Nuclear Charge Radii

Krassimira Marinova
Joint Institute for Nuclear Research, 141980 Dubna, Moscow Region, Russia
Istvan Angeli
Institute of Experimental Physics, University of Debrecen, H-4010 Debrecen Pf. 105, Hungary

The table of experimental nuclear charge radii covers an extended range of isotopes and elements (909 isotopes of 92 elements from ^{1}H to ^{96}Cm) and is recently published in Atomic Data and Nuclear Data Tables (ADNDT) 99 (2013) 69-95.

It is based on the combined analysis of two types of experimental data:

1. radii changes determined from optical and — to a lesser extent — K_{α}X-ray isotope shifts and
2. absolute radii measured by muonic spectra and electron scattering experiments.

The table combines the results of two working groups, using respectively two different methods of evaluation, published in ADNDT earlier. Such a procedure reduces possible systematic errors arising from the differing approach of the evaluators.
The data obtained are not simple compilation of individual measurements, but constitute a self-consistent set of *rms* R-values giving a global survey of nuclear charge radii over the whole nuclide chart.
Compared with the last published IAEA database on mean squared charge radii (IAEA, 2010) new data are added and/or updated due to progress recently achieved by laser spectroscopy up to early 2011.

Determination of radii changes from optical isotope shifts is a field of physics that has experienced a strong push forward in recent years due to the development of new highly sensitive methods of laser spectroscopy investigations and the availability of intense radioactive beams at accelerators.
Recently new measurements appeared on the optical isotope shifts, correspondingly the charge radii changes $\delta\langle r^2\rangle$.
The radii changes in long isotopic sequences for Mg [Yo12] , Ga [Pr12] have been obtained for the first time; several isotopic chains have been re-measured with higher accuracy and extended to regions far off stability (Be [Kr12], K [Kr14]). In some cases, new information is added including odd-N isotopes, e.g. Po [Se13], or extended either to the neutron deficient isotopes ($^{97\text{-}100}$Ag [Fe14], ^{183,185}Tl [Ba13], $^{202\text{-}205}$Fr [Fl13] or to neutron rich isotopes ^{175,177}Yb [Fl12].

Using these recent data, new or updated charge radii values of R can be added to the table of 2013. These data are summarized in the last two colums of the table. Please note that these data should be regarded as preliminary as the nuclear radii have been extracted using only the algorithm of [Na94].

References ↓

When new measurements lead to the same value, they are shown in *italics*

				Published data ADNDT 99 (2013) 69-95		Preliminary data	
Z	**Elem.**	**Mass**	**n**	**R_{av}(fm)**	**ΔR_{av}(fm)**	**R_{av}(fm)**	**ΔR_{av}(fm)**
0	**n**	1	1	-0.1149	0.0027		
1	**H**	1	0	0.8783	0.0086		
		2	1	2.1421	0.0088		
		3	2	1.7591	0.0363		
2	**He**	3	1	1.9661	0.0030		
		4	2	1.6755	0.0028		
		6	4	2.0660	0.0111		
		8	6	1.9239	0.0306		
3	**Li**	6	3	2.5890	0.0390		
		7	4	2.4440	0.0420		

		8	5	2.3390	0.0440		
		9	6	2.2450	0.0460		
		11	8	2.4820	0.0430		
4	**Be**	7	3	2.6460	0.0160	*2.6460*	*0.0160*
		9	5	2.5190	0.0120	*2.5190*	*0.0120*
		10	6	2.3550	0.0170	2.3610	*0.0170*
		11	7	2.4630	0.0150	2.4660	*0.0150*
		12	8			2.5030	0.0150
5	**B**	10	5	2.4277	0.0499		
		11	6	2.4060	0.0294		
6	**C**	12	6	2.4702	0.0022		
		13	7	2.4614	0.0034		
		14	8	2.5025	0.0087		
7	**N**	14	7	2.5582	0.0070		
		15	8	2.6058	0.0080		
8	**O**	16	8	2.6991	0.0052		
		17	9	2.6932	0.0075		
		18	10	2.7726	0.0056		
9	**F**	19	10	2.8976	0.0025		
10	**Ne**	17	7	3.0413	0.0088		
		18	8	2.9714	0.0076		
		19	9	3.0082	0.0040		
		20	10	3.0055	0.0021		
		21	11	2.9695	0.0033		
		22	12	2.9525	0.0040		
		23	13	2.9104	0.0071		
		24	14	2.9007	0.0078		
		25	15	2.9316	0.0088		
		26	16	2.9251	0.0100		
		28	18	2.9642	0.0134		
11	**Na**	20	9	2.9718	0.0420		
		21	10	3.0136	0.0284		
		22	11	2.9852	0.0169		
		23	12	2.9936	0.0021		
		24	13	2.9735	0.0169		
		25	14	2.9769	0.0252		
		26	15	2.9928	0.0331		
		27	16	3.0136	0.0467		
		28	17	3.0400	0.0581		
		29	18	3.0922	0.0723		
		30	19	3.1180	0.0884		
		31	20	3.1704	0.0893		
12	**Mg**	21	9			3.0626	0.0067
		22	10			3.0688	0.0052
		23	11			3.0425	0.0039
		24	12	3.0570	0.0016	3.0568	0.0018
		25	13	3.0284	0.0022	3.0288	0.0020
		26	14	3.0337	0.0018	*3.0337*	*0.0018*
		27	15			3.0324	0.0022
		28	16			3.0691	0.0034
		29	17			3.0756	0.0040
		30	18			3.1107	0.0056
		31	19			3.1486	0.0076
		32	20			3.1861	0.0131
13	**Al**	27	14	3.0610	0.0031		

14	**Si**	28	14	3.1224	0.0024		
		29	15	3.1176	0.0052		
		30	16	3.1336	0.0040		
15	**P**	31	16	3.1889	0.0019		
16	**S**	32	16	3.2611	0.0018		
		34	18	3.2847	0.0021		
		36	20	3.2985	0.0024		
17	**Cl**	35	18	3.3654	0.0191		
		37	20	3.3840	0.0170		
18	**Ar**	32	14	3.3468	0.0062		
		33	15	3.3438	0.0058		
		34	16	3.3654	0.0040		
		35	17	3.3636	0.0042		
		36	18	3.3905	0.0023		
		37	19	3.3908	0.0022		
		38	20	3.4028	0.0019		
		39	21	3.4093	0.0031		
		40	22	3.4274	0.0026		
		41	23	3.4251	0.0030		
		42	24	3.4414	0.0041		
		43	25	3.4354	0.0039		
		44	26	3.4454	0.0046		
		46	28	3.4377	0.0044		
19	**K**	37	18			3.4194	0.0292
		38	19	3.4264	0.0051	3.4236	0.0259
		39	20	3.4349	0.0019	3.4361	0.0223
		40	21	3.4381	0.0028	3.4324	0.0188
		41	22	3.4518	0.0055	3.4489	0.0157
		42	23	3.4517	0.0070	3.4469	0.0129
		43	24	3.4556	0.0086	3.4497	0.0100
		44	25	3.4563	0.0101	3.4472	0.0074
		45	26	3.4605	0.0118	3.4531	0.0048
		46	27	3.4558	0.0126	3.4417	0.0023
		47	28	3.4534	0.0138	3.4419	0.0000
		48	29			3.4689	0.0023
		49	30			3.4913	0.0046
		50	31			3.5046	0.0067
		51	32			3.5196	0.0087
20	**Ca**	39	19	3.4595	0.0025		
		40	20	3.4776	0.0019		
		41	21	3.4780	0.0019		
		42	22	3.5081	0.0021		
		43	23	3.4954	0.0019		
		44	24	3.5179	0.0021		
		45	25	3.4944	0.0021		
		46	26	3.4953	0.0020		
		47	27	3.4783	0.0024		
		48	28	3.4771	0.0020		
		50	30	3.5168	0.0064		
21	**Sc**	42	21	3.5702	0.0238		
		43	22	3.5575	0.0147		
		44	23	3.5432	0.0016		
		45	24	3.5459	0.0025		
		46	25	3.5243	0.0089		
22	**Ti**	44	22	3.6115	0.0051		
		45	23	3.5939	0.0032		
		46	24	3.6070	0.0022		
		47	25	3.5962	0.0019		

		48	26	3.5921	0.0017		
		49	27	3.5733	0.0021		
		50	28	3.5704	0.0022		
23	**V**	51	28	3.6002	0.0022		
24	**Cr**	50	26	3.6588	0.0065		
		52	28	3.6452	0.0042		
		53	29	3.6511	0.0075		
		54	30	3.6885	0.0074		
25	**Mn**	50	25	3.7120	0.0196		
		51	26	3.7026	0.0212		
		52	27	3.6706	0.0128		
		53	28	3.6662	0.0076		
		54	29	3.6834	0.0049		
		55	30	3.7057	0.0022		
		56	31	3.7146	0.0052		
26	**Fe**	54	28	3.6933	0.0019		
		56	30	3.7377	0.0016		
		57	31	3.7532	0.0017		
		58	32	3.7745	0.0014		
27	**Co**	59	32	3.7875	0.0021		
28	**Ni**	57	29	3.7757	0.0020		
		59	31	3.8118	0.0016		
		60	32	3.8225	0.0019		
		61	33	3.8399	0.0021		
		63	35	3.8572	0.0023		
29	**Cu**	63	34	3.8823	0.0015		
		65	36	3.9022	0.0014		
30	**Zn**	64	34	3.9283	0.0015		
		66	36	3.9491	0.0014		
		67	37	3.9530	0.0027		
		68	38	3.9658	0.0014		
		70	40	3.9845	0.0019		
31	**Ga**	63	32			3.9308	0.0124
		64	33			3.9390	0.0110
		66	35			3.9706	0.0071
		68	37			3.9850	0.0048
		69	38	3.9973	0.0017	*3.9973*	0.0016
		70	39			3.9998	0.0027
		71	40	4.0118	0.0018	*4.0118*	0.0016
		72	41			4.0318	0.0031
		73	42			4.0420	0.0042
		74	43			4.0395	0.0045
		75	44			4.0472	0.0055
		76	45			4.0460	0.0060
		77	46			4.0500	0.0068
		78	47			4.0453	0.0072
		79	48			4.0478	0.0079
		80	49			4.0418	0.0083
		81	50			4.0441	0.0089
		82	51			4.0671	0.0108
32	**Ge**	70	38	4.0414	0.0012		
		72	40	4.0576	0.0013		
		73	41	4.0632	0.0014		
		74	42	4.0742	0.0012		
		76	44	4.0811	0.0012		

33	**As**	75	42	4.0968	0.0020
34	**Se**	74	40	4.0700	0.0200
		76	42	4.1395	0.0016
		77	43	4.1395	0.0018
		78	44	4.1406	0.0017
		80	46	4.1400	0.0018
		82	48	4.1400	0.0019
35	**Br**	79	44	4.1629	0.0021
		81	46	4.1599	0.0021
36	**Kr**	72	36	4.1635	0.0060
		74	38	4.1870	0.0041
		75	39	4.2097	0.0041
		76	40	4.2020	0.0036
		77	41	4.2082	0.0037
		78	42	4.2038	0.0033
		79	43	4.2034	0.0032
		80	44	4.1970	0.0029
		81	45	4.1952	0.0026
		82	46	4.1919	0.0025
		83	47	4.1871	0.0023
		84	48	4.1884	0.0022
		85	49	4.1846	0.0022
		86	50	4.1835	0.0021
		87	51	4.1984	0.0027
		88	52	4.2171	0.0043
		89	53	4.2286	0.0054
		90	54	4.2423	0.0069
		91	55	4.2543	0.0081
		92	56	4.2724	0.0099
		93	57	4.2794	0.0107
		94	58	4.3002	0.0129
		95	59	4.3067	0.0136
		96	60	4.3267	0.0158
37	**Rb**	76	39	4.2273	0.0070
		77	40	4.2356	0.0080
		78	41	4.2385	0.0083
		79	42	4.2284	0.0065
		80	43	4.2271	0.0061
		81	44	4.2213	0.0051
		82	45	4.2160	0.0042
		83	46	4.2058	0.0028
		84	47	4.1999	0.0023
		85	48	4.2036	0.0024
		86	49	4.2025	0.0023
		87	50	4.1989	0.0021
		88	51	4.2170	0.0038
		89	52	4.2391	0.0074
		90	53	4.2554	0.0102
		91	54	4.2723	0.0131
		92	55	4.2903	0.0163
		93	56	4.3048	0.0187
		94	57	4.3184	0.0211
		95	58	4.3391	0.0248
		96	59	4.3501	0.0267
		97	60	4.4231	0.0395
		98	61	4.4336	0.0414
38	**Sr**	77	39	4.2569	0.0044
		78	40	4.2561	0.0040
		79	41	4.2586	0.0039
		80	42	4.2562	0.0037

		81	43	4.2547	0.0034
		82	44	4.2478	0.0030
		83	45	4.2455	0.0027
		84	46	4.2394	0.0024
		85	47	4.2304	0.0021
		86	48	4.2307	0.0020
		87	49	4.2249	0.0019
		88	50	4.2240	0.0018
		89	51	4.2407	0.0023
		90	52	4.2611	0.0037
		91	53	4.2740	0.0046
		92	54	4.2924	0.0064
		93	55	4.3026	0.0075
		94	56	4.3191	0.0091
		95	57	4.3305	0.0102
		96	58	4.3522	0.0125
		97	59	4.3625	0.0135
		98	60	4.4377	0.0214
		99	61	4.4495	0.0226
		100	62	4.4640	0.0240
39	**Y**	86	47	4.2513	0.0023
		87	48	4.2498	0.0022
		88	49	4.2441	0.0021
		89	50	4.2430	0.0021
		90	51	4.2573	0.0026
		92	53	4.2887	0.0050
		93	54	4.3052	0.0065
		94	55	4.3142	0.0074
		95	56	4.3284	0.0087
		96	57	4.3402	0.0099
		97	58	4.3580	0.0116
		98	59	4.3711	0.0129
		99	60	4.4658	0.0223
		100	61	4.4705	0.0228
		101	62	4.4863	0.0244
		102	63	4.4911	0.0249
40	**Zr**	87	47	4.2789	0.0030
		88	48	4.2787	0.0025
		89	49	4.2706	0.0010
		90	50	4.2694	0.0010
		91	51	4.2845	0.0013
		92	52	4.3057	0.0013
		94	54	4.3320	0.0013
		96	56	4.3512	0.0015
		97	57	4.3792	0.0136
		98	58	4.4012	0.0164
		99	59	4.4156	0.0181
		100	60	4.4891	0.0289
		101	61	4.5119	0.0318
		102	62	4.5292	0.0340
41	**Nb**	90	49	4.2891	0.0040
		91	50	4.2878	0.0040
		92	51	4.3026	0.0043
		93	52	4.3240	0.0017
		99	58	4.4062	0.0125
		101	60	4.4861	0.0203
		103	62	4.5097	0.0227
42	**Mo**	90	48	4.3265	0.0016
		91	49	4.3182	0.0012
		92	50	4.3151	0.0012

		94	52	4.3529	0.0013		
		95	53	4.3628	0.0018		
		96	54	4.3847	0.0015		
		97	55	4.3880	0.0015		
		98	56	4.4091	0.0018		
		100	58	4.4468	0.0025		
		102	60	4.4914	0.0038		
		103	61	4.5145	0.0046		
		104	62	4.5249	0.0051		
		105	63	4.5389	0.0057		
		106	64	4.5490	0.0058		
		108	66	4.5602	0.0067		
44	**Ru**	96	52	4.3908	0.0047		
		98	54	4.4229	0.0055		
		99	55	4.4338	0.0042		
		100	56	4.4531	0.0031		
		101	57	4.4606	0.0020		
		102	58	4.4809	0.0018		
		104	60	4.5098	0.0020		
45	**Rh**	103	58	4.4945	0.0023		
46	**Pd**	102	56	4.4827	0.0044		
		104	58	4.5078	0.0027		
		105	59	4.5150	0.0030		
		106	60	4.5318	0.0029		
		108	62	4.5563	0.0027		
		110	64	4.5782	0.0030		
47	**Ag**	97	50			4.4202	0.0226
		98	51			4.4518	0.0180
		99	52			4.4630	0.0179
		100	53			4.4719	0.0280
		101	54	4.4799	0.0088	*4.4799*	0.0111
		103	56	4.5036	0.0065	*4.5036*	*0.0065*
		104	57	4.5119	0.0058	*4.5119*	*0.0058*
		105	58	4.5269	0.0045	*4.5269*	*0.0045*
		107	60	4.5454	0.0031	*4.5454*	*0.0031*
		109	62	4.5638	0.0025	*4.5638*	*0.0025*
48	**Cd**	102	54	4.4810	0.0122		
		103	55	4.4951	0.0105		
		104	56	4.5122	0.0083		
		105	57	4.5216	0.0070		
		106	58	4.5383	0.0036		
		107	59	4.5466	0.0039		
		108	60	4.5577	0.0031		
		109	61	4.5601	0.0035		
		110	62	4.5765	0.0026		
		111	63	4.5845	0.0058		
		112	64	4.5944	0.0024		
		113	65	4.6012	0.0028		
		114	66	4.6087	0.0023		
		115	67	4.6114	0.0046		
		116	68	4.6203	0.0059		
		117	69	4.6136	0.0025		
		118	70	4.6246	0.0060		
		120	72	4.6300	0.0069		
49	**In**	104	55	4.5184	0.0117		
		105	56	4.5311	0.0103		
		106	57	4.5375	0.0095		
		107	58	4.5494	0.0082		
		108	59	4.5571	0.0071		

		109	60	4.5685	0.0061
		110	61	4.5742	0.0056
		111	62	4.5856	0.0044
		112	63	4.5907	0.0041
		113	64	4.6010	0.0031
		114	65	4.6056	0.0029
		115	66	4.6156	0.0026
		116	67	4.6211	0.0027
		117	68	4.6292	0.0032
		118	69	4.6335	0.0033
		119	70	4.6407	0.0040
		120	71	4.6443	0.0042
		121	72	4.6505	0.0047
		122	73	4.6534	0.0051
		123	74	4.6594	0.0056
		124	75	4.6625	0.0060
		125	76	4.6670	0.0064
		126	77	4.6702	0.0068
		127	78	4.6733	0.0071
50	**Sn**	108	58	4.5605	0.0029
		109	59	4.5679	0.0027
		110	60	4.5785	0.0025
		111	61	4.5836	0.0024
		112	62	4.5948	0.0022
		113	63	4.6015	0.0021
		114	64	4.6099	0.0020
		115	65	4.6148	0.0019
		116	66	4.6250	0.0019
		117	67	4.6302	0.0019
		118	68	4.6393	0.0019
		119	69	4.6438	0.0020
		120	70	4.6519	0.0021
		121	71	4.6566	0.0021
		122	72	4.6634	0.0022
		123	73	4.6665	0.0023
		124	74	4.6735	0.0023
		125	75	4.6765	0.0026
		126	76	4.6833	0.0043
		127	77	4.6867	0.0048
		128	78	4.6921	0.0054
		129	79	4.6934	0.0058
		130	80	4.7019	0.0066
		131	81	4.7078	0.0073
		132	82	4.7093	0.0076
51	**Sb**	121	70	4.6802	0.0026
		123	72	4.6879	0.0025
52	**Te**	116	64	4.6847	0.0128
		118	66	4.6956	0.0105
		120	68	4.7038	0.0088
		122	70	4.7095	0.0031
		123	71	4.7117	0.0035
		124	72	4.7183	0.0029
		125	73	4.7204	0.0030
		126	74	4.7266	0.0032
		128	76	4.7346	0.0029
		130	78	4.7423	0.0025
		132	80	4.7500	0.0031
		134	82	4.7569	0.0041
		136	84	4.7815	0.0089
53	**I**	127	74	4.7500	0.0081

54	**Xe**	116	62	4.7211	0.0096
		118	64	4.7387	0.0070
		120	66	4.7509	0.0063
		122	68	4.7590	0.0059
		124	70	4.7661	0.0055
		126	72	4.7722	0.0052
		127	73	4.7747	0.0038
		128	74	4.7774	0.0050
		129	75	4.7775	0.0050
		130	76	4.7818	0.0049
		131	77	4.7808	0.0049
		132	78	4.7859	0.0048
		133	79	4.7831	0.0048
		134	80	4.7899	0.0047
		136	82	4.7964	0.0047
		137	83	4.8094	0.0049
		138	84	4.8279	0.0079
		139	85	4.8409	0.0100
		140	86	4.8566	0.0125
		141	87	4.8694	0.0147
		142	88	4.8841	0.0169
		143	89	4.8942	0.0187
		144	90	4.9082	0.0208
		146	92	4.9315	0.0245
55	**Cs**	118	63	4.7832	0.0092
		119	64	4.7896	0.0089
		120	65	4.7915	0.0075
		121	66	4.7769	0.0078
		122	67	4.7773	0.0070
		123	68	4.7820	0.0070
		124	69	4.7828	0.0062
		125	70	4.7880	0.0062
		126	71	4.7872	0.0056
		127	72	4.7936	0.0055
		128	73	4.7921	0.0052
		129	74	4.7981	0.0050
		130	75	4.7992	0.0049
		131	76	4.8026	0.0047
		132	77	4.8002	0.0046
		133	78	4.8041	0.0046
		134	79	4.8031	0.0046
		135	80	4.8067	0.0047
		136	81	4.8059	0.0052
		137	82	4.8128	0.0050
		138	83	4.8255	0.0050
		139	84	4.8422	0.0069
		140	85	4.8554	0.0088
		141	86	4.8689	0.0108
		142	87	4.8825	0.0132
		143	88	4.8965	0.0151
		144	89	4.9055	0.0161
		145	90	4.9188	0.0191
		146	91	4.9281	0.0193
56	**Ba**	120	64	4.8092	0.0058
		121	65	4.8176	0.0052
		122	66	4.8153	0.0054
		123	67	4.8135	0.0055
		124	68	4.8185	0.0052
		125	69	4.8177	0.0052
		126	70	4.8221	0.0050
		127	71	4.8204	0.0051
		128	72	4.8255	0.0048

		129	73	4.8248	0.0049
		130	74	4.8283	0.0047
		131	75	4.8276	0.0048
		132	76	4.8303	0.0047
		133	77	4.8286	0.0047
		134	78	4.8322	0.0047
		135	79	4.8294	0.0047
		136	80	4.8334	0.0046
		137	81	4.8314	0.0047
		138	82	4.8378	0.0046
		139	83	4.8513	0.0049
		140	84	4.8684	0.0059
		141	85	4.8807	0.0069
		142	86	4.8953	0.0083
		143	87	4.9087	0.0096
		144	88	4.9236	0.0112
		145	89	4.9345	0.0123
		146	90	4.9479	0.0138
		148	92	4.9731	0.0167
57	**La**	135	78	4.8488	0.0060
		137	80	4.8496	0.0053
		138	81	4.8473	0.0051
		139	82	4.8550	0.0049
58	**Ce**	136	78	4.8739	0.0018
		138	80	4.8737	0.0018
		140	82	4.8771	0.0018
		142	84	4.9063	0.0020
		144	86	4.9303	0.0024
		146	88	4.9590	0.0028
		148	90	4.9893	0.0035
59	**Pr**	141	82	4.8919	0.0050
60	**Nd**	132	72	4.9174	0.0026
		134	74	4.9128	0.0026
		135	75	4.9086	0.0026
		136	76	4.9111	0.0026
		137	77	4.9080	0.0026
		138	78	4.9123	0.0026
		139	79	4.9076	0.0025
		140	80	4.9101	0.0026
		141	81	4.9057	0.0026
		142	82	4.9123	0.0025
		143	83	4.9254	0.0026
		144	84	4.9421	0.0027
		145	85	4.9535	0.0028
		146	86	4.9696	0.0030
		148	88	4.9999	0.0036
		150	90	5.0400	0.0044
62	**Sm**	138	76	4.9599	0.0034
		139	77	4.9556	0.0034
		140	78	4.9565	0.0034
		141	79	4.9517	0.0034
		142	80	4.9518	0.0034
		143	81	4.9479	0.0034
		144	82	4.9524	0.0034
		145	83	4.9651	0.0034
		146	84	4.9808	0.0035
		147	85	4.9892	0.0035
		148	86	5.0042	0.0034
		149	87	5.0134	0.0035
		150	88	5.0387	0.0048

		151	89	5.0550	0.0057
		152	90	5.0819	0.0060
		153	91	5.0925	0.0068
		154	92	5.1053	0.0067
63	**Eu**	137	74	4.9762	0.0095
		138	75	4.9779	0.0094
		139	76	4.9760	0.0093
		140	77	4.9695	0.0091
		141	78	4.9697	0.0091
		142	79	4.9607	0.0091
		143	80	4.9636	0.0091
		144	81	4.9612	0.0091
		145	82	4.9663	0.0091
		146	83	4.9789	0.0092
		147	84	4.9938	0.0094
		148	85	5.0045	0.0097
		149	86	5.0202	0.0103
		150	87	5.0296	0.0108
		151	88	5.0522	0.0046
		152	89	5.1064	0.0066
		153	90	5.1115	0.0062
		154	91	5.1239	0.0079
		155	92	5.1221	0.0069
		156	93	5.1264	0.0071
		157	94	5.1351	0.0075
		158	95	5.1413	0.0078
		159	96	5.1498	0.0084
64	**Gd**	145	81	4.9786	0.0077
		146	82	4.9801	0.0140
		148	84	5.0080	0.0171
		150	86	5.0342	0.0159
		152	88	5.0774	0.0048
		154	90	5.1223	0.0040
		155	91	5.1319	0.0041
		156	92	5.1420	0.0042
		157	93	5.1449	0.0042
		158	94	5.1569	0.0043
		160	96	5.1734	0.0044
65	**Tb**	147	82	4.9201	0.1508
		148	83	4.9291	0.1507
		149	84	4.9427	0.1506
		150	85	4.9499	0.1505
		151	86	4.9630	0.1504
		152	87	4.9689	0.1504
		153	88	4.9950	0.1502
		154	89	5.0333	0.1501
		155	90	5.0391	0.1500
		157	92	5.0489	0.1500
		159	94	5.0600	0.1500
66	**Dy**	146	80	5.0438	0.2389
		148	82	5.0455	0.2389
		149	83	5.0567	0.2394
		150	84	5.0706	0.2413
		151	85	5.0801	0.2435
		152	86	5.0950	0.2482
		153	87	5.1035	0.2516
		154	88	5.1241	0.2618
		155	89	5.1457	0.2751
		156	90	5.1622	0.2869
		157	91	5.1709	0.2936

		158	92	5.1815	0.3023		
		159	93	5.1825	0.3031		
		160	94	5.1951	0.3139		
		161	95	5.1962	0.0459		
		162	96	5.2074	0.0172		
		163	97	5.2099	0.0120		
		164	98	5.2218	0.0106		
67	**Ho**	151	84	5.0398	0.0354		
		152	85	5.0614	0.0343		
		153	86	5.0760	0.0339		
		154	87	5.0856	0.0333		
		155	88	5.1076	0.0326		
		156	89	5.1156	0.0326		
		157	90	5.1535	0.0316		
		158	91	5.1571	0.0316		
		159	92	5.1675	0.0314		
		160	93	5.1662	0.0315		
		161	94	5.1785	0.0313		
		162	95	5.1817	0.0313		
		163	96	5.1907	0.0313		
		165	98	5.2022	0.0312		
68	**Er**	150	82	5.0548	0.0254		
		152	84	5.0843	0.0257		
		154	86	5.1129	0.0268		
		156	88	5.1429	0.0285		
		158	90	5.1761	0.0312		
		160	92	5.2045	0.0336		
		162	94	5.2246	0.0040		
		164	96	5.2389	0.0035		
		166	98	5.2516	0.0031		
		167	99	5.2560	0.0031		
		168	100	5.2644	0.0035		
		170	102	5.2789	0.0041		
69	**Tm**	153	84	5.0643	0.0190		
		154	85	5.0755	0.0166		
		156	87	5.0976	0.0135		
		157	88	5.1140	0.0074		
		158	89	5.1235	0.0069		
		159	90	5.1392	0.0060		
		160	91	5.1504	0.0055		
		161	92	5.1616	0.0050		
		162	93	5.1713	0.0048		
		163	94	5.1849	0.0042		
		164	95	5.1906	0.0042		
		165	96	5.2004	0.0038		
		166	97	5.2046	0.0038		
		167	98	5.2129	0.0036		
		168	99	5.2170	0.0036		
		169	100	5.2256	0.0035		
		170	101	5.2303	0.0036		
		171	102	5.2388	0.0037		
		172	103	5.2411	0.0052		
70	**Yb**	152	82	5.0423	0.0146	*5.0423*	*0.0146*
		154	84	5.0875	0.0105	*5.0875*	*0.0105*
		155	85	5.1040	0.0110	*5.1040*	*0.0110*
		156	86	5.1219	0.0103	*5.1219*	*0.0103*
		157	87	5.1324	0.0100	*5.1324*	*0.0100*
		158	88	5.1498	0.0088	*5.1498*	*0.0088*
		159	89	5.1629	0.0084	*5.1629*	*0.0084*
		160	90	5.1781	0.0076	*5.1781*	*0.0076*

		161	91	5.1889	0.0072	*5.1889*	*0.0072*
		162	92	5.2054	0.0067	*5.2054*	*0.0067*
		163	93	5.2157	0.0064	*5.2157*	*0.0064*
		164	94	5.2307	0.0060	*5.2307*	*0.0060*
		165	95	5.2399	0.0058	*5.2399*	*0.0058*
		166	96	5.2525	0.0057	*5.2525*	*0.0057*
		167	97	5.2621	0.0056	*5.2621*	*0.0056*
		168	98	5.2702	0.0056	*5.2702*	*0.0056*
		169	99	5.2771	0.0056	*5.2771*	*0.0056*
		170	100	5.2853	0.0056	*5.2853*	*0.0056*
		171	101	5.2906	0.0057	*5.2906*	*0.0057*
		172	102	5.2995	0.0058	*5.2995*	*0.0058*
		173	103	5.3046	0.0059	*5.3046*	*0.0059*
		174	104	5.3108	0.0060	*5.3108*	*0.0060*
		175	105	5.3135	0.0061	*5.3135*	*0.0061*
		176	106	5.3215	0.0062	*5.3215*	*0.0062*
		177	107			5.3239	0.0062
71	**Lu**	161	90	5.2293	0.0320		
		162	91	5.2398	0.0317		
		163	92	5.2567	0.0312		
		164	93	5.2677	0.0310		
		165	94	5.2830	0.0307		
		166	95	5.2972	0.0305		
		167	96	5.3108	0.0303		
		168	97	5.3227	0.0302		
		169	98	5.3290	0.0302		
		170	99	5.3364	0.0302		
		171	100	5.3436	0.0302		
		172	101	5.3486	0.0302		
		173	102	5.3577	0.0303		
		174	103	5.3634	0.0303		
		175	104	5.3700	0.0304		
		176	105	5.3739	0.0304		
		177	106	5.3815	0.0305		
		178	107	5.3857	0.0306		
		179	108	5.3917	0.0307		
72	**Hf**	170	98	5.2898	0.0055		
		171	99	5.3041	0.0049		
		172	100	5.3065	0.0043		
		173	101	5.3140	0.0038		
		174	102	5.3201	0.0035		
		175	103	5.3191	0.0036		
		176	104	5.3286	0.0032		
		177	105	5.3309	0.0031		
		178	106	5.3371	0.0031		
		179	107	5.3408	0.0031		
		180	108	5.3470	0.0032		
		182	110	5.3516	0.0036		
73	**Ta**	181	108	5.3507	0.0034		
74	**W**	180	106	5.3491	0.0022		
		182	108	5.3559	0.0017		
		183	109	5.3611	0.0020		
		184	110	5.3658	0.0023		
		186	112	5.3743	0.0026		
75	**Re**	185	110	5.3596	0.0172		
		187	112	5.3698	0.0173		
76	**Os**	184	108	5.3823	0.0022		
		186	110	5.3909	0.0017		
		187	111	5.3933	0.0018		

		188	112	5.3993	0.0011
		189	113	5.4016	0.0012
		190	114	5.4062	0.0013
		192	116	5.4126	0.0015
77	**Ir**	182	105	5.3705	0.1061
		183	106	5.3780	0.1061
		184	107	5.3805	0.1061
		185	108	5.3854	0.1061
		186	109	5.3900	0.1061
		187	110	5.3812	0.1061
		188	111	5.3838	0.1061
		189	112	5.3898	0.1061
		191	114	5.3968	0.1061
		193	116	5.4032	0.1061
78	**Pt**	178	100	5.3728	0.0066
		179	101	5.3915	0.0050
		180	102	5.3891	0.0049
		181	103	5.3996	0.0041
		182	104	5.3969	0.0041
		183	105	5.4038	0.0036
		184	106	5.4015	0.0036
		185	107	5.4148	0.0028
		186	108	5.4037	0.0036
		187	109	5.4063	0.0037
		188	110	5.4053	0.0034
		189	111	5.4060	0.0035
		190	112	5.4108	0.0030
		191	113	5.4102	0.0031
		192	114	5.4169	0.0028
		193	115	5.4191	0.0027
		194	116	5.4236	0.0025
		195	117	5.4270	0.0026
		196	118	5.4307	0.0027
		198	120	5.4383	0.0032
79	**Au**	183	104	5.4247	0.0043
		184	105	5.4306	0.0041
		185	106	5.4296	0.0041
		186	107	5.4354	0.0039
		187	108	5.4018	0.0058
		188	109	5.4049	0.0055
		189	110	5.4084	0.0052
		190	111	5.4109	0.0049
		191	112	5.4147	0.0046
		192	113	5.4179	0.0044
		193	114	5.4221	0.0042
		194	115	5.4252	0.0040
		195	116	5.4298	0.0040
		196	117	5.4332	0.0039
		197	118	5.4371	0.0038
		198	119	5.4400	0.0038
		199	120	5.4454	0.0039
80	**Hg**	181	101	5.4364	0.0032
		182	102	5.3833	0.0052
		183	103	5.4405	0.0031
		184	104	5.3949	0.0047
		185	105	5.4397	0.0031
		186	106	5.4017	0.0043
		187	107	5.4046	0.0042
		188	108	5.4085	0.0040
		189	109	5.4100	0.0040

		190	110	5.4158	0.0037		
		191	111	5.4171	0.0037		
		192	112	5.4232	0.0035		
		193	113	5.4238	0.0035		
		194	114	5.4309	0.0033		
		195	115	5.4345	0.0032		
		196	116	5.4385	0.0031		
		197	117	5.4412	0.0031		
		198	118	5.4463	0.0031		
		199	119	5.4474	0.0031		
		200	120	5.4551	0.0031		
		201	121	5.4581	0.0032		
		202	122	5.4648	0.0033		
		203	123	5.4679	0.0035		
		204	124	5.4744	0.0036		
		205	125	5.4776	0.0038		
		206	126	5.4837	0.0040		
81	**Tl**	183	102			5.3786	0.0105
		185	104			5.3896	0.0098
		188	107	5.4017	0.0072	*5.4017*	*0.0072*
		190	109	5.4121	0.0056	*5.4121*	*0.0056*
		191	110	5.4169	0.0048	*5.4169*	*0.0048*
		192	111	5.4191	0.0051	*5.4191*	*0.0051*
		193	112	5.4243	0.0042	*5.4243*	*0.0042*
		194	113	5.4259	0.0046	*5.4259*	*0.0046*
		195	114	5.4325	0.0039	*5.4325*	*0.0039*
		196	115	5.4327	0.0042	*5.4327*	*0.0042*
		197	116	5.4388	0.0036	*5.4388*	*0.0036*
		198	117	5.4396	0.0036	*5.4396*	*0.0036*
		199	118	5.4479	0.0031	*5.4479*	*0.0031*
		200	119	5.4491	0.0031	*5.4491*	*0.0031*
		201	120	5.4573	0.0029	*5.4573*	*0.0029*
		202	121	5.4595	0.0027	*5.4595*	*0.0027*
		203	122	5.4666	0.0027	*5.4666*	*0.0027*
		204	123	5.4704	0.0028	*5.4704*	*0.0028*
		205	124	5.4759	0.0026	*5.4759*	*0.0026*
		207	126	5.4853	0.0027	*5.4853*	*0.0027*
		208	127	5.4946	0.0028	*5.4946*	*0.0028*
82	**Pb**	182	100	5.3788	0.0035		
		183	101	5.3869	0.0030		
		184	102	5.3930	0.0029		
		185	103	5.3984	0.0028		
		186	104	5.4027	0.0027		
		187	105	5.4079	0.0026		
		188	106	5.4139	0.0025		
		189	107	5.4177	0.0024		
		190	108	5.4222	0.0023		
		191	109	5.4229	0.0026		
		192	110	5.4300	0.0025		
		193	111	5.4310	0.0023		
		194	112	5.4372	0.0023		
		195	113	5.4389	0.0045		
		196	114	5.4444	0.0024		
		197	115	5.4446	0.0024		
		198	116	5.4524	0.0022		
		199	117	5.4529	0.0022		
		200	118	5.4611	0.0020		
		201	119	5.4629	0.0019		
		202	120	5.4705	0.0017		
		203	121	5.4727	0.0017		
		204	122	5.4803	0.0014		
		205	123	5.4828	0.0015		

		206	124	5.4902	0.0014		
		207	125	5.4943	0.0014		
		208	126	5.5012	0.0013		
		209	127	5.5100	0.0014		
		210	128	5.5208	0.0016		
		211	129	5.5290	0.0017		
		212	130	5.5396	0.0019		
		214	132	5.5577	0.0023		
83	**Bi**	202	119	5.4840	0.0912		
		203	120	5.4911	0.0911		
		204	121	5.4934	0.0910		
		205	122	5.5008	0.0909		
		206	123	5.5034	0.0909		
		207	124	5.5103	0.0907		
		208	125	5.5147	0.0907		
		209	126	5.5211	0.0906		
		210	127	5.5300	0.0904		
		212	129	5.5489	0.0901		
		213	130	5.5586	0.0900		
84	**Po**	192	108	5.5220	0.0178	*5.5220*	0.0194
		193	109			5.5185	0.0189
		194	110	5.5167	0.0178	*5.5167*	0.0192
		195	111			5.5127	0.0189
		196	112	5.5136	0.0178	*5.5136*	0.0189
		197	113			5.5112	0.0189
		198	114	5.5146	0.0178	*5.5146*	0.0193
		199	115			5.5123	0.0189
		200	116	5.5199	0.0178	*5.5199*	0.0190
		201	117			5.5190	0.0189
		202	118	5.5281	0.0177	*5.5281*	0.0191
		203	119			5.5297	0.0189
		204	120	5.5378	0.0177	*5.5378*	0.0189
		205	121	5.5389	0.0177	*5.5389*	0.0189
		206	122	5.5480	0.0177	*5.5480*	0.0189
		207	123	5.5501	0.0177	*5.5501*	0.0189
		208	124	5.5584	0.0176	*5.5584*	*0.0176*
		209	125	5.5628	0.0176	5.5631	0.0187
		210	126	5.5704	0.0176	*5.5704*	0.0185
		211	127			5.5798	0.0187
		216	132	5.6359	0.0174	5.6394	0.0186
		218	134	5.6558	0.0173	*5.6558*	0.0186
86	**Rn**	202	116	5.5521	0.0181		
		204	118	5.5568	0.0180		
		205	119	5.5569	0.0180		
		206	120	5.5640	0.0178		
		207	121	5.5652	0.0178		
		208	122	5.5725	0.0177		
		209	123	5.5743	0.0177		
		210	124	5.5813	0.0177		
		211	125	5.5850	0.0176		
		212	126	5.5915	0.0176		
		218	132	5.6540	0.0187		
		219	133	5.6648	0.0191		
		220	134	5.6731	0.0194		
		221	135	5.6834	0.0199		
		222	136	5.6915	0.0203		
87	**Fr**	202	115			5.5505	0.0178
		203	116			5.5560	0.0178
		205	118			5.5609	0.0178
		207	120	5.5720	0.0176	5.5689	0.0177

		208	121	5.5729	0.0176	5.5699	0.0177
		209	122	5.5799	0.0176	5.5780	0.0177
		210	123	5.5818	0.0176	5.5803	0.0177
		211	124	5.5882	0.0176	5.5876	*0.0176*
		212	125	5.5915	0.0176	*5.5915*	*0.0176*
		213	126	5.5977	0.0176	5.5986	*0.0176*
		220	133	5.6688	0.0177	5.6803	0.0174
		221	134	5.6790	0.0177	5.6920	0.0173
		222	135	5.6890	0.0177	5.7018	0.0173
		223	136	5.6951	0.0178	5.7104	0.0173
		224	137	5.7061	0.0178	5.7229	0.0173
		225	138	5.7112	0.0178	5.7288	0.0173
		226	139	5.7190	0.0178	5.7376	0.0172
		227	140	5.7335	0.0179	5.7542	0.0172
		228	141	5.7399	0.0179	5.7614	0.0172
88	**Ra**	208	120	5.5850	0.0183		
		209	121	5.5853	0.0182		
		210	122	5.5917	0.0180		
		211	123	5.5929	0.0179		
		212	124	5.5991	0.0177		
		213	125	5.6020	0.0177		
		214	126	5.6079	0.0177		
		220	132	5.6683	0.0215		
		221	133	5.6795	0.0228		
		222	134	5.6874	0.0239		
		223	135	5.6973	0.0253		
		224	136	5.7046	0.0263		
		225	137	5.7150	0.0279		
		226	138	5.7211	0.0288		
		227	139	5.7283	0.0300		
		228	140	5.7370	0.0315		
		229	141	5.7455	0.0329		
		230	142	5.7551	0.0346		
		232	144	5.7714	0.0375		
90	**Th**	227	137	5.7404	0.0165		
		228	138	5.7488	0.0152		
		229	139	5.7557	0.0143		
		230	140	5.7670	0.0131		
		232	142	5.7848	0.0124		
92	**U**	233	141	5.8203	0.0049		
		234	142	5.8291	0.0052		
		235	143	5.8337	0.0041		
		236	144	5.8431	0.0038		
		238	146	5.8571	0.0033		
94	**Pu**	238	144	5.8535	0.0378		
		239	145	5.8601	0.0378		
		240	146	5.8701	0.0379		
		241	147	5.8748	0.0379		
		242	148	5.8823	0.0380		
		244	150	5.8948	0.0382		
95	**Am**	241	146	5.8928	0.0042		
		243	148	5.9048	0.0035		
96	**Cm**	242	146	5.8285	0.0192		
		244	148	5.8429	0.0181		
		245	149	5.8475	0.0182		
		246	150	5.8562	0.0184		
		248	152	5.8687	0.0193		

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