Stimulating Emission: The Principles of the Maser and Laser

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Maser-Laser

- Microwave or Light Amplification through the Stimulated Emission of Radiation
- First functioning laser completed in 1960
- Innumerable uses in modern society

The Beginning: Einstein's Thermodynamics

- In 1917, Einstein investigated the black body law

$$dI/dt = ANb - BINa + B'INb$$

- A-Spontaneous Emission
- B-Spontaneous Absorption
- B'-Stimulated Emission

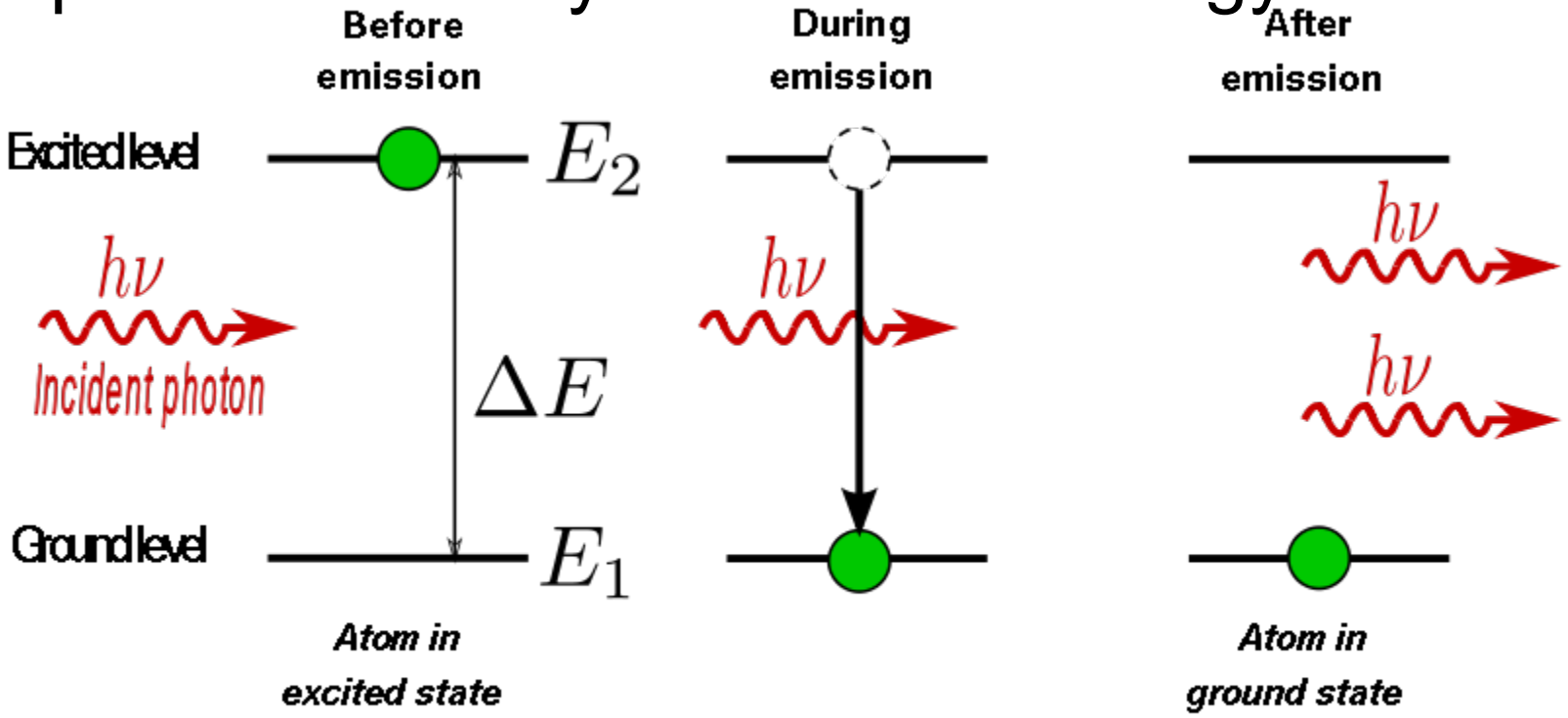
Spontaneous Emission/Absorption

- Spontaneous Emission: random emission of a photon due to upper to lower energy level transition

- Spontaneous Absorption: absorption of a photon causing a transition from lower to upper energy levels

Stimulated Emission

- When an electron is 'stimulated' by a passing photon to decay into a lower energy level



$$E_2 - E_1 = \Delta E = h\nu$$

The Beginning: Einstein's Thermodynamics

- Boltzmann's Law

$$Nb=Na*e^{(-W/kT)}$$

- Nb must be less than Na at any Temperature

The Beginning: Einstein's Thermodynamics

- However, if Nb>Na

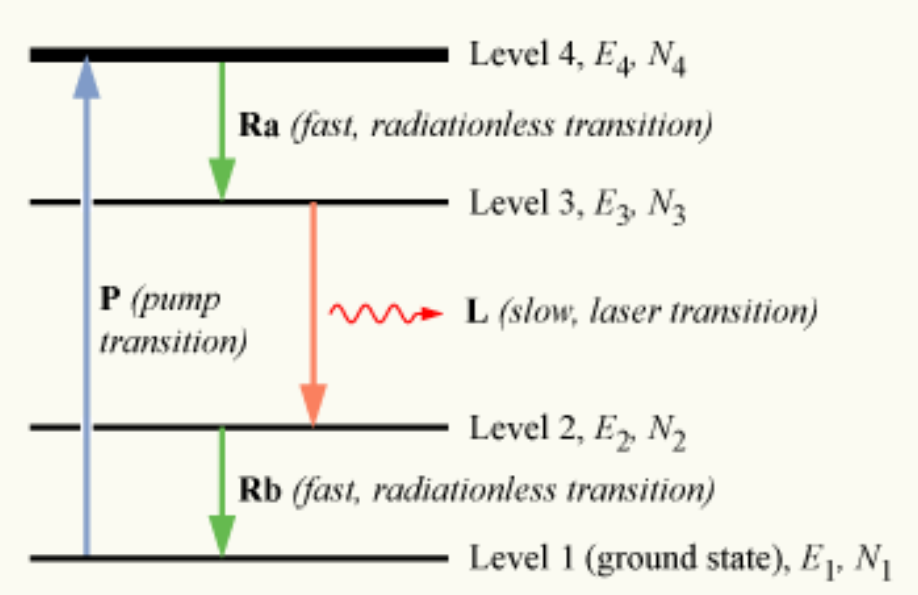
$$dI/dt = ANb - BINa + B'INb$$

- Then dI/dt will be positive, and the radiation will be amplified

The Theory: Population Inversion

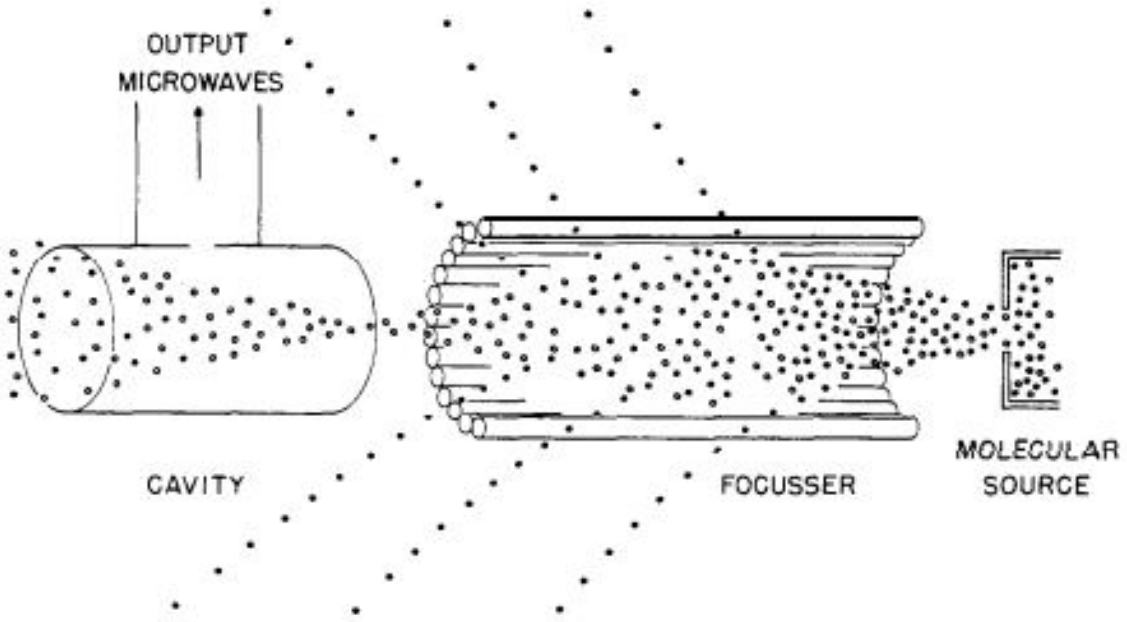
- For the radiation to be amplified, Nb > Na

- Most common method for lasers is with the use of four energy levels



The First Maser

- Created by Charles H. Townes in 1953
- Ammonia is the gain medium



The Maser: Applications

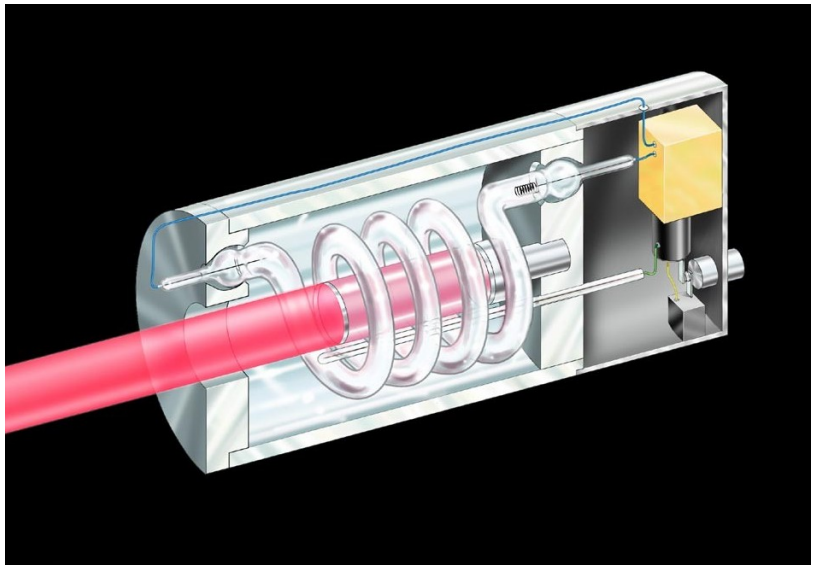
- Currently, the maser serves as the best atomic clock

- Maser detection has astrophysical uses

The First Laser

- Theodore Maiman operated first functioning laser in 1960

- Chromium-doped ruby was the gain medium



The Laser: Rapid Advances

- "Optical Maser" first theorized in 1958
- First functional laser (solid-state) in 1960
- First gas laser (He-Ne) later in 1960
- First laser diode in 1962
- First semiconductor laser later in 1962

The Laser:
Modern Applications

- "Solution looking for a problem"
- Thousands of problems since the 1960s solved
- Used in nearly every aspect of society; Medicine, Industry, Consumer Electronics, Entertainment, Law Enforcement

The Laser:
Future Applications

- Igniting nuclear fusion
- Biological lasers
- Current most powerful laser: 1.3 PW (1.3 x 10^15 W)

Conclusion

- Since the first laser was built, rapid advancements
- Allowed investigation of many different branches of physics
- One of the most important inventions of the 20th century