Relativistic Corrections

\[ E_{\text{rel}}^1 \sim \frac{Z^2 \alpha^2 m c^2}{2 n^2} \]

unusual metals with large Z: gold (79) and mercury (80)
Relativistic Corrections

<table>
<thead>
<tr>
<th>Atom</th>
<th>Average atomic mass</th>
<th>Ground state configuration</th>
</tr>
</thead>
<tbody>
<tr>
<td>79</td>
<td>Au</td>
<td>[Kr] 4d^{10} 4f^{14} 5s^2 5p^6 5d^{10} 6s^1</td>
</tr>
<tr>
<td>80</td>
<td>Hg</td>
<td>[Kr] 4d^{10} 4f^{14} 5s^2 5p^6 5d^{10} 6s^2</td>
</tr>
<tr>
<td>81</td>
<td>Tl</td>
<td>[Kr] 4d^{10} 4f^{14} 5s^2 5p^6 5d^{10} 6s^2 6p^1</td>
</tr>
</tbody>
</table>

Relativistic corrections shrink s-wave orbitals. Electrons not shared, almost chemically inert.
Shrinking s-wave

Figure 1. Radial densities for the 1s, 2s, 3s, and 2p states of a hydrogen-like atom with Z = 80. The dashed curves are nonrelativistic (NR) and the full curves relativistic. The contractions for 1s, 2s, 2p_{1/2}, and 3s are of the same order of magnitude while that for 2p_{3/2} is much smaller. Reproduced with permission from Burke and Grant.28b
Relativistic Corrections

Relativistic corrections shrink 5d-6s splitting.

Gold reflects yellow, but absorbs shorter wavelengths.
Anomalous Magnetic Moment

\[ \vec{M} = g \frac{e}{2m} \vec{S} \]

\[ g = 2 \]
Anomalous Magnetic Moment
Anomalous Magnetic Moment

$p^\mu + q^\mu$

$q^\mu$

$p^\mu$
Anomalous Magnetic Moment
Anomalous Magnetic Moment

\[ g = 2 + \frac{\alpha}{\pi} \]

integrate over momentum:
Anomalous Magnetic Moment

integrate over momentum:

\[ g = 2 + \frac{\alpha}{\pi} + c_2 \alpha^2 + c_3 \alpha^3 + c_4 \alpha^4 \]
Anomalous Magnetic Moment

\[
\alpha^{-1} = 137.035999070(98)
\]

spectroscopy: \( \alpha^{-1} = 137.03599878(91) \)
quantum corrections

\[ \alpha(10^{-10} \text{ m}) \approx \frac{1}{137} \]

\[ \alpha(10^{-17} \text{ m}) \approx \frac{1}{128} \]