Population Inversion :

We have seen that when atoms are in equilibrium with the surrounding, the population of atoms in the ground state is more than that in any of the excited states. Population of excited states can be increased by absorption of radiation. However, the life time in the excited states being typically of the order of 10^{-8} seconds, atoms which make transitions to the excited states fall back to the ground state soon thereafter. This is also indicated by the ratios of the Einstein coefficients. It is, therefore, not possible to keep the population in the excited states higher than that in the ground state.

Population Inversion

•In order to achieve $G > 1$, that is, stimulated emission must exceed absorption:

•

$$B N_2 I > B N_1 I$$

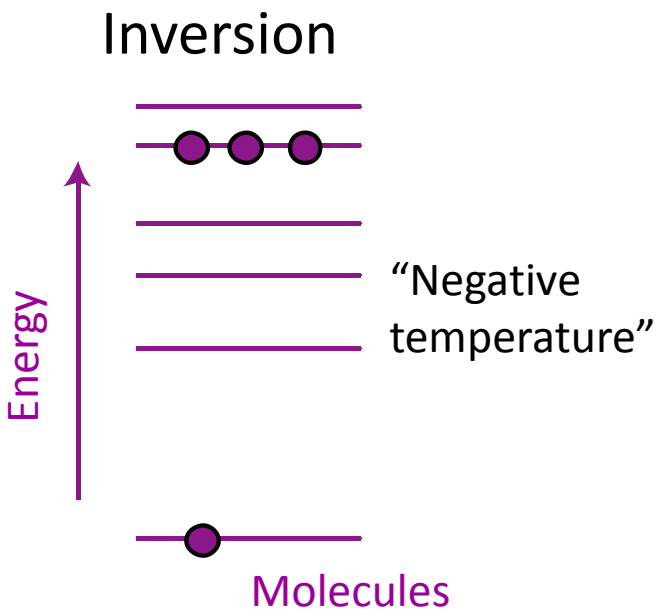
•

Or, equivalently,

•

$$N_2 > N_1$$

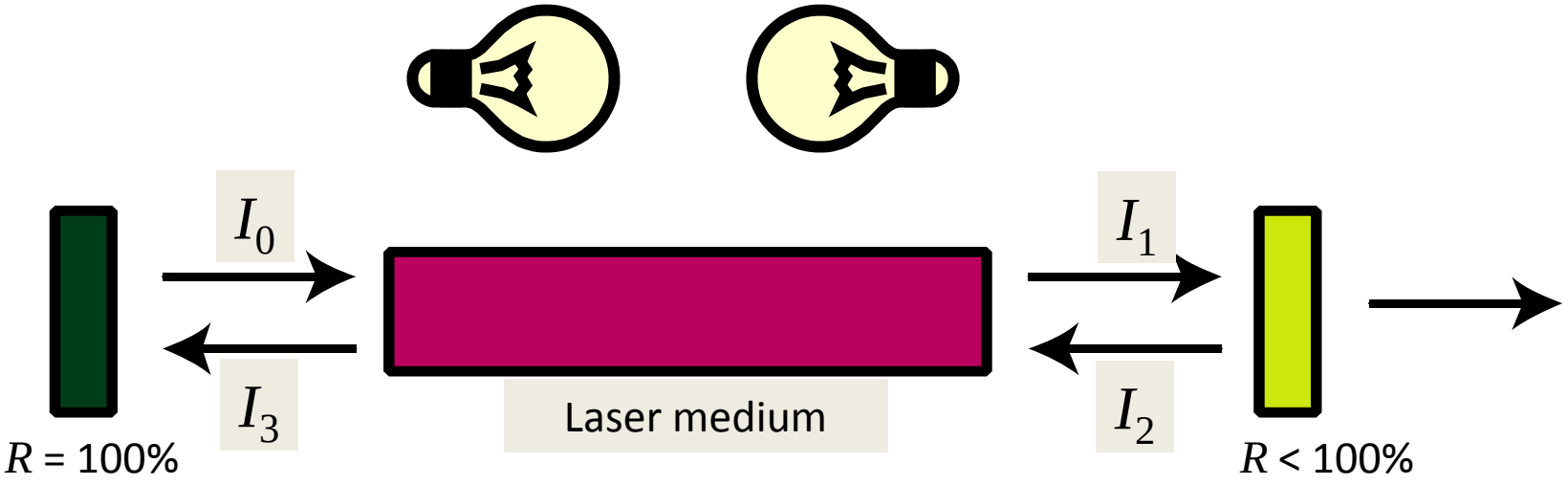
•This condition is called **inversion**.
•It does not occur naturally. It is
•inherently a non-equilibrium state.



•In order to achieve inversion, we must hit the laser medium very hard in some way and choose our medium correctly.

Achieving inversion: Pumping the laser medium

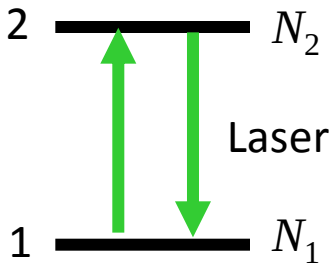
Now let I be the intensity of (flash lamp) light used to pump energy into the laser medium:



Will this intensity be sufficient to achieve inversion, $N_2 > N_1$?

It'll depend on the laser medium's energy level system.

Why inversion is impossible in a two-level system



$$\frac{d\Delta N}{dt} = -2BI\Delta N + AN - A\Delta N$$

In steady-state:

$$0 = -2BI\Delta N + AN - A\Delta N$$

$$\Rightarrow (A + 2BI)\Delta N = AN$$

$$\Rightarrow \Delta N = AN/(A + 2BI)$$

$$\Rightarrow \Delta N = N/(1 + 2BI/A)$$

$$\Rightarrow \boxed{\Delta N = \frac{N}{1 + I/I_{sat}}}$$

where: $I_{sat} = A/2B$

I_{sat} is the saturation intensity.

ΔN is always positive, no matter how high I is!

It's impossible to achieve an inversion in a two-level system!