Supporting Information

Atomic / Ionic Radius as Mathematical Limit of System Energy Evolution

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Table S1. Experimental static dipole polarizabilities of ions, in a_0^3. *) The polarizability of Li^{-1} is predicted value.

Ion		**Static Dipole Polarizability**
H	-1	211.49 [1], 230.1 [2,3], 212 [4], 203.8 [5]
Li	-1	1050.0 *[,6]
	+1	0.193 [1], 0.202 [7], 0.1883 [8], 0.159 [9], 0.191 [10-12], 0.216 [13], 0.202 [14], 0.16 [15], 0.169 [16],
Be	+2	0.0398 [9], 0.047 [1,15,16], 0.027 [17]
B	+3	0.019 [9], 0.013 [15,17], 0.0223 [1,16]
C	+4	0.0088 [9], 0.00999 [12], 0.0067 [15], 0.00810 [17], 0.0101 [1,16]
N	+4	1.606 [18]
O	-2	3.4-21.6 [7], 18.56 [17], 52.37 [19]
F	-1	4.32 [7], 10.53 [11], 6.68 [1,22], 6.61 [17], 12.41 [19], 13.56 [19], 7.33 [17,20,21], 8.01 [21,22]
Ne	+1	1.3028 [23], 1.310 [23]
Na	+1	1.147 [1,16], 0.9987 [10,11,27], 1.316 [13], 1.181 [15], 1.32 [17],0.30 [17,20,21], 0.11 [21,22], 1.49 [21,22], 0.978 [24], 1.0015 [25], 0.9980 [26]
Mg	+1	34.62 [28], 33.0 [29], 33.8 [30], 35.02 [31]
	+2	0.675 [1,16], 0.63 [15], 0.742 [17], 0.810 [17], 0.489 [24], 0.486 [32],
Al	+1	24.20 [33]
	+2	12.18 [34]
	+3	0.36 [15], 0,452 [17], 0.358 [1,16,35]
Si	+2	11.666 [36], 11.669 [37]
	+3	6.858 [38], 7.404 [39]
	+4	0.22 [15], 0.27 [17], 0.29 [1,22]
P	+3	6.312 [40]
	+4	3.699 [41]
	+5	0.14 [15]

S	-2	32.4-39.8 [7], 58.04 [17],
	+4	4.49 [33]
	+5	2.45 [42]
Cl	-1	19.98 [7], 29.76 [11], 23.82 [17], 32.93 [19], 23.69 [17,20,21], 21.74 [21,22], 22.93 [21,22], 20.58 [1,22]
	+5	2.77 [33]
	+6	1.62 [43]
Ar	+6	2.00 [33]
K	+1	5.47 [11,24], 5.54 [15], 5.932 [17], 5.94 [17], 5.40 [1,16]
Ca	+1	70.89 [28], 75.3 [44], 72.5 [45], 73.89 [46], 74.05 [47], 76.1 [48]
	+2	3.16 [15], 3.64 [1,16], 3.44 [17], 3.017 [17], 3.26 [24], 3.17 [49], 7.42 [49]
Sc	+3	1.94 [15], 2.36 [17]
Ti	+4	1.24 [15], 1.59 [17]
V	+5	0.823 [15]
Cr	+6	0.57 [15]
Ni	+1	7.92 [50], 7.949 [51]
Cu	+1	10.8 [52]
Zn	+2	1.91 [15], 1.95 [21]
Ga	+1	18.14 [33]
	+3	1.32 [15]
Ge	+2	10.68 [33]
	+4	0.924 [15]
As	+3	6.19 [33]
	+5	0.674 [15]
Se	-2	40.5-50.6 [7], 75.58 [17]
	+4	4.61 [33]
	+6	0.49 [15]
Br	-1	28.07 [7], 39.41 [11], 33.54 [17], 32.83 [17,20,21], 29.91 [21,22], 31.91 [21,22]
	+5	3.37 [33]
Kr	+6	2.70 [33]
	+7	2.69 [53]
Rb	+1	9.25 [11], 9.697 [15], 10.1 [16], 10.53 [17], 9.63 [17,21,22], 10.20 [21,22], 11.09 [21,22], 9.0 [54], 9.05 [55]
Sr	+2	5.81 [15], 6.7 [16], 5.959 [17], 5.80 [17], 5.20 [55]
Y	+3	3.67 [15]
Zr	+4	2.41 [15]
Nb	+5	1.63 [15]
Mo	+6	1.14 [15]
Ag	+1	11.01 [15], 11.71 [21]
Cd	+2	7.11 [15], 7.41 [21]

In	+1	18.8 [33]
	+3	4.46 [15]
Sn	+2	11.9 [33]
	+4	3.23 [15]
Sb	+3	7.19 [33]
	+5	2.25 [15]
Te	-2	56.0-68.8 [7], 105.95 [17],
	+4	5.50 [33]
	+6	1.63 [15]
I	-1	43.39 [7], 60.13 [11], 50.95 [17], 48.87 [17,21,22], 43.92 [21,22], 46.03 [21,22],
	+5	4.04 [33]
Xe	+6	3.28 [33]
Cs	+1	16.53 [11], 15.86 [16], 17.28 [17], 16.69 [17,21,22], 16.85 [21,22], 17.36 [21,22], 15.3 [56]
Ba	+2	10.76 [15], 11.34 [17], 10.1 [56]
La	+3	7.099 [15], 8.77 [17]
Ce	+4	4.74 [15]
Yb	+1	47 [57]
Hf	+4	2.48 [15]
Ta	+5	1.25 [15]
W	+6	0.99 [15]
Au	+1	13.95 [15]
Hg	+2	9.32 [15], 8.49 [21]
Tl	+1	12.7 [33]
Pb	+2	24.45 [15], 7.8 [33],13.62 [58], 13.38 [59]
	+3	13.38 [59]
	+4	3.61 [58], 3.63 [60]
Bi	+3	5.7 [33]
Po	+4	4.3 [33]
At	+5	3.33 [33]
Rn	+6	2.64 [33]
Fr	+7	2.15 [33]
Ra	+8	1.78 [33]
Ac	+9	1.49 [33]
Th	+3	15.42 [61]
	+4	7.702 [61], 7.61 [62], 7.02 [63], 7.72 [64]
	+10	1.26 [33]
Pa	+11	1.08 [33]
U	+12	0.94 [33]

Table S2. Hardness of cations calculated from experimental ionization potentials [65], in Hartree.

		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
2	He	0.548											
3	Li	1.291	0.860										
4	Be	0.163	2.493	1.173									
5	B	0.310	0.235	4.069	1.486								
6	C	0.241	0.432	0.305	6.019	1.799							
7	N	0.277	0.328	0.552	0.375	8.345	2.113						
8	O	0.395	0.364	0.413	0.670	0.445	11.046	2.428					
9	F	0.322	0.510	0.449	0.498	0.789	0.515	14.125	2.742				
10	Ne	0.356	0.413	0.619	0.535	0.583	0.907	0.585	17.579	3.057			
11	Na	0.774	0.447	0.501	0.726	0.621	0.667	1.024	0.654	21.411	3.373		
12	Mg	0.136	1.196	0.535	0.588	0.836	0.703	0.752	1.141	0.725	25.620	3.691	
13	Al	0.236	0.177	1.682	0.622	0.674	0.942	0.788	0.835	1.261	0.795	30.207	4.009
14	Si	0.151	0.315	0.214	2.235	0.707	0.758	1.048	0.874	0.923	1.378	0.865	35.173
15	P	0.171	0.192	0.390	0.250	2.855	0.793	0.846	1.149	0.960	1.012	1.495	0.936
16	S	0.238	0.210	0.228	0.466	0.284	3.544	0.878	0.933	1.249	1.053	1.096	1.613
17	Cl	0.199	0.290	0.255	0.263	0.537	0.315	4.301	0.951	1.021	1.353	1.152	1.189
18	Ar	0.218	0.241	0.350	0.279	0.294	0.612	0.352	5.126	1.033	1.107	1.457	1.247
19	K	0.501	0.260	0.278	0.400	0.308	0.334	0.686	0.385	6.027	1.119	1.189	1.566
20	Ca	0.106	0.717	0.301	0.317	0.446	0.338	0.368	0.759	0.418	6.994	1.200	1.275
21	Sc	0.115	0.220	0.895	0.334	0.350	0.502	0.369	0.403	0.830	0.452	8.040	1.274
22	Ti	0.124	0.256	0.290	1.030	0.372	0.391	0.544	0.399	0.438	0.903	0.486	9.120
23	V	0.145	0.269	0.320	0.341	1.155	0.413	0.419	0.595	0.454	0.463	0.963	0.518
24	Cr	0.179	0.266	0.334	0.373	0.389	1.278	0.451	0.452	0.645	0.485	0.500	1.044
25	Mn	0.151	0.331	0.322	0.390	0.426	0.434	1.384	0.502	0.487	0.693	0.522	0.537
26	Fe	0.152	0.266	0.444	0.371	0.443	0.476	0.479	1.517	0.524	0.516	0.746	0.555
27	Co	0.169	0.302	0.327	0.518	0.413	0.494	0.531	0.521	1.640	0.544	0.570	0.790
28	Ni	0.193	0.313	0.362	0.389	0.587	0.459	0.533	0.570	0.581	1.771	0.570	0.588
29	Cu	0.231	0.304	0.377	0.412	0.426	0.661	0.496	0.606	0.606	0.612	1.905	0.588
30	Zn	0.157	0.400	0.362	0.426	0.467	0.478	0.735	0.533	0.643	0.661	0.676	2.001
31	Ga	0.267	0.187	0.612									
32	Ge	0.148	0.336	0.211	0.878								
33	As	0.163	0.179	0.400	0.230	1.194							
34	Se	0.210	0.177	0.223	0.466	0.246	1.354						
35	Br	0.183	0.261	0.208	0.228	0.531	0.265	1.650					
36	Kr	0.190	0.231	0.286	0.224	0.254	0.597	0.272	1.930	0.686	0.731	0.772	0.753
37	Rb	0.425	0.234	0.232	0.338	0.246	0.272	0.676	0.257	2.335			
38	Sr	0.098	0.585	0.259	0.268	0.353	0.279	0.300	0.729	0.276	2.703		
39	Y	0.111	0.152	0.736	0.301	0.294	0.423	0.239	0.316	0.823	0.276	3.087	
40	Zr	0.119	0.181	0.209	0.845								
41	Nb	0.139	0.197	0.244	0.225	0.946	0.422						
42	Mo	0.167	0.202	0.354	0.149	0.263	1.044	0.330	0.377	0.409	0.421	0.385	0.897
43	Tc	0.147	0.262										
44	Ru	0.173	0.215										
45	Rh	0.195	0.239										

46	Pd	0.204	0.248				
47	Ag	0.256	0.245				
48	Cd	0.145	0.378				
49	In	0.240	0.168	0.477			
50	Sn	0.134	0.292	0.188	0.580		
51	Sb	0.146	0.161	0.347	0.217	0.955	
52	Te	0.176	0.172	0.174	0.392	0.220	1.218
53	I	0.159	0.255				
54	Xe	0.167	0.201				
55	Cs	0.354					
56	Ba	0.088					
57	La	0.101	0.149	0.565	0.214		
58	Ce	0.098	0.172	0.304	0.529	0.221	
59	Pr	0.093	0.203	0.319	0.341		
60	Nd	0.096	0.209	0.336			
61	Pm	0.098	0.209	0.345			
62	Sm	0.100	0.227	0.331			
63	Eu	0.102	0.251	0.327			
64	Gd	0.109	0.157	0.429			
65	Tb	0.104	0.191	0.329			
66	Dy	0.105	0.205	0.343			
67	Ho	0.106	0.203	0.361			
68	Er	0.107	0.199	0.367			
69	Tm	0.108	0.214	0.349			
70	Yb	0.109	0.237	0.340			
71	Lu	0.156	0.130	0.446	0.396		
72	Hf	0.148	0.154	0.184			
...							
78	Pt	0.176	0.173				
79	Au	0.207	0.175				
80	Hg	0.153	0.284				
81	Tl	0.263	0.173				
82	Pb	0.140	0.311	0.191	0.487		
83	Bi	0.173	0.163	0.363	0.197	0.593	-1.622
...							
88	Ra	0.089					
89	Ac	0.127					
90	Th	0.095	0.156	0.162			

Table S3. Experimental vs. theoretical polarizabilities in Zn^{2+}, Ag^{+}, Tl^{+} isoelectronic series.

Ions		Expr.	Theoretical
Zn	+2	1.91 [15], 1.95 [21]	2.24 [66], 2.294 [67], 2.132 [68], 2.658 [68], 2.206 [68], 2.732 [68]
Ga	+3	1.32 [15]	1.35 [21], 1.228 [66], 1.242 [67]
Ge	+4	0.924 [15]	0.97 [21], 0.762 [67]
As	+5	0.674 [15]	0.70 [21], 0.506 [67]
Se	+6	0.49 [15]	0.51 [21], 0.358 [67]
Ag	+1	11.71 [21], 11.01 [15]	8.27 [66], 7.78 [69], 8.23 [69], 8.40 [69], 8.93 [69], 8.68 [69], 9.20 [69], 8.47 [69], 9.00 [69], 6.88 [69], 7.29 [69], 7.56 [69], 7.96 [69], 10.598 [70]
Cd	+2	7.41 [21], 7.11 [15]	4.70 [66], 4.974 [67], 4.450 [68], 4.776 [68], 4.668 [68], 4.994 [68]
In	+3	4.46 [15]	4.98 [21], 3.220 [67], 3.345 [71]
Sn	+4	3.23 [15]	3.41 [21], 2.261 [67]
Sb	+5	2.25 [15]	2.46 [21], 1.680 [67]
Te	+6	1.63 [15]	1.78 [21]
Tl	+1	12.7 [33]	35.1 [72], 21.43 [73],
Pb	+2	24.45 [15], 7.8 [33],13.62 [58], 13.38 [59]	17.88 [67]
Bi	+3	5.7 [33]	10.18 [72]

References

1. Dalgarno, A., Atomic Polarizabilities and Shielding Factors. *Advan. Phys*. **1962**, 11, 281-315.

2. Bates, D.R.; Lewis, J .T., Inelastic Heavy Particle Collisions Involving the Crossing of Potential Energy Curves III: Charge Transfer from Negative Ions of Atomic Hydrogen to Protons. *Proc. Phys. Soc. A* **1955**, 68, 173-180.
3. Dalgarno, A.; Stewart, A.L., A Perturbation Calculation of Properties of the Helium Iso-Electronic Sequence. *Proc. R. Soc. London A* **1958**, 247, 245-259.
4. Schwartz, C., Lamb Shift in the Helium Atom. *Phys. Rev.* **1961**, 123, 1700-1705.
5. Geltman, S., The Bound-Free Absorption Coefficient of the Hydrogen Negative Ion. *Astrophys. J.* **1962**, 136, 935-945.
6. Cohen, H.D. Electric-Dipole Polarizability of Atoms by the Hartree-Fock Method. II. The Isoelectronic Two- and Four-Electron Series. *J. Chem. Phys.* **1965**, 43, 3558-3562.
7. Tessman, J.R.; Kahn, A.H.; Shockley, W., Electronic Polarizabilities of Ions in Crystals. *Phys. Rev.* **1953**, 92, 890-895.
8. Cooke, W.E.; Gallagher, T.F.; Hill, R.M.; Edelstein, S.A., Resonance Measurements of d-f and d-g Intervals in Lithium Rylberg States. *Phys. Rev. A* **1977**, 16, 1141-1145.
9. Sternheimer, R.M. Electronic Polarizabilities of Ions from the Hartree-Fock Wave Functions. *Phys. Rev.* **1954**, 96, 951-968.
10. Risberg, P., A Revision of the Term Systems for NaI and KI Based on Hollow Cathode Observations. *Arkiv. Fysik* **1956**, 10, 583-605.
11. Wilson, J.N.; Curtis, R.M., Dipole Polarizabilities of Ions in Alkali Halide Crystals. *J. Phys. Chem.* **1970**, 74, 187-196.
12. Blockasten, K., A Study of CIV - Term Values, Series Formulae, and Stark Effect. *Arkiv. Fysik* **1956**, 10, 567-582.
13. Fajans, K. , *Encyclopedia of Chemistry*; Clark and Hawley Reinhold Publ. Co.: New York; **1957**, p 764.
14. Mitskevich, V.V., Deviation from polarizability additivity and diamagnetic susceptibilities in cubic ion crystals. *Soviet Phys. Solid State* **1964**, 6, 557-562.
15. Kordes, E., Relation Between Fine Structure and Physical Properties of Glasses. *Z. Phys. Chem.* **1939**, B44, 249-260.
16. Mayer, J.E.; Mayer, M.G., The Polarizabilities of Ions from Spectra. *Phys. Rev.* **1933**, 43, 605-611.
17. Fajans, K.; Joos, G. Molrefraktion von Ionen und Molekülen im Lichte der Atomstruktur. *Z. Physik* **1924**, 23, 1-46.
18. Hallin, R., The spectrum of N IV. *Ark. Fys.* **1966**, 32, 201-210.
19. Fowler, P.W.; Tole, P., Anionic Polarisability in Halides and Chalcogenides. *Rev. Solid State Sci*. **1991**, 5, 149–176.
20. Heydweiller, A., Optische Untersuchungen an Wasserigen Elektrolytlosungen. *Phys. Z.* **1925**, 26, 526-556.

21. Pauling, L., The Theoretical Prediction of the Physical Properties of Many-Electron Atoms and Ions. Mole Refraction, Diamagnetic Susceptibility, and Extension in Space. *Proc. R. Soc. London A* **1927**, 114, 181-211.
22. Born, M.; Heisenberg, W., Über den Einfluß der Deformierbarkeit der Ionen auf optische und chemische Konstanten. I. *Z. Physik* **1924**, 23, 388-410.
23. Ward, Jr., R.F.; Sturrus, W.G.; Lundeen, S.R., Microwave Spectroscopy of High-L Rydberg States of Neon. *Phys. Rev. A* **1996**, 53, 113-121.
24. Öpik, U., The Polarization of a Closed-Shell Core of an Atomic System by an Outer Electron II. Pvaluation of the Polarizabilities from Observed Spectra. *Proc. Phys. Soc. London* **1967**, 92, 566-572.
25. Freeman, R.R.; Kleppner, D., Core Polarization and Quantum Defects in High-Angular-Momentum States of Alkali Atoms. *Phys. Rev. A* **1976**, 14, 1614-1619.
26. Gray, L.G.; Sun, X.; MacAdam, K.B., Resonance Measurements of d-f-g-h Intervals in Rydberg States of Sodium and a Redetermination of the Core Polarizabilities. *Phys. Rev. A* **1988**, 38, 4985-4993.
27. Lim, I.S.; Schwerdtfeger, P., Four-Component and Scalar Relativistic Douglas-Kroll Calculations for Static Dipole Polarizabilities of the Alkaline-Earth-Metal Elements and Their Ions from Ca^n to Ra^n (n=0,+1,+2). *Phys. Rev. A* **2004**, 70, 062501.
28. Theodosiou, C.E.; Curtis, L.J.; Nicolaides, C.A., Determination of Dipole Polarizabilities for Mg+ and Ca+ Ions from Precision Lifetime Measurements and Transition-Moment Cancellations. *Phys. Rev. A* **1995**, 52, 3677-3680.
29. Chang, E.S.; Noyes, R.W., Solar Emission Lines Near 12 Microns. *Astrophys. J.* **1983**, 275, L61-L66.
30. Lyons, B.J.; Gallagher, T.F., Mg 3snf−3sng−3snh−3sni Intervals and the Mg+ Dipole Polarizability. *Phys. Rev. A* **1998**, 57, 2426-2429.
31. Mitroy, J.; Zhang, J.Y., Long Range Interactions of the Mg+ and Ca+ Ions. *Eur. Phys. J. D* **2008**, 46, 415-424.
32. Bockasten, K., Polarizability of Mg+2 Derived from Hydrogen-Like Terms of Mg II. *Phys. Rev.* **1956**, 102, 729-730.
33. Reshetnikov, N.; Curtis, L.J.; Brown, M.S.; Irving, R.E., Determination of Polarizabilities and Lifetimes for the Mg, Zn, Cd and Hg Isoelectronic Sequences. *Phys. Scr*. **2008**, 77, 015301.
34. Muszynska, J.; Papierowska, D.; Pipin, J.; Woźnicki, W., Bounds to Atomic Properties: Electric Polarizabilities of Lithium Isoelectronic Sequence Ions. *Int. Qumtum. Chem*. **1982**, 22, 1153-1175.
35. Originaly erroneous value 3.58, obviously is missing 10^{-1} factor.
36. Komara, R.A.; Gearba, M.A.; Fehrenbach, C.W.; Lundeen, S.R., Ion Properties from High-L Rydberg Fine Structure: Dipole Polarizability of Si^{2+}. *J. Phys. B* **2005**, 38, S87-S95.

37. Mitroy, J., Polarizability of the Si^{2+} Ion. *Phys. Rev. A* **2008**, 78, 052515.
38. Toresson, Y.G., Spectrum and Term System of Doubly Ionized Silicon, Si III. *Arkiv. Fysik* **1960**, 18, 389-416.
39. Komara, R.A.; Gearba, M.A.; Lundeen, S.R.; Fehrenbach, C.W., Determination of the Polarizability of Na-Like Silicon by Study of the Fine Structure of High-L Rydberg States of Si^{2+}. *Phys. Rev. A* **2003**, 67, 062502.
40. Magnusson, C.E.; Zetterberg P.O., The Spectrum of Doubly Ionized Phosphorus, P III. *Phys. Scr.* **1977**, 15, 237–250.
41. Zetterberg, P.O.; Magnusson, C.E., The Spectrum and Term System of P IV. *Physica Scripta* **1977**, 15, 189-201.
42. Dynefors, B.I.; Martinson, I., Beam-Foil Studies of Ionized Sulfur. *Physica Scripta* **1978**, 17, 123-129.
43. Bashkin, S.; Bromander, J.; Leavitt, J.A.; Martinson, I., Beam-Foil Studies of Radiative Transitions and Lifetimes in Cl IV - Cl X. *Physica Scripta* **1973**, 8, 285-291.
44. Chang, E.S., Identification of the X State in Ca and a New Rydberg Series. *J. Phys. B* **1983**, 16, L539-L542.
45. Curtis, L.J., Dipole Polarisabilities for Single Valence Electron Ions. *Phys. Scr.* **1980**, 21, 162-164.
46. Sahoo, B.K.; Das, B.P.; Mukherjee, D., Relativistic Coupled-Cluster Studies of Ionization Potentials, Lifetimes, and Polarizabilities in Singly Ionized Calcium. *Phys. Rev. A* **2009**, 79, 052511.
47. Theodosiou, C.E.; Curtis, L.J.; Nicolaides, C.A. , Determination of Dipole Polarizabilities for Mg+ and Ca+ Ions From Precision Lifetime Measurements and Transition-Moment Cancellations. *Phys. Rev. A* **1995**, 52, 3677-3680.
48. Arora, B.; Safronova, M.S. ; Clark, C.W. , Determination of Electric-Dipole Matrix Elements in K and Rb From Stark Shift Measurements. *Phys. Rev. A* **2007**, 76, 052516.
49. Fischer-Hjalmars, I.; Sundbom, M., Theoretical Determination of the Electronic Polarizability of Lithium and Scandium. *Acta Chem. Scand*. **1957**, 11, 1068-1069.
50. Keele, J.A.; Woods, S.L.; Hanni, M.E.; Lundeen, S.R.; Sturrus, W.G., Optical Spectroscopy of High-L Rydberg States of Nickel. *Phys. Rev. A* **2010**, 81, 022506.
51. Woods, S.; Smith, C.; Keele, J.; Lundeen, S.R.; Microwave Spectroscopy of High-L, n = 9 Rydberg Levels of Nickel: Polarizabilities and Moments of the Ni+ Ion. *Phys. Rev. A* **2013**, 87, 022511.
52. Sternheimer, R.M., Electronic Polarizabilities of Ions from the Hartree-Fock Wave Functions. *Phys. Rev*. **1954**, 96, 951-968.
53. Lundeen, S.R.; Fahrenbach, C.W., Polarizability of Kr^{6+} from High-L Kr^{5+} Fine-Structure Measurements. *Phys. Rev. A* **2007**, 75, 032523.

54. Johansson, I., Spectra of the alkali metals in the lead-sulphide region. *Ark. Fys.* **1961**, 20, 135-146.
55. Miller, T.M.; Bederson, B., Atomic and Molecular Polarizabilities-A Review of Recent Advances. *Adv. At. Mol. Phys*. **1977**, 13, 1-55.
56. Fowler, P.W.; Pyper, N.C., In-Crystal Ionic Polarizabilities Derived by Combining Experimental and ab initio Results. *Proc. R. Soc. A* **1985**, 398, 377-393.
57. Roy, A.; De, S.; Arora, B.; Sahoo, B.K., Accurate Determination of Black-Body Radiation Shift, Magic and Tune-Out Wavelengths for the $^6S_{1/2} \rightarrow {}^5D_{3/2}$ Clock Transition in Yb+. *J. Phys. B* **2017**, 50, 205201.
58. Hanni, M.E.; Keele, J.A.; Lundeen, S.R.; Fehrenbach, C.W.; Sturrus, W.G., Polarizabilities of Pb2+ and Pb4+ and Ionization Energies of Pb^+ and Pb^{3+} from Spectroscopy of High-L Rydberg States of Pb^+ and Pb^{3+}. *Phys. Rev. A* **2010**, 81, 042512.
59. Ross, C.B.; Wood, D.R.; Scholl, P.S., Series Limit and Hydrogenlike Series in PbII. *J. Opt. Soc. Am.* **1976**, 66, 36-39.
60. Safronova, M.S.; Kozlov, M.G.; Safronova, U.I., Atomic Properties of Pb III. *Phys. Rev. A* **2012**, 85, 012507.
61. Keele, J.A.; Hanni, M.E.; Woods, S.L.; Lundeen, S.R.; Fehrenbach, C.W., Properties of Fr-like Th^{3+} from Spectroscopy of High-L Rydberg Levels of Th^{2+}. *Phys. Rev. A* **2011**, 83, 062501.
62. Hanni, M.E.; Keele, J.A.;. Lundeen, S.R.; Fehrenbach, C.W., Polarizability of Rn-Like Th^{4+} from Spectroscopy of High-L Rydberg Levels of Th^{3+}. *Phys. Rev. A* **2010**, 82, 022512.
63. Keele, J.A.; Smith, C.S.; Lundeen, S.R.; Fehrenbach, C.W., Measurements of Dipole and Quadrupole Polarizabilities of Rn-Like Th^{4+}. *Phys. Rev. A* **2012**, 85, 064502.
64. Keele, J.A.; Lundeen, S.R.; Fehrenbach, C.W., Polarizabilities of Rn-Like Th^{4+} from rf Spectroscopy of Th^{3+} Rydberg Levels. *Phys. Rev. A* **2011**, 83, 062509.
65. *CRC Handbook of Chemistry and Physics, 84th Edition*; David, R.L., Eds.; CRC Press: Boca Raton, Florida, 2003**.**
66. Schmidt, P.C.; Weiss, A.; Das, T.P., Effect of Crystal Fields and Self-Consistency on Dipole and Quadrupole Polarizabilities of Closed-Shell Ions. *Phys. Rev. B* **1979**, 19, 5525-5534.
67. Johnson, W.R.; Kolb, D.; Huang, K.-N., Electric-Dipole, Quadrupole, and Magnetic-Dipole Susceptibilities and Shielding Factors for Closed-Shell Ions of the He, Ne, Ar, Ni(Cu^+), Kr, Pb, and Xe Isoelectronic Sequences. *At. Data Nucl. Data Table* **1983**, 28, 333-340.
68. Kellö, V.; Sadlej, A.J. Polarized Basis Sets for High-Level-Correlated Calculations of Molecular Electric Properties. *Theor. Chim. Acta* **1995**, 91, 353-371.
69. Neogrády, P.; Kellö, V.; Urban, M.; Sadlej, A.J., Polarized Basis Sets for High-Level-Correlated Calculations of Molecular Electric Properties. *Theor. Chim. Acta* **1996**, 93, 101-129.

70. Koch, V.; Andrae, D., Static Electric Dipole Polarizabilities for Isoelectronic Sequences. *Int. J. Quant. Chem*. **2011**, 111, 891-903.
71. Yu, Y.-M.; Suo, B.-B.; Feng, H.-H.; Fan, H.; Liu, W.-M.; Finite-Field Calculation of Static Polarizabilities and Hyperpolarizabilities of In+ and Sr. *Phys. Rev. A* **2015**, 92, 052515.
72. Dimitrov, V.; Komatsu, T., Electronic Ion Polarizability, Optical Basicity and Metal (or Nonmetal) Binding Energy of Simple Oxides. *J. Ceram. Soc. Jpn*. **1999**, 107, 879-886.
73. Zuhrianda, Z.; Safronova, M.S.; Kozlov, M.G.; Anomalously Small Blackbody Radiation Shift in the Tl+ Frequency Standard. *Phys. Rev. A* **2012**, 85, 022513.