

# Optics

## Masers, Lasers

**Ammonia maser:** (1953, Columbia, Townes)

First Microwave Amplifier by Stimulated Emission of Radiation. Later the “m” was changed to mean “molecular” to indicate a larger variety of devices with amplification in other parts of the spectrum.

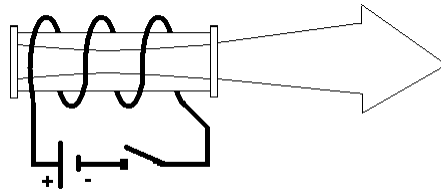
The first maser operated with the ground state and the first low lying level of the ammonia molecule. Beam techniques were used to separate the excited state from the ground state and generate the inverted population.

### Notes:

Townes and Schawlow wrote *Microwave Spectroscopy*, the best reference on that subject.

The hydrogen maser is presently used in atomic clocks. It uses the hyperfine transition in hydrogen to generate a well defined signal. First built by Norman Ramsey (author of *Molecular Beams*)

**Elements of a laser:** Light Amplification by Stimulated Emission of Radiation.



**Ruby laser:** (Maiman, Hughes, 1960)

Energy was pumped using a flashlamp. Gain medium is  $\text{Al}_2\text{O}_3\cdot\text{Cr}$  and uses 3 levels. Pulsed laser at 694.3 nm. The mirrors were originally the same ends of the crystal cut and polished, now external mirrors are used instead and the crystal is cut at the Brewster angle. This last scheme forces the beam to be polarized along one particular axis.

Main use in holography with its short pulse of extremely high coherent radiation it eliminates the need for long exposures.

### **Nd:YAG:**

Yttrium aluminum garnet doped with neodymium. It generates a beam in the infrared ( $1.064\mu\text{m}$ ). The pump is usually a discharge lamp. Operation is usually pulsed. It can be doubled (532nm) or tripled (353nm). In variable frequency lasers it is used as an energy pump. Another important use is in laser ablation for electronic materials.

**He-Ne laser:**

A ratio between helium and neon of 10 to 1 at low pressure. Helium is excited by an electric discharge and some of its energy is transferred preferentially to neon, which gets two electrons promoted to an excited state, this is due to a coincidence in the energies (this kind of scheme is exploited in many other lasers). The excited neon provides the upper level for lasing action. The low level is a fast decaying state, so the net result is population inversion. Wavelength 632.8nm