Table 8. Scaling

Sequence	B_α	d_α	p_α	B_β	d_β	p_β
Mg	2427	2.43	3.18	1148	0.61	3.37
Zn	504.7	1.96	2.42	2545	1.74	3.40
Cd	548.0	2.04	2.38	2667	1.78	3.28
Hg	231.4	2.05	2.08	1509	2.09	3.15

so the ratio of the bracketing width to the lower limit of β decreases even faster, as $1/\zeta^2$. For α_d the relationship is more complicated, but for very large Z the bracketing and the upper limit scale together.

6.3. Charge scaling of the results

The polarizability data in tables 4 - 7 were fitted to the charge scaling equations

$$\alpha_d = \frac{B_\alpha}{(\zeta + d_\alpha)^{p_\alpha}} \; ; \qquad \beta = \frac{B_\beta}{(\zeta + d_\beta)^{p_\beta}} \; . \tag{33}$$

The fitted values are listed in table 8.

7. Relativistic effects in the Hg sequence

Homologous comparisons of these four isoelectronic sequences reveal interesting trends. It can be seen from tables 4-7 that the oscillator strengths $f_{ns,np}$ decrease with increasing ionicity, consistent with the $\Delta n = 0$ scaling with $1/\zeta$ that was predicted in equation (30). However, table 7 reveals that for the Hg sequence the oscillator $f_{6s,6p}$ is nearly constant over the sequence, as would be expected for a $\Delta n \neq 0$ transition as predicted in equation (29). In all four sequences the $E_{ns,np}$ energy decreases with ζ as expected, so the difference in scaling resides in the line strength factor.

The origin of this behavior lies in significant relativistic corrections that affect Hg and its isoelectronic sequence [76, 77]. In earlier studies of the Cd [45] and Hg [31] sequences, multiconfiguration Dirac Hartree Fock (MCDHF) calculations showed that $6s^2$ and 6s6p remain lower than plunging levels from the 5f and 5g subshells for all ions through uranium. In contrast, for the Cd sequence, plunging levels from the 4f subshell perturb the 5s5p levels above Z=60 and for $Z > 62$ the 4f levels replace $5s^2$ as the ground state. Moreover, whereas the mixing angle reduction could be accomplished using the Schrödinger formalism with LS coupling for the Mg, Zn, and Cd sequences, MCDHF calculations for the Hg sequence indicated a significant difference between the Dirac transition matrices $\langle s_{1/2}|r|p_{1/2}\rangle$ and $\langle s_{1/2}|r|p_{3/2}\rangle$, requiring use of the Dirac formalism and jj coupling.

The reasons for these observations are closely related to the unusual fact that mercury is a liquid at ambient temperatures. The 6s electron (and each s electron in the core) is drawn in because of relativistic effects at small r. It can be made plausible in terms of the Bohr orbit picture, since the speed of the 6s electron at periapsis is $v \approx Zc/137$ (for Z=80, $v = 0.58$c). The increase in the relativistic mass causes the effective Bohr radius to shrink (although Zitterbewegung and the Darwin term decrease the effect somewhat). Moreover, the magnetic coupling of the two

paired s electrons is enhanced by the predominance of jj coupling, since spin-own-orbit coupling to the nucleus dominates over spin-spin, orbit-orbit and spin-other-orbit coupling to other electrons. Thus mercury atoms and ions in the Hg sequence behave more like an inert gas than an alkaline earth.

It has been noted [76] that gold and mercury differ in melting points, densities, electrical conductivities, the ability to amalgamate with noble metals, *etc.*, by greater factors than virtually any other pair of neighbors in the Periodic table. Similarly, Tl II is more stable than Tl I, Pb III is more stable than Pb II, and Bi IV is more stable than Bi III. Relativistic calculations have also explained the difference in color between gold and silver [77].

Only the first four members of the Hg sequence are radioactively stable, and measurements of the atomic structure properties of its radioactive members are lacking. However, the atomic properties of the radioactive members have applications in, *e.g.*, modeling calculations of radiation transfer in astrophysical and controlled fusion. Thus semiempirical extrapolations can provide useful estimates for the ions in this sequence with $Z \geq 84$.

8. Conclusions

For atomic systems in which the ground state oscillator strength is dominantly concentrated in one low-lying resonance transition, the method described here provides a powerful means to interconnect measurements and predictions of the quantities α_d, β, and τ. If a precision measurement of τ is available, α_d and β can be deduced. Alternatively, if a precision measurement of α_d is available, τ and β can be deduced. Moreover, screening parametrizations of line strength data permit isoelectronic interpolation of a few precise measurements to obtain estimates of these quantities for the entire sequence. The Mg, Zn, Cd and Hg sequences satisfy these criteria very well, and the results presented here provide an extensive data base spanning both homologous and isoelectronic sequences.

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