RUBY LASER

Dr. ANANT KUMAR SINHA
ASSOCIATE PROFESSOR
DEPTT. OF PHYSICS
A.M. COLLEGE, GAYA
OVERVIEW

• Introduction
• Historical importance
• Construction
• Working
• Application
• Drawbacks
**INTRODUCTION**

- A ruby laser is a solid-state laser that uses a synthetic ruby crystal as its gain medium.
- It was the first type of laser invented, and was first operated by Theodore H. "Ted" Maiman at Hughes Research Laboratories on 1960-05-16.
- The ruby mineral (corundum) is aluminum oxide with a small amount (about 0.05%) of chromium which gives it its characteristic pink or red color by absorbing green and blue light. The ruby laser is used as a pulsed laser, producing red light at 694.3 nm. After receiving a pumping flash from the flash tube, the laser light emerges for as long as the excited atoms persist in the ruby rod, which is typically about a millisecond.
HISTORICAL IMPORTANCE

- A pulsed ruby laser was used for the famous laser ranging experiment which was conducted with a corner reflector placed on the Moon by the Apollo astronauts. This determined the distance to the Moon with an accuracy of about 15 cm. A three level solid state laser.
Laser output at 694.3 nm

Electrode

Partially reflecting mirror (99%)

Flash tube for optical pumping

Ruby

Electrode

Totally reflecting mirror (99.9%)

Natural line width of laser transition

Optical resonant frequencies of the mirrored rod.

Laser output sharpened by optical resonance
LASER CONSTRUCTION

- The active laser medium (laser gain/amplification medium) is a synthetic ruby rod. Ruby is an aluminum oxide crystal in which some of the aluminum atoms have been replaced with chromium atoms (0.05% by weight). Chromium gives ruby its characteristic red color and is responsible for the lasing behavior of the crystal. Chromium atoms absorb green and blue light and emit or reflect only red light. For a ruby laser, a crystal of ruby is formed into a cylinder.

- The rod's ends had to be polished with great precision, such that the ends of the rod were flat to within a quarter of a wavelength of the output light, and parallel to each other within a few seconds of arc. The finely polished ends of the rod were silvered: one end completely, the other only partially. The rod with its reflective ends then acts as a Fabry-Pérot etalon (or a Gires-Tournois etalon).

- A xenon lamp is rolled over ruby rod and is used for pumping ions to excited state.
WORKING OF RUBY LASER

- Ruby laser is based on three energy levels. The upper energy level E3 is short-lived, E1 is ground state, E2 is metastable state with lifetime of 0.003 sec.
When a flash of light falls on ruby rod, radiations of wavelength $5500 \text{ Å}$ are absorbed by Cr$^{3+}$ which are pumped to E3.
The ions after giving a part of their energy to the crystal lattice decay to the E2 state undergoing a non-radiation less transition.

In metastable state, the concentration of ions increases while that of E1 decreases. Hence, population inversion is achieved.
ION AT E2 LEVEL INITIATES THE STIMULATED EMISSION BY OTHER CR3+ IONS IN METASTABLE STATE

Metastable state

Non-radiative transitions to the metastable state from the pumped levels.

Laser output in extreme red at 694.3 nm

1.79 eV
Ruby lasers have declined in use with the discovery of better lasing media. They are still used in a number of applications where short pulses of red light are required. Holographers around the world produce holographic portraits with ruby lasers, in sizes up to a metre squared.

Many non-destructive testing labs use ruby lasers to create holograms of large objects such as aircraft tires to look for weaknesses in the lining.

Ruby lasers were used extensively in tattoo and hair removal
DRAWBACKS OF RUBY LASER

- The laser requires high pumping power because the laser transition terminates at the ground state and more than half of ground state atoms must be pumped to higher state to achieve population inversion.
- The efficiency of ruby laser is very low because only green component of the pumping light is used while the rest of components are left unused.
- The laser output is not continuous but occurs in the form of pulses of microseconds duration.
- The defects due to crystalline imperfection are also present in this laser.
CONCLUSION

- A ruby laser is a solid-state laser that uses a synthetic ruby crystal as its gain medium.
- Many non-destructive testing labs use ruby lasers to create holograms of large objects such as aircraft tires to look for weaknesses in the lining.
- It is used to find distance between planets.