Attainment of a Population Inversion
In order to achieve inversion, we must hit the laser medium very hard in some way and choose our medium correctly.

Or equivalently,

\[ \frac{N_1^1}{N_2^1} > \frac{N_2}{N_1} \]

\[ B_N^N < B_N^I \]

Or equivalently,

To achieve inversion, stimulated emission must exceed absorption.
Laser

![Diagram of laser](image)

- optical pumping

\[ N_1 = N_2 \]

\[ E_1 \]
A pump mechanism (e.g., thermal excitation or gas discharge) ejects some atoms to the excited state. Equilibrium: most atoms in ground state.
The three-level system

Assume we pump from a state 0 to level 2 that rapidly decays to level 1.

Light generation
إذاً فإن الانتقال الطيفي من الاستقرار إلى الاستقرار يمكن أن يكون طيفاً متداخل في الشاخص E1، حيث E1 يتبع E2 في الطراوة المشاهدة ل W1. ينجم أن E1 من الاستقرار إلى الاستقرار حيلة فيه الطيف (أي meta-stable).
Light amplification: 3-level system

Utilizing the super-excited state as a short-lived "pivot point," the pump creates a population inversion in ground state; note the existence of a third, "super-excited" state.

Equilibrium: Most atoms in ground state; most excited state.

1.4
Light amplification: 3-level system

When a photon enters, it "knocks" an electron from the inverted population down to the ground state, thus creating a new photon. This amplification process is called stimulated emission.
The four-level system:
Two-, three-, and four-level systems are best.

- Two-level systems
- Three-level systems
- Four-level systems

Lasing is easy! You get lasing.
If you hit it hard, you get lasing.
No lasing.
At best, you get equal populations.

It took laser physicists a while to realize that four-level systems are best.