LAMB SHIFT

In 1947, W. Lamb discovered that the $2\ ^2P_{1/2}$ state is slightly lower than the $2\ ^2S_{1/2}$ state resulting in a slight shift of the corresponding spectral line.

It was a puzzle because due to Dirac and Schrodinger theory two states are degenerate.

According to Dirac and Schrodinger, states with same n and j quantum numbers are degenerate.

However the famous experiment by Lamb and Rutherford in 1947 showed that the $^2S_{1/2}$ (n=2, l=0, j =1/2) and $^2P_{1/2}$ (n=2, l=1, j =1/2) states of hydrogen atom were not degenerate but the S state had slightly higher energy by an amount now known to be 1057.864 MHz.

The effect is explained by the theory of Quantum Electrodynamics, in which the electromagnetic interaction is itself quantized.

Relevance of the experiment - Inspired and tested Quantum Electrodynamics.

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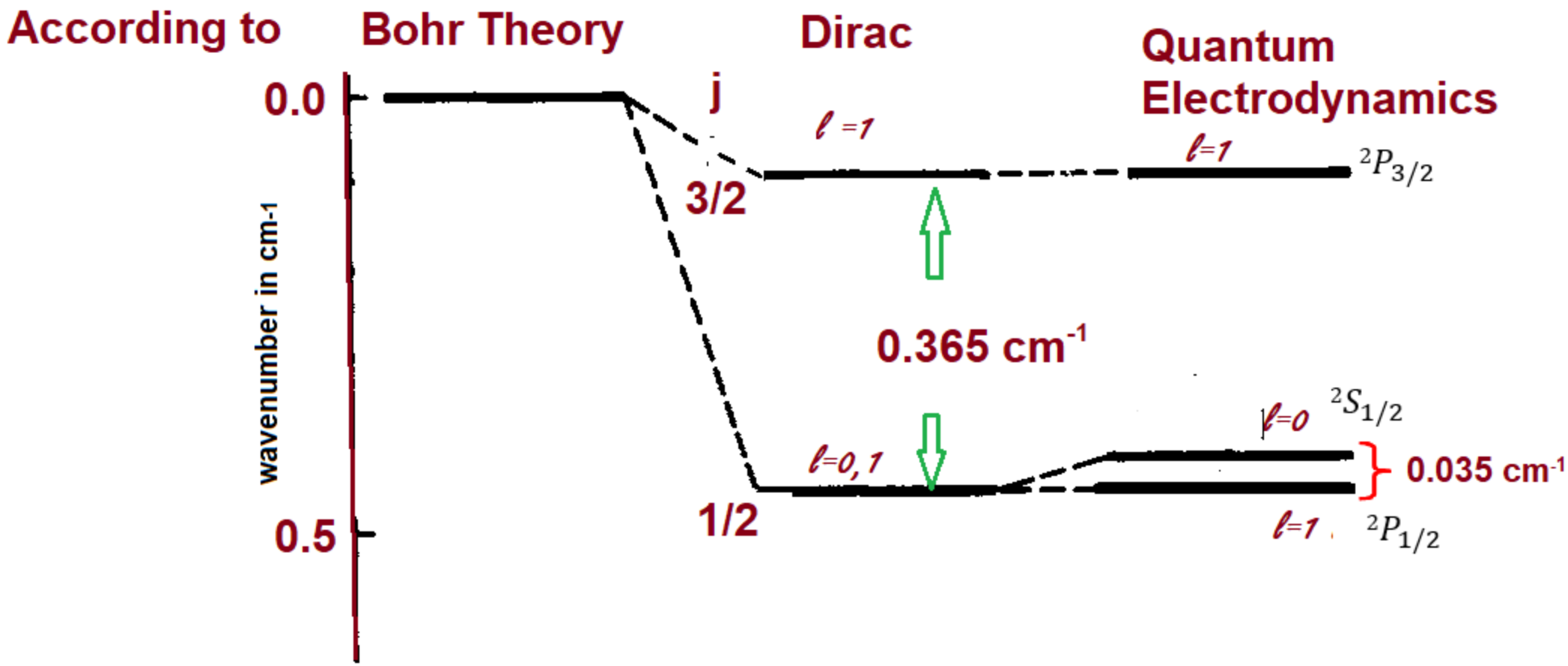
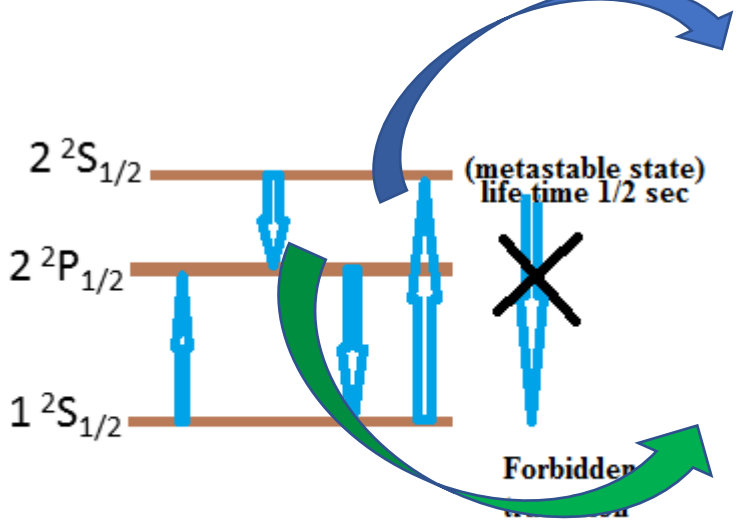


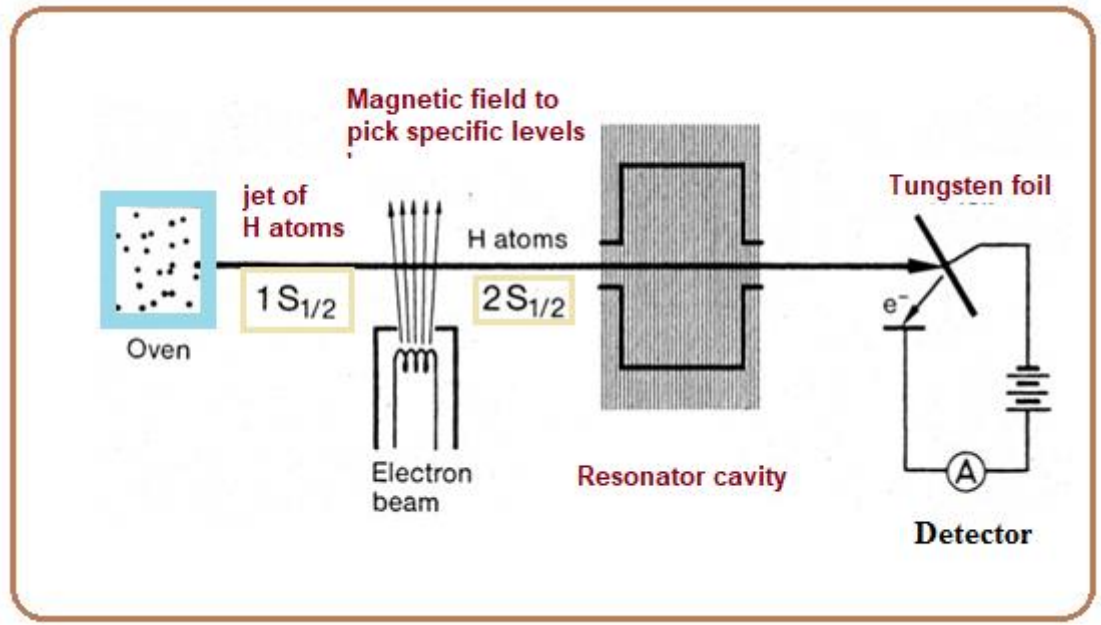
Block diagram of Experimental setup



Excite H-atoms to $2^2S_{1/2}$ metastable state by e^- bombardment. Forbidden to spontaneously decay to $1^2S_{1/2}$ optically.

Transitions *only* occur when radiowaves tuned to transition frequency.

- Molecular hydrogen was thermally dissociated
- Jet of atoms is cross-bombarded by an electron stream. One part is 9 hundred million atoms is excited to $2\,^2S_{1/2}$
- Transition from $1\,^2S_{1/2}$ state to $2\,^2P_{1/2}$ and $2\,^2S_{1/2}$ states takes place.
- The atoms are exposed to radio waves. RF frequency is so adjusted that $\Delta E = h\upsilon_{radiofreq}$ ie. It brings metastable atom to non metastable state atom.
- The experiment was carried out in magnetic field -> used Zeeman effect to pick specific m_j levels
- Energy levels are subjected to Zeeman splitting. Frequency of possible transition depend on magnetic field.
- Experiment was performed with various values of magnetic field.
- Acc to Dirac theory since $2\,^2S_{1/2}$ and $2\,^2P_{1/2}$ states are degenerate therefore ΔE should be equal to zero but ΔE was found to be 1057 MHz


Magnetic field to
pick specific levels
jet of
H atoms
H atoms
Tungsten foil
1 S1/2
2 S1/2
e⁻
Oven
Electron
beam
Resonator cavity
A
Detector