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LASER, light amplified, in a special way

Laser light differs from ordinary light like an army column marching in step differs from a jostling crowd, says **S.Ananthanaryanan**

Laser light is unidirectional, monochromatic and most important, the photons that compose laser light are ‘in phase’, which is the same thing as, ‘in step’.

The beginning

During World War II, physisicst Charles H Townes worked on radio waves of shorter wavelengths, so that radar beams could be more directional and antennae on the aircraft could be smaller. After the war, Townes continued with research into the interaction of radiation with molecules of gases, which needed radio waves of very short wavelengths indeed. When building a device to generate such short wavelengths became difficult, Townes got the idea of using molecules themselves to generate the waves.

The ammonia maser

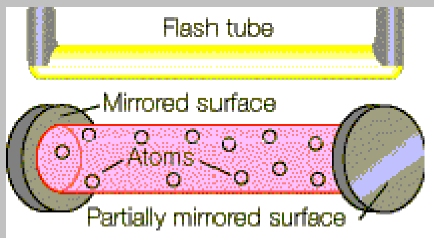
In 1953, Townes, with Gordon and Zeiger, produced ‘coherent’, microwave light using ammonia molecules. The principle was that the ammonia molecule has energy levels separated by the energy of a microwave photon. If a molecule at the higher energy level is struck by exactly such a photon, then the molecule ‘de-excites’ and gives off a photon of its own, and the two go on, in the same direction and in ‘step’.

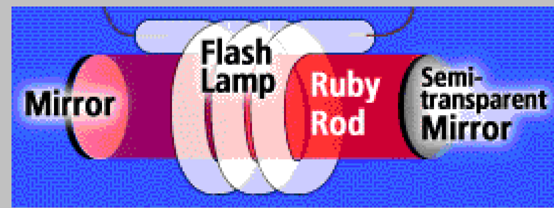
 Townes	 Schawlow	Townes realized that a device that could generate similar radiation in the infrared or visible region would be even more useful.

The succeeding work by Townes and Schawlow resulted in a paper on the laser in 1958 and the Nobel Prize in 1964.

Its done with mirrors

The principle is that atoms of a gas, like neon, or in a crystal, like the ruby, have characteristic frequencies at which they absorb and emit radiation. In neon signs, for instance, the ‘excited’ atoms of the gas emit the ‘neon glow’, but in random directions, at random times. The result is incoherent light, or a jumble of photons going in all directions.



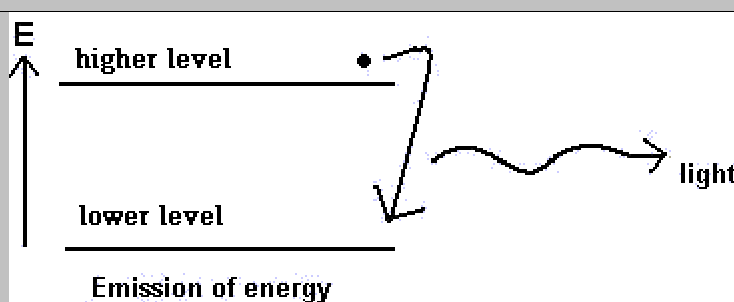


The trick in generating coherent light, or photons all ‘in phase’, in one precise direction, is to find the right atoms with the right internal storage mechanisms and create conditions where they can all cooperate to give up their light at the right time and in the same direction.

Population Inversion

In a laser, the atoms or molecules of a crystal, gas or liquid that have the right energy levels are excited in a cavity with reflective surfaces at both ends. This makes the energy reflect back and forth, exciting the atoms of the substance to the higher energy levels, till more of them are at the higher than are at lower energy level.

When the population is ‘inverted’ like this, it is more likely that an excited atom be struck, to de-excite and give off two photons, than an atom in the ground



state absorbing a photon and getting ‘excited’. When this happens, huge numbers de-excite and there is a cascading of ‘stimulated emission’ or a ‘laser burst’!

The reflectors at the ends of the cavity are ‘half reflectors’, which keep up the ‘pumping’ of the atoms to the higher state and we have a continuous emission of laser light, monochromatic, in phase and intense!