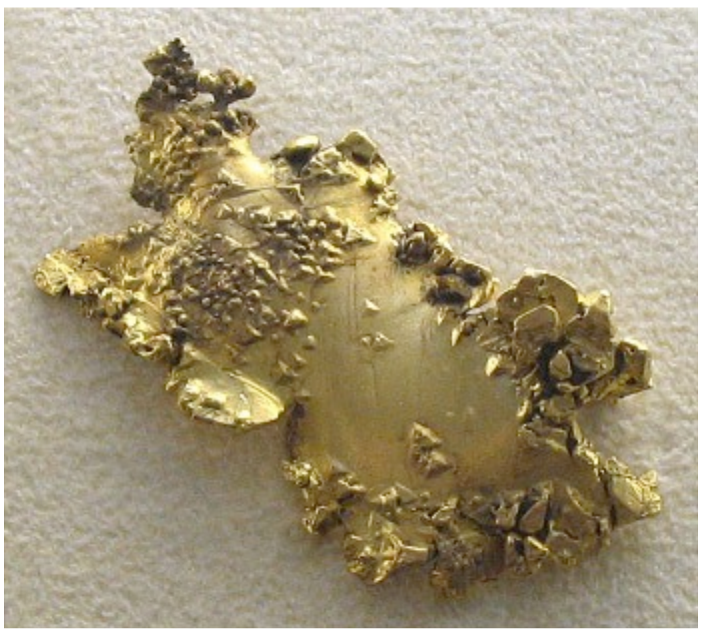
Relativistic Corrections

$$E^1_{\mathrm{rel}} \sim \frac{Z^2\,\alpha^2\,m\,c^2}{2\,n^2}$$

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



Relativistic Corrections

	Atom	Average atomic mass	Ground state configuration
79	Au	196.9665	[Kr] $4d^{10}\ 4f^{14}\ 5s^2\ 5p^6\ 5d^{10}\ 6s^1$
80	Hg	200.59	[Kr] $4d^{10}\ 4f^{14}\ 5s^2\ 5p^6\ 5d^{10}\ 6s^2$
81	Tl	204.383	[Kr] $4d^{10}\ 4f^{14}\ 5s^2\ 5p^6\ 5d^{10}\ 6s^2\ 6p^1$

relativistic corrections shrink s-wave orbitals
electrons not shared, almost chemically inert

Shrinking s-wave

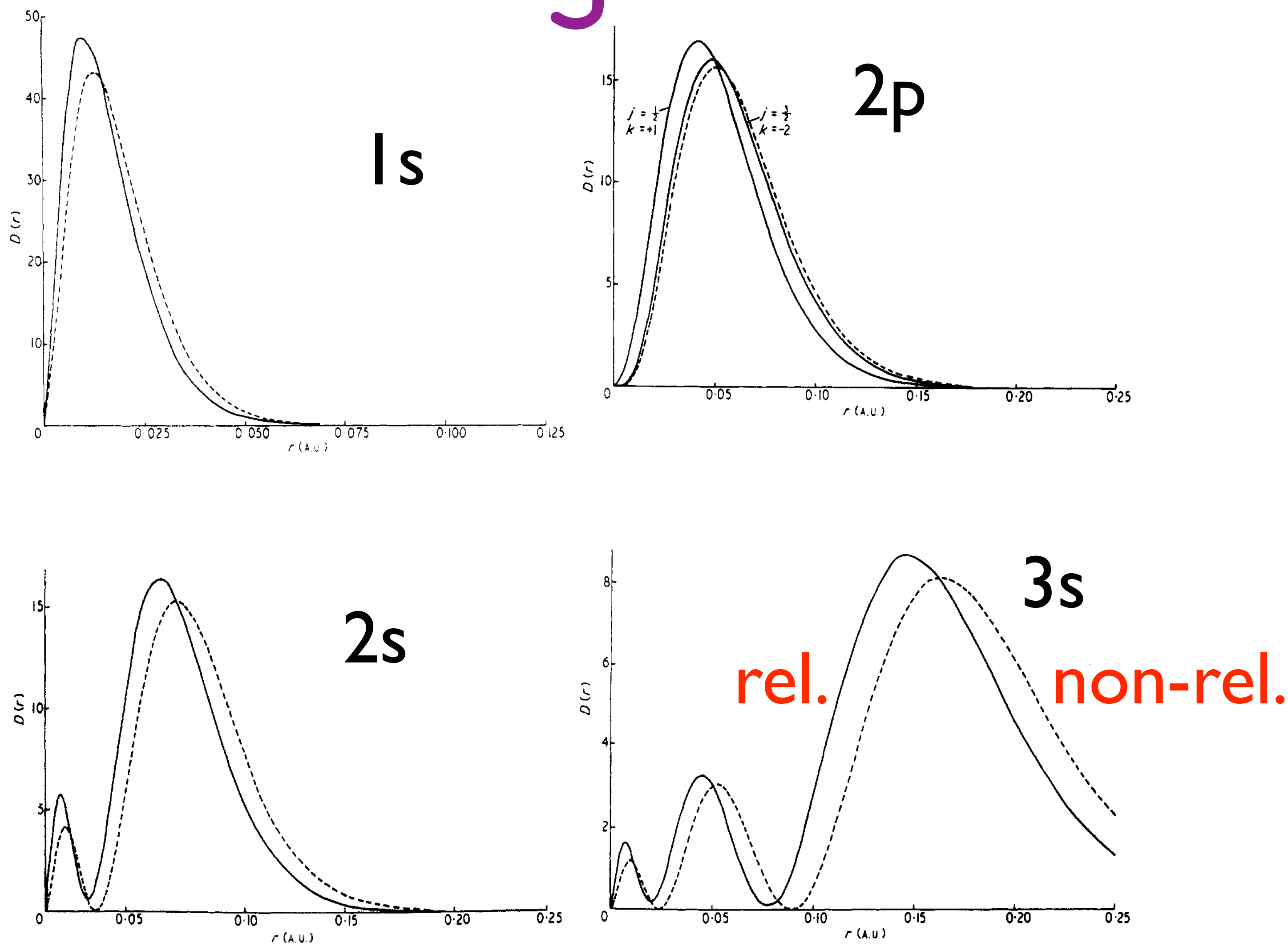
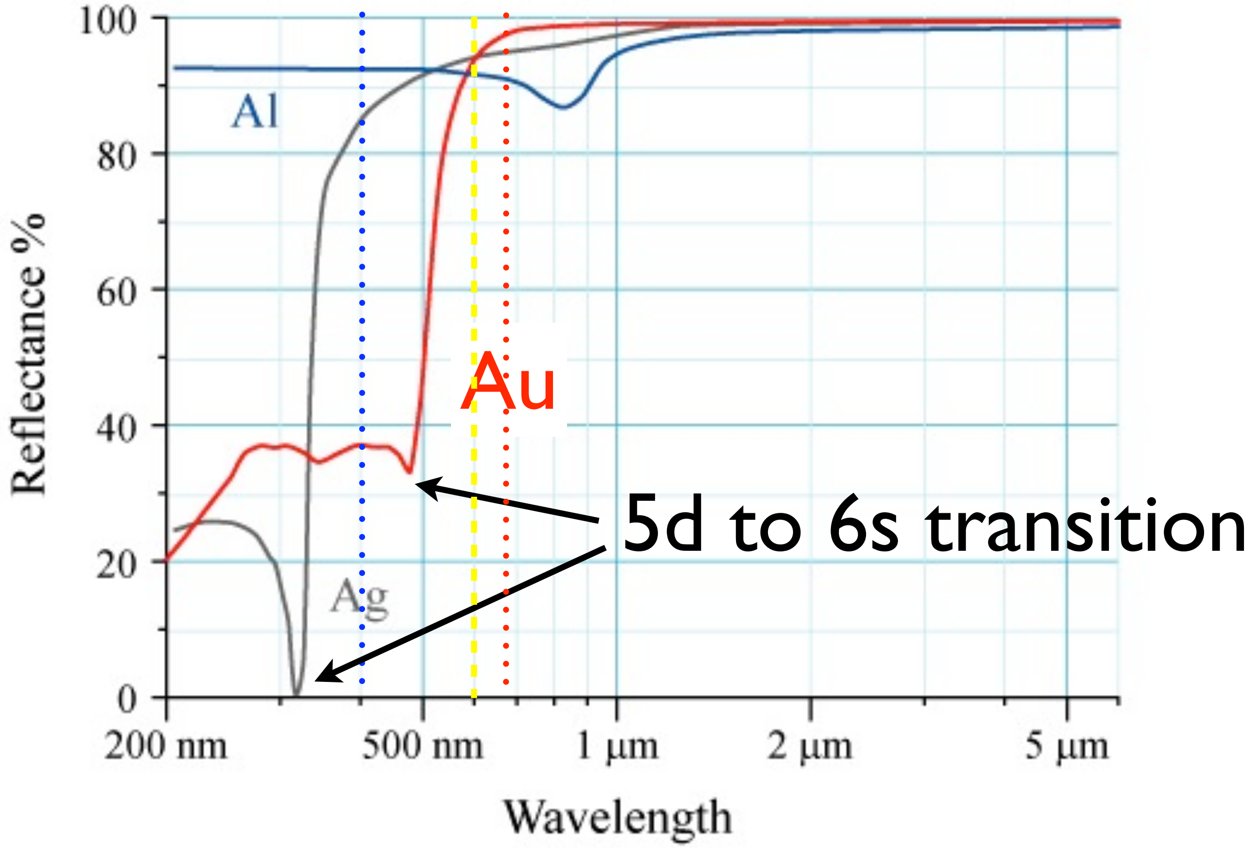


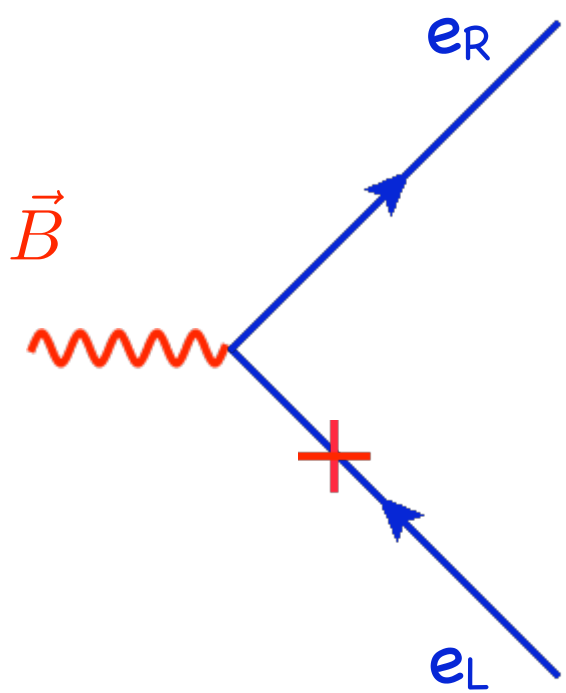
Figure 1. Radial densities for the 1s, 2s, 3s, and 2p states of a hydrogen-like atom with $Z = 80$. The dashed curves are nonrelativistic (NR) and the full curves relativistic. The contractions for 1s, 2s, $2p_{1/2}$, and 3s are of the same order of magnitude while that for $2p_{3/2}$ is much smaller. Reproduced with permission from Burke and Grant.[23b]

Relativistic Corrections



relativistic corrections shrink 5d-6s splitting
gold reflects yellow, but absorbs shorter wavelengths

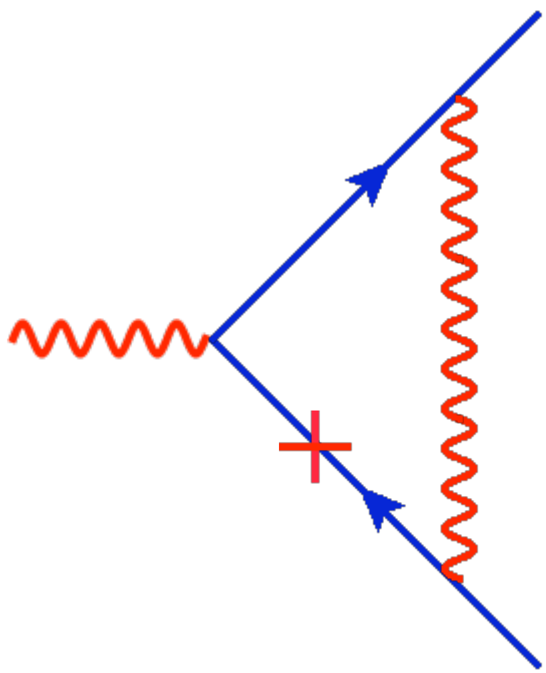
Anomalous Magnetic Moment



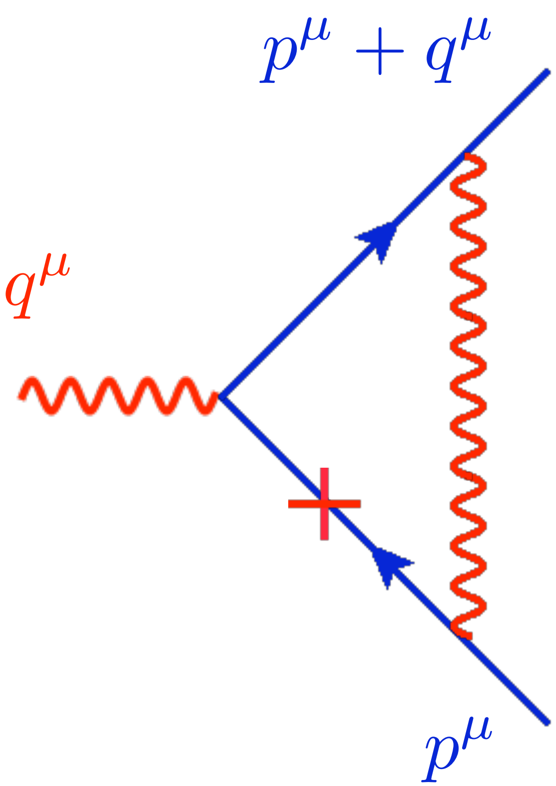
$$\vec{M} = g\frac{e}{2m}\vec{S}$$

$$g = 2$$

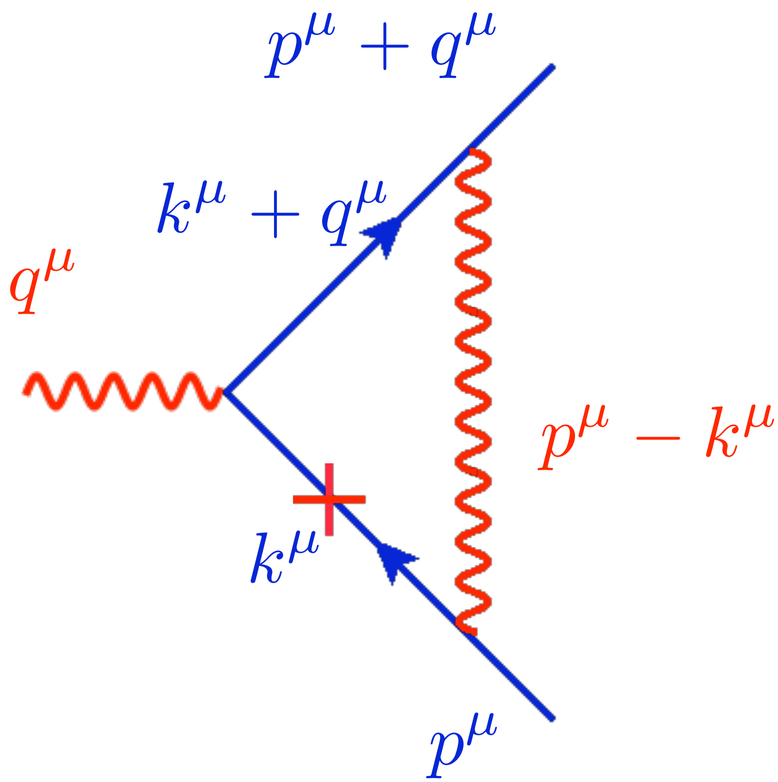
Anomalous Magnetic Moment



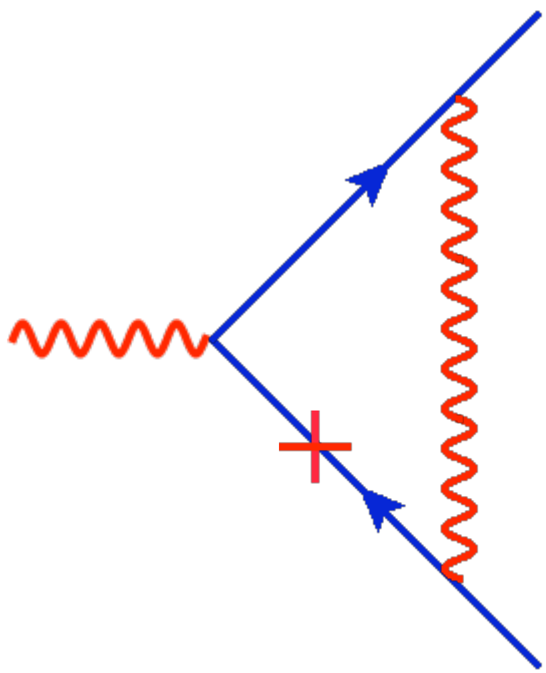
Anomalous Magnetic Moment



Anomalous Magnetic Moment



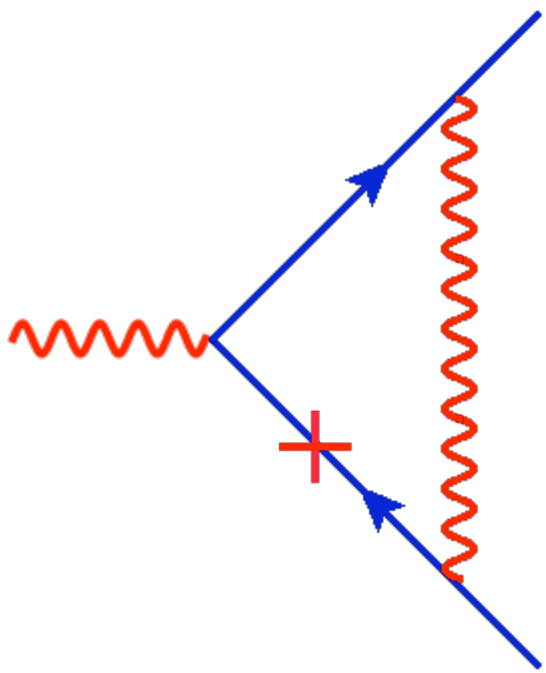
Anomalous Magnetic Moment



integrate over momentum:

$$g = 2 + \frac{\alpha}{\pi}$$

Anomalous Magnetic Moment

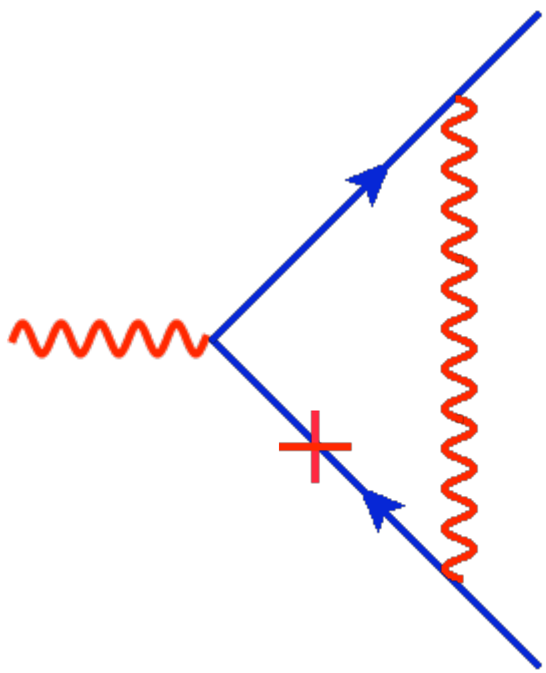


integrate over momentum:

$$g = 2 + \frac{\alpha}{\pi}$$

$$g = 2 + \frac{\alpha}{\pi} + c_2\,\alpha^2 + c_3\,\alpha^3 + c_4\,\alpha^4$$

Anomalous Magnetic Moment



integrate over momentum:

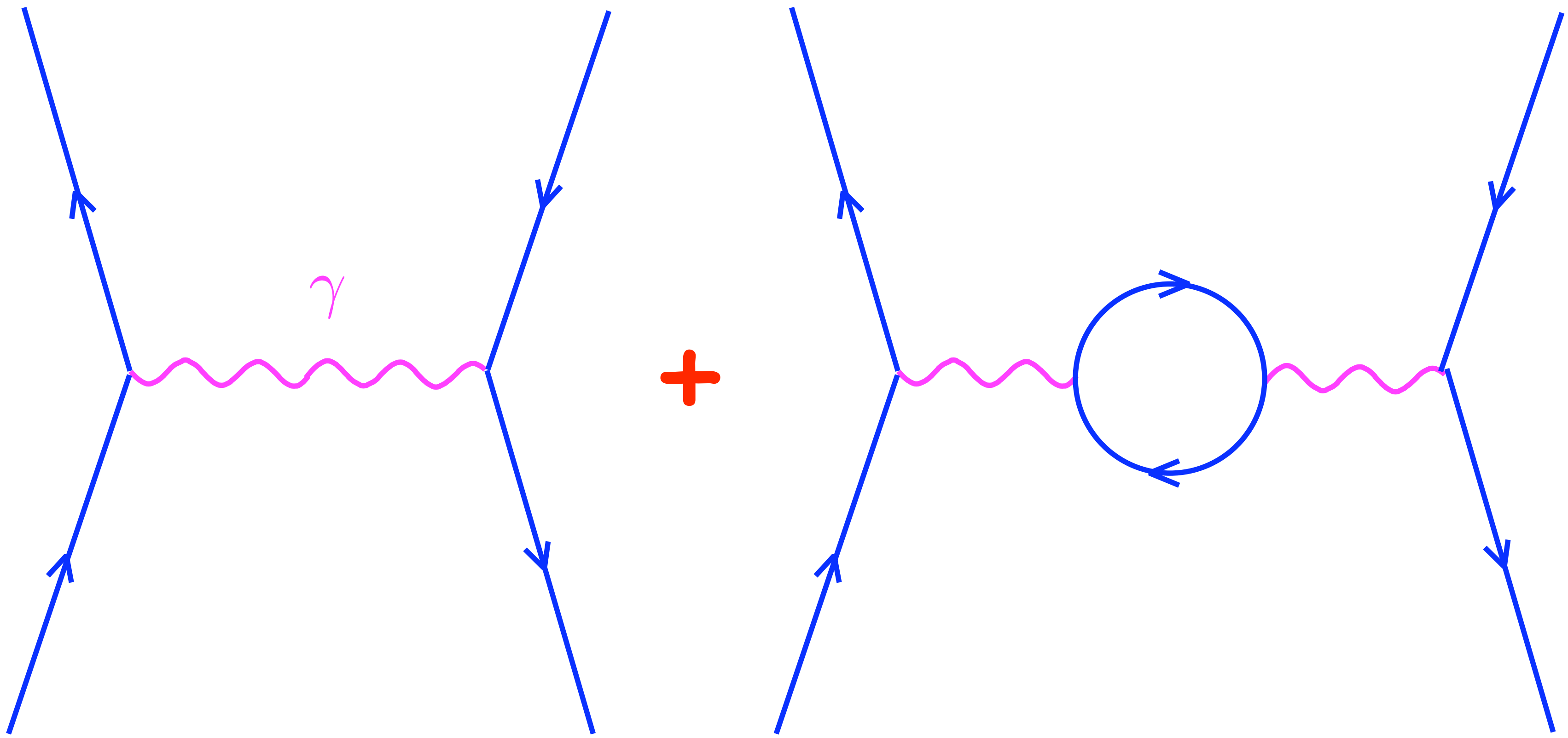
$$g = 2 + \frac{\alpha}{\pi}$$

$$g = 2 + \frac{\alpha}{\pi} + c_2\,\alpha^2 + c_3\,\alpha^3 + c_4\,\alpha^4$$

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

spectroscopy: $\alpha^{-1} = 137.03599878(91).$

Quantum Corrections



coupling is distance dependent

$$\alpha(10^{-10}\ \mathrm{m}) \approx \frac{1}{137} \qquad \alpha(10^{-17}\ \mathrm{m}) \approx \frac{1}{128}$$