762335	5.4296
	79	186	107	6.487344211	2.516287897	5.570418027	5.4354
	79	187	108	6.487344211	2.520547036	5.577975054	5.4018
	79	188	109	6.487344211	2.524783048	5.585435114	5.4049
	79	189	110	6.487344211	2.528996167	5.592799871	5.4084
	79	190	111	6.487344211	2.533186625	5.600070953	5.4109
	79	191	112	6.487344211	2.537354649	5.607249952	5.4147
	79	192	113	6.487344211	2.541500465	5.614338429	5.4179
	79	193	114	6.487344211	2.545624294	5.621337911	5.4221
	79	194	115	6.487344211	2.549726353	5.628249892	5.4252
	79	195	116	6.487344211	2.553806859	5.635075839	5.4298
	79	196	117	6.487344211	2.557866022	5.641817184	5.4332
	79	197	118	6.487344211	2.561904052	5.648475333	5.4371
	79	198	119	6.487344211	2.565921154	5.65505166	5.44
	79	199	120	6.487344211	2.569917532	5.661547514	5.4454
Hg	80	181	101	6.51460228	2.495079112	5.535624814	5.4364
	80	182	102	6.51460228	2.499476739	5.543870681	5.3833
	80	183	103	6.51460228	2.503849933	5.552008625	5.4405
	80	184	104	6.51460228	2.508198947	5.560040529	5.3949
	80	185	105	6.51460228	2.512524033	5.567968237	5.4397

	80	186	106	6.51460228	2.51682543	5.57579355	5.4017
	80	187	107	6.51460228	2.52110340	5.58351824	5.4046
	80	188	108	6.51460228	2.52535816	5.59114402	5.4085
	80	189	109	6.51460228	2.52958996	5.59867260	5.41
	80	190	110	6.51460228	2.53379903	5.60610563	5.4158
	80	191	111	6.51460228	2.53798559	5.61344472	5.4171
	80	192	112	6.51460228	2.54214988	5.62069147	5.4232
	80	193	113	6.51460228	2.54629210	5.62784742	5.4238
	80	194	114	6.51460228	2.55041249	5.63491411	5.4309
	80	195	115	6.51460228	2.55451126	5.64189301	5.4345
	80	196	116	6.51460228	2.55858862	5.64878559	5.4385
	80	197	117	6.51460228	2.56264477	5.65559328	5.4412
	80	198	118	6.51460228	2.5666799	5.66231748	5.4463
	80	199	119	6.51460228	2.57069430	5.66895956	5.4474
	80	200	120	6.51460228	2.57468808	5.67552086	5.4551
	80	201	121	6.51460228	2.5786614	5.68200270	5.4581
	80	202	122	6.51460228	2.58261465	5.68840637	5.4648
	80	203	123	6.51460228	2.58654783	5.69473314	5.4679
	80	204	124	6.51460228	2.59046119	5.70098423	5.4744
	80	205	125	6.51460228	2.59435491	5.7071608	5.4776
Elem.	**Z**	**A**	**N**	**$r\,(n=\infty)$**	**$r\,(n=1)$**	**$r\,(n=5)$**	**R_{av}(fm)**
	80	206	126	6.51460228	2.59822919	5.71326425	5.4837
Tl	81	183	102	6.54163413	2.50428336	5.5564298	
	81	185	104	6.54163413	2.51299502	5.57273681	
	81	188	107	6.54163413	2.52588496	5.59641873	5.4017
	81	190	109	6.54163413	2.53436268	5.61170817	5.4121
	81	191	110	6.54163413	2.53856756	5.6192083	5.4169
	81	192	111	6.54163413	2.54275010	5.62661443	5.4191
	81	193	112	6.54163413	2.54691051	5.63392788	5.4243
	81	194	113	6.54163413	2.55104902	5.64115029	5.4259
	81	195	114	6.54163413	2.5551658	5.64828317	5.4325
	81	196	115	6.54163413	2.55926117	5.65532801	5.4327
	81	197	116	6.54163413	2.56333524	5.66228625	5.4388
	81	198	117	6.54163413	2.56738825	5.66915933	5.4396
	81	199	118	6.54163413	2.5714204	5.67594864	5.4479
	81	200	119	6.54163413	2.57543190	5.68265554	5.4491
	81	201	120	6.54163413	2.57942294	5.68928138	5.4573
	81	202	121	6.54163413	2.58339371	5.69582747	5.4595
	81	203	122	6.54163413	2.58734441	5.70229509	5.4666
	81	204	123	6.54163413	2.59127523	5.70868551	5.4704
	81	205	124	6.54163413	2.59518636	5.71499996	5.4759

	81	207	126	6.541634134	2.602950264	5.727405769	5.4853
	81	208	127	6.541634134	2.606803404	5.7334994	5.4946
Pb	82	182	100	6.568444413	2.500260317	5.551925943	5.3788
	82	183	101	6.568444413	2.504671069	5.560418369	5.3869
	82	184	102	6.568444413	2.509057497	5.568800649	5.393
	82	185	103	6.568444413	2.513419852	5.577074686	5.3984
	82	186	104	6.568444413	2.517758383	5.585242343	5.4027
	82	187	105	6.568444413	2.522073334	5.593305442	5.4079
	82	188	106	6.568444413	2.526364943	5.601265768	5.4139
	82	189	107	6.568444413	2.530633449	5.609125069	5.4177
	82	190	108	6.568444413	2.534879083	5.616885054	5.4222
	82	191	109	6.568444413	2.539102076	5.624547398	5.4229
	82	192	110	6.568444413	2.543302654	5.632113743	5.43
	82	193	111	6.568444413	2.547481039	5.639585693	5.431
	82	194	112	6.568444413	2.551637451	5.646964823	5.4372
	82	195	113	6.568444413	2.555772106	5.654252672	5.4389
	82	196	114	6.568444413	2.559885218	5.661450751	5.4444
	82	197	115	6.568444413	2.563976996	5.668560537	5.4446
	82	198	116	6.568444413	2.568047648	5.67558348	5.4524
	82	199	117	6.568444413	2.572097378	5.682520997	5.4529
Elem.	**Z**	**A**	**N**	$r\,(n=\infty)$	$r\,(n=1)$	$r\,(n=5)$	R_{av}(fm)
	82	200	118	6.568444413	2.576126387	5.689374481	5.4611
	82	201	119	6.568444413	2.580134874	5.696145292	5.4629
	82	202	120	6.568444413	2.584123033	5.702834766	5.4705
	82	203	121	6.568444413	2.588091059	5.709444212	5.4727
	82	204	122	6.568444413	2.59203914	5.715974913	5.4803
	82	205	123	6.568444413	2.595967465	5.722428124	5.4828
	82	206	124	6.568444413	2.599876218	5.728805079	5.4902
	82	207	125	6.568444413	2.603765582	5.735106986	5.4943
	82	208	126	6.568444413	2.607635737	5.741335029	5.5012
	82	209	127	6.568444413	2.611486859	5.747490368	5.51
	82	210	128	6.568444413	2.615319125	5.753574142	5.5208
	82	211	129	6.568444413	2.619132706	5.759587469	5.529
	82	212	130	6.568444413	2.622927772	5.765531442	5.5396
	82	214	132	6.568444413	2.630463033	5.777215603	5.5577
Bi	83	202	119	6.595037592	2.584804108	5.70943428	5.484
	83	203	120	6.595037592	2.58878926	5.716186494	5.4911
	83	204	121	6.595037592	2.592754408	5.722858419	5.4934
	83	205	122	6.595037592	2.596699737	5.729451331	5.5008
	83	206	123	6.595037592	2.600625435	5.735966486	5.5034
	83	207	124	6.595037592	2.604531683	5.742405111	5.5103

	83	208	125	6.595037592	2.608418661	5.748768411	5.5147
	83	209	126	6.595037592	2.612286548	5.755057567	5.5211
	83	210	127	6.595037592	2.616135518	5.761273739	5.53
	83	212	129	6.595037592	2.6237774	5.773491646	5.5489
	83	213	130	6.595037592	2.627570651	5.77949559	5.5586
Po	84	192	108	6.621418023	2.544270475	5.641866357	5.522
	84	193	109	6.621418023	2.548484189	5.649658188	
	84	194	110	6.621418023	2.552675799	5.65735364	5.5167
	84	195	111	6.621418023	2.556845523	5.664954304	
	84	196	112	6.621418023	2.560993575	5.672461738	5.5136
	84	197	113	6.621418023	2.565120165	5.679877469	
	84	198	114	6.621418023	2.569225502	5.687202993	5.5146
	84	199	115	6.621418023	2.573309791	5.694439776	
	84	200	116	6.621418023	2.577373234	5.701589255	5.5199
	84	201	117	6.621418023	2.581416029	5.708652839	
	84	202	118	6.621418023	2.585438374	5.715631907	5.5281
	84	203	119	6.621418023	2.589440462	5.722527811	
	84	204	120	6.621418023	2.593422484	5.729341878	5.5378
	84	205	121	6.621418023	2.597384628	5.736075407	5.5389
	84	206	122	6.621418023	2.601327079	5.742729674	5.548
Elem.	**Z**	**A**	**N**	$r\,(n=\infty)$	$r\,(n=1)$	$r\,(n=5)$	R_{av}**(fm)**
	84	207	123	6.621418023	2.605250022	5.749305926	5.5501
	84	208	124	6.621418023	2.609153637	5.755805389	5.5584
	84	209	125	6.621418023	2.613038101	5.762229265	5.5628
	84	210	126	6.621418023	2.616903591	5.768578731	5.5704
	84	211	127	6.621418023	2.620750279	5.774854943	
	84	216	132	6.621418023	2.639707611	5.805176092	5.6359
	84	218	134	6.621418023	2.647164749	5.816829803	5.6558
Rn	86	202	116	6.673557332	2.586571965	5.726844407	5.5521
	86	204	118	6.673557332	2.59462257	5.741131387	5.5568
	86	205	119	6.673557332	2.598617785	5.748148813	5.5569
	86	206	120	6.673557332	2.602593191	5.755083952	5.564
	86	207	121	6.673557332	2.606548972	5.761938103	5.5652
	86	208	122	6.673557332	2.61048531	5.768712528	5.5725
	86	209	123	6.673557332	2.614402383	5.775408468	5.5743
	86	210	124	6.673557332	2.618300368	5.78202714	5.5813
	86	211	125	6.673557332	2.622179438	5.788569739	5.585
	86	212	126	6.673557332	2.626039766	5.795037434	5.5915
	86	218	132	6.673557332	2.648817476	5.832333472	5.654
	86	219	133	6.673557332	2.652551228	5.838307823	5.6648
	86	220	134	6.673557332	2.656267532	5.844215876	5.6731

	86	221	135	6.67355732	2.65996654	5.850058619	5.6834
	86	222	136	6.67355732	2.663648403	5.85583702	5.6915
Fr	87	202	115	6.699324206	2.587073901	5.731870424	
	87	203	116	6.699324206	2.591125675	5.739202705	
	87	205	118	6.699324206	2.599168686	5.753609148	
	87	207	120	6.699324206	2.607132231	5.767680391	5.572
	87	208	121	6.699324206	2.611084663	5.774593573	5.5729
	87	209	122	6.699324206	2.615017774	5.781426818	5.5799
	87	210	123	6.699324206	2.618931741	5.788181363	5.5818
	87	211	124	6.699324206	2.622826739	5.794858419	5.5882
	87	212	125	6.699324206	2.62670294	5.801459178	5.5915
	87	213	126	6.699324206	2.630560513	5.807984806	5.5977
	87	220	133	6.699324206	2.657055751	5.851654068	5.6688
	87	221	134	6.699324206	2.660770153	5.85761812	5.679
	87	222	135	6.699324206	2.664467358	5.863516609	5.689
	87	223	136	6.699324206	2.668147516	5.869350503	5.6951
	87	224	137	6.699324206	2.671810773	5.87512075	5.7061
	87	225	138	6.699324206	2.675457275	5.880828282	5.7112
	87	226	139	6.699324206	2.679087163	5.886474016	5.719
	87	227	140	6.699324206	2.682700582	5.892058859	5.7335
Elem.	**Z**	**A**	**N**	$r\,(n=\infty)$	$r\,(n=1)$	$r\,(n=5)$	R_{av}(fm)
	87	228	141	6.699324206	2.686297668	5.897583665	5.7399
Ra	88	208	120	6.724894394	2.611641382	5.780099997	5.585
	88	209	121	6.724894394	2.615590358	5.787071369	5.5853
	88	210	122	6.724894394	2.619520136	5.793962604	5.5917
	88	211	123	6.724894394	2.62343089	5.800774936	5.5929
	88	212	124	6.724894394	2.627322792	5.807509573	5.5991
	88	213	125	6.724894394	2.631196014	5.814167699	5.602
	88	214	126	6.724894394	2.635050722	5.82075048	5.6079
	88	220	132	6.724894394	2.657799315	5.858727335	5.6683
	88	221	133	6.724894394	2.661528947	5.864813485	5.6795
	88	222	134	6.724894394	2.665241333	5.870832848	5.6874
	88	223	135	6.724894394	2.66893662	5.876786405	5.6973
	88	224	136	6.724894394	2.672614956	5.882675123	5.7046
	88	225	137	6.724894394	2.676276487	5.888499948	5.715
	88	226	138	6.724894394	2.679921355	5.894261811	5.7211
	88	227	139	6.724894394	2.683549704	5.899961626	5.7283
	88	228	140	6.724894394	2.687161672	5.90560029	5.737
	88	229	141	6.724894394	2.690757399	5.911178683	5.7455
	88	230	142	6.724894394	2.69433702	5.916697671	5.7551
	88	232	144	6.724894394	2.701448483	5.927560816	5.7714

Th	90	227	137	6.775459408	2.685115625	5.914707982	5.7404
	90	228	138	6.775459408	2.688756894	5.920576583	5.7488
	90	229	139	6.775459408	2.692381826	5.926382661	5.7557
	90	230	140	6.775459408	2.695990558	5.932127121	5.767
	90	232	142	6.775459408	2.703159961	5.94343467	5.7848
U	92	233	141	6.825280752	2.708289158	5.963728178	5.8203
	92	234	142	6.825280752	2.711862583	5.969454463	5.8291
	92	235	143	6.825280752	2.715420378	5.975121266	5.8337
	92	236	144	6.825280752	2.718962673	5.980729416	5.8431
	92	238	146	6.825280752	2.726001263	5.991773006	5.8571
Pu	94	238	144	6.874385179	2.727543653	6.006263982	5.8535
	94	239	145	6.874385179	2.731067362	6.01191315	5.8601
	94	240	146	6.874385179	2.734575981	6.017504862	5.8701
	94	241	147	6.874385179	2.738069632	6.023039902	5.8748
	94	242	148	6.874385179	2.741548434	6.028519042	5.8823
	94	244	150	6.874385179	2.748461962	6.039312639	5.8948
Am	95	241	146	6.898676495	2.738821388	6.030120627	5.8928
	95	243	148	6.898676495	2.745790738	6.041230991	5.9048
Cm	96	242	146	6.922797937	2.74303967	6.042574624	5.8285
	96	244	148	6.922797937	2.750005736	6.053780103	5.8429
Elem.	**Z**	**A**	**N**	**r (n = ∞)**	**r (n = 1)**	**r (n = 5)**	**R_{av}(fm)**
	96	245	149	6.922797937	2.753466843	6.059299157	5.8475
	96	246	150	6.922797937	2.756913486	6.064763415	5.8562
	96	248	152	6.922797937	2.76376383	6.075530454	5.8687

In table 1, charge radii r(n=5) for 957 nuclei are calculated using Eq. 4. Average deviation of nuclear charge radius $\langle\sigma\rangle$ were calculated to indicate agreements between our results and experimental data presented by Krassimira [19]. The value of $\langle\sigma\rangle$ is,

$$\langle\sigma\rangle = \frac{\sum_{i=1}^{957}(r_{n=5} - R_{av})}{957} = 0.30297\ fm \qquad 7$$

IV. DISCUSSIONS

We compare the values of r(n=5) and R_{av}(fm) starting with H. As one neutron is added to ${}^{1}_{1}H$ to get ${}^{2}_{1}H$, the values of r and R_{av} show abrupt increase. Now when another neutron is added to get ${}^{3}_{1}H$,there is an abrupt decrease in Rav, But the increase in the value of r(n=5) is gradual, whereas R_{av} decreases and increases. However, beyond ${}^{10}_{5}B$, The up and down variation in R_{av} is very small, whereas the value of r(n=5) more or less increases as Z, A and N change. In general the value of r(n=5) is less than R_{av}. But if the average deviation of the nuclear charge radius given in Eq. 7 is combined with the values of r(n=5), we get values of r(n=5) that are very close to R_{av}. Starting from ${}^{27}_{13}A$, the agreement between r(n=5) values and R_{av} values is very good. The agreement is excellent for ${}^{41}_{18}\mathrm{Ar}$, ${}^{42}_{18}\mathrm{Ar}$ and the best agreement is for ${}^{43}_{18}\mathrm{Ar}$, ${}^{44}_{18}\mathrm{Ar}$, ${}^{46}_{18}\mathrm{Ar}$, ${}^{43}_{19}\mathrm{K}$, ${}^{44}_{19}\mathrm{K}$, ${}^{45}_{19}\mathrm{K}$, ${}^{46}_{19}\mathrm{K}$, ${}^{45}_{20}\mathrm{Ca}$, ${}^{46}_{20}\mathrm{Ca}$, ${}^{46}_{21}\mathrm{Sc}$, ${}^{48}_{22}\mathrm{Ti}$, ${}^{49}_{22}\mathrm{Ti}$, ${}^{51}_{23}\mathrm{V}$, ${}^{52}_{24}\mathrm{Cr}$, ${}^{53}_{24}\mathrm{Cr}$, ${}^{54}_{24}\mathrm{Cr}$, ${}^{52}_{25}\mathrm{Mn}$(*), ${}^{53}_{25}\mathrm{Mn}$, ${}^{54}_{25}\mathrm{Mn}$, ${}^{55}_{25}\mathrm{Mn}$, ${}^{56}_{25}\mathrm{Mn}$, ${}^{54}_{26}\mathrm{Fe}$, ${}^{56}_{26}\mathrm{Fe}$, ${}^{57}_{26}\mathrm{Fe}$, ${}^{58}_{26}\mathrm{Fe}$(*), ${}^{59}_{27}\mathrm{Co}$, ${}^{57}_{28}\mathrm{Ni}$(*), ${}^{59}_{28}\mathrm{Ni}$(*), ${}^{60}_{28}\mathrm{Ni}$(*), ${}^{63}_{29}\mathrm{Cu}$(*), ${}^{65}_{29}\mathrm{Cu}$(*), ${}^{64}_{30}\mathrm{Zn}$(*), ${}^{71}_{31}\mathrm{Ga}$(*), ${}^{70}_{32}\mathrm{Ge}$(*)(shows a wonderful agreement), ${}^{72}_{32}\mathrm{Ge}$, ${}^{78}_{36}\mathrm{Kr}$(*), ${}^{79}_{36}\mathrm{Kr}$(wonderful agreement), ${}^{79}_{37}\mathrm{Rb}$(*), ${}^{80}_{37}\mathrm{Rb}$(wonderful agreement), ${}^{97}_{37}\mathrm{Rb}$(*), ${}^{98}_{37}\mathrm{Rb}$(*), ${}^{81}_{38}\mathrm{Sr}$(*), ${}^{98}_{38}\mathrm{Sr}$, ${}^{99}_{38}\mathrm{Sr}$, ${}^{99\text{-}102}_{39}\mathrm{Y}$, ${}^{100}_{40}\mathrm{Zr}$ and so on.

The agreement is excellent all the way up to $^{248}_{96}Cm$. However, in some cases the average deviation of the nuclear charge radius given by Eq. (7) may have to be taken into account to get better agreement between our calculations and the experimental values given in "[19]". Here (*) stands for excellent agreement between r(n=5) and R_{av}.

V. CONCLUSION

The agreement between the calculated values of r(n=5) and R_{av} leads to the conclusion that the Coulomb potential proposed by us for n=5 gives an expression for the Coulomb energy E_c that can now be used in the binding energy expression B(A,Z) to calculate the value of B(A,Z) that may show better agreement with the experimental values. This may also assist in understanding the stability of some Super Heavy Nuclei (SHN) in the "Island of stability" since the stability of super heavy nuclei (SHN) is at the limits of Coulomb stability [20]. These calculations are being done and will be sent for publication soon.

REFERENCES

[1] Fricke G. Bernhardt C. Heilig K. Schaller L. A. Schellenberg L. Shera E. B. Dejager C. W. "Nuclear ground state charge radii from electromagnetic interactions". At. Data Nucl. Data Tables 60, 177 (1995), and references therein.

[2] P. Aufmuth, K. Heilig, and A. Steudel. "Changes in mean-square nuclear charge radii from optical isotope shifts." Atom. Data And Nucl. Data Tables 37, 455 (1987).

[3] E. W. Otten. "Treatise on heavy-ion". science vol. 8, ed D. A. Bromley (New York: Pleum) p. 515.

[4] J. Billowes and P. Campbell. "High-resolution laser spectroscopy for the study of nuclear sizes and shapes" J. Phys. G: Nucl. Part. Phys. 21, 707 (1995), and references therein.

[5] H. A. Schuessler, A. Alousi, R. M. Evans, M. Brieger, F. Buchinger, and Y. F. Li. "Isotope shifts and nuclear charge radii of krypton isotopes across the N=50 shell closure". Phys. Rev. Lett. 65, 1332 (1990).

[6] J. M. G. Levins, D. M. Benton, J. Billowes, P. Campbell, T. G. Cooper, P. Dendooven, D. E. Evans, D. H. Forest, I. S. Grant, J. A. R. Griffith, J. Huikari, A. Jokinen, K. Peräjärvi, G. Tungate, G. Yeandle, and J. Äystö. "First on-line laser spectroscopy of radioisotopes of a refractory element". Phys. Rev. Lett. 82, 2476 (1999).

[7] H. De Vries, C. W. De Jager, and C. De Vries. "Nuclear charge-density-distribution parameters from elastic electron scattering". At. Data Nucl. Data Tables 36, 495 (1987).

[8] K. K. Sirma, and K. M. Khanna. "Interaction between neutron-proton core and neutron skin region in super heavy nuclei". World Scientific News 144 (2020) 243-265

[9] Itin, Yakov, Claus, L., and Volker, P. "Finsler-type modification of the coulomb law". Phys. Rev. D 90, 12 (2014): 124057

[10] Antia, A. D., Ituen, E. E., Obong, H. P., and Isonguyo, C. N. "Analytical solution of the modified coulomb potential using the factorisation method". Int. J. Rec. Adv. Phys 4 (2015) 55

[11] Jackson, J. D. Classical Electrodynamics. 3rd ed. John Wiley and sons. Inc, New York. (1999)

[12] Pedram, P. "Modification of coulomb's law in closed spaces". American Journal of Physics 78, 4 (2010) 403-406.

[13] Paul, D. "The simplified nuclear potential well". Monroe Community College. (2019) https//phys.libretexts.org

[14] Hadrons as Projectiles, Modified Coulomb Potential. 3 Jan. (2019) http://folk.uio.no/farido/fys3510/FundamentalAspectsNuclea rInteractions14.pdf.

[15] Cherop, H. K., Muguro, K, M., and Khanna, K. M. "The role of the modified coulomb energy in the binding energy equations for finite nuclei". Scientific Israel-Technological Advantages 21 (5,6) (2019) 82-89

[16] Bjornholm, S., and Lynn, J. E. "The Double-humped fission barrier". Reviews of Modern Physics 52 4 (1980) 725.

[17] Bozena, N. P., and Pomorski, K. "Simple formula for nuclear charge radius". (2018) arxiv:nucl-th/9401015v1

[18] Zhang, S. Q., Meng, J., Zhou, S. G., and Zeng, J. Y. "Isospin and Z1/3 dependence of the nuclear charge radii." (2001) arxiv:nucl-th/0107040v1

[19] Krassimira, M., and Istvan, A. "Nuclear charge radii". International Atomic Energy Agency 2020. https://www-nds.iaea.org/radii/.

[20] Yuri, Oganessian. "Nuclei in the island of stability". Phys. Conf. Ser. 337 (2012) 012005

