Franck-Hertz experiment (1914)

To confirm that the internal energy states of an atom are quantized. 

\[ E = h\nu = \frac{hc}{\lambda} \]

\[ E = 4.9\,\text{eV} \]

- at \( \nu \approx 4.9\,\text{eV} \) I drops 
- 9.8 eV — again 
- etc

4.9 eV — \( e^- \) has energy to excite Hg atom 
loses energy, cannot get enough 

\[ 4.9\,\text{eV} \rightarrow \text{1st excited state} \]

\[ 9.8\,\text{eV} \rightarrow \text{2nd excited state} \]

\[ \text{2nd excited state} \rightarrow \text{1st excited state} \]

\[ 9.8\,\text{eV} \rightarrow \text{1st excited state} \]

\[ 2\,\text{Hg atoms} \]

- Observing spectrum of Hg, Franck and Hertz saw emission line at 2536 Å

\[ E = h\nu = \frac{hc}{\lambda} \]

\[ 2536\,\text{Å}, \quad E = 4.9\,\text{eV} \]

- \( e^- \) may also gain enough energy to excite Hg atom from ground to 

\[ \text{2nd, 3rd ... excited state} \rightarrow \text{drops in I also verified} \]

\[ 6.7\,\text{eV} \]

\[ \rightarrow \] can directly measure the energy difference of the quantum states of the atom

\[ \rightarrow \] to find \( E \) of ground state, we need to ionize the atom

(DISCRETE SPECTRA is due to DISCRETE energy levels of the atom)
Old quantum theory

- Improvements with respect to orbit - could be elliptical
- Good predictions to several experiments
- But it has limitations
  - Fails for atoms with more e⁻
  - Cannot predict the rate of transitions $E_i \rightarrow E_f$

Is conceptually different from what we now call quantum mechanics

(Schrödinger equation)

The idea of a precise orbit does not make sense anymore
Uncertainty in $\Delta x$ - there is always an uncertainty in $x$

What remains from old quantum theory:

- $E_i - E_f = \frac{\hbar}{n}$
- $L$ can be quantized
- **Correspondence Principle**

"In the limit of large quantum numbers, large energies, quantum calculations must agree with classical calculations" (large temperatures)

Which have worked so well in the macroscopic world

Classical limit

\[
\begin{align*}
\lim_{n \to \infty} & \\
E \to \infty & \\
\hbar \to 0 &
\end{align*}
\]