WJEC (Eduqas) Physics A-level

Topic 3.5: Lasers

Notes

Stimulated Emission

This is the process by which lasers produce light. It occurs when an electron is **already in an excited state**. If a photon has an energy equal to the energy difference between the electrons excited level and the level below, it can stimulate the electron to **drop down to that lower level** releasing a **photon of equal energy** to the incoming photon.

The photons produced by stimulated emission have a constant phase difference and frequency (because they are of the same energy) and therefore form **coherent light**.

Population Inversion

A **process required by laser technology**, population inversion is when there are more electrons in the upper level than the lower level. More electrons need to be in the upper level compared to the lower level because otherwise, the process of absorption will have a higher chance of taking place as opposed to stimulated emission.

Two-state laser systems do not usually exist because the probability of the incoming photon causing an electron to be excited and remain there is the same as causing it to fall back down. Therefore, when each level has the same number of electrons, the number of electrons going up will be equal to the number going down. Hence, you cannot get more electrons in the higher state.

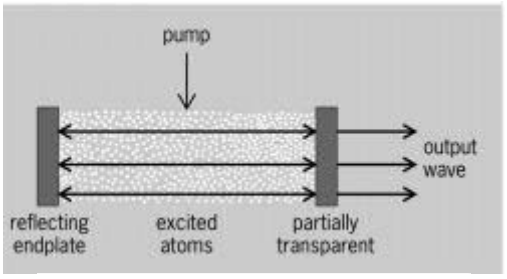
On the other hand, a population inversion can be attained in 3 and 4-level systems. In a 3-level system, electrons are 'pumped' (this is called **pumping**) up to the **third level initially** and then decay rapidly (without releasing radiation but instead transferring their energy to heat around the atom) to the second level. Here, **many electrons accumulate and a population inversion is attained**. At least half the electrons must be moved from the lowest level to the highest level, the system must be 'very strongly pumped'.

In a 4-level system, it is more complicated. It is like a three-level system except there is another level below. **Electrons are pumped up to the fourth level** and decay rapidly (without releasing radiation) to the third level. Then some electrons may fall down to the second level by spontaneous emission or by stimulated emission. Then, **any on the second level rapidly decay** (without releasing radiation) to the first/ground level. Therefore, very few electrons sit on the fourth and second levels. However, most now sit on the third level. Thus, we have formed a **population inversion between the third and second levels**.

Pumping is simply when external energy (in the form of electrical currents or light) is used to cause ground state electrons to rise to the highest energy level.

Typical Laser Structure

A laser consists of an **amplifying medium**. This is a medium composed of atoms which are subject to the pumping process. This is the region where stimulated emission takes place. Then, light could be travelling in multiple directions after emission and so **two mirrors, one of which reflects all light and one which transmits some light,** are used to redirect the light into a beam travelling in a single direction.



http://encyclopedia2.thefreedictionary.com/Laser

Semiconductor Lasers

In comparison with other lasers (see above), semiconductor lasers are **smaller and cheaper** to produce. Therefore, they are often used in domestic appliances such as **CD and DVD players**. **Barcode scanners and laser printers** also use semiconductor lasers. In addition to this, semiconductor lasers use **much less power** (and are **more efficient**) than other lasers allowing them to be run on low voltage sources – suitable for domestic appliances.