

Contents

HISTORICAL INTRODUCTION, 1

BACKGROUND MATERIAL ON RADIATION, 3

1. Light and the General Laws of Radiation, 3

Definitions: radiative flux, flux density, radiance, energy density. Laws of Planck, Stefan-Boltzmann, and Wien. Properties of classical light sources. Limitations of image brightness.

2. Coherence and Incoherence, 7

Addition of light originating from different sources. The significance of phase. Interference. Temporal coherence of radiation. Coherence as a measure of phase correlation. Coherent beam from an extended incoherent source. Advantages of an extended coherent radiator.

3. Emission, Absorption, and Amplification of Radiation, 10

Stationary atomic states. Bohr's frequency relation. Spontaneous and stimulated transitions. Einstein's relations. Systems in thermal equilibrium. Boltzmann's law. Absorption. Integrated absorption. The Füchtbauer-Ladenburg formula. Inversion of population. Negative temperature and negative absorption. Lifetime and transition rate. Selection rules. Metastable states.

4. Units and Physical Constants, 19

Deviations from the CGS system. Wave number, frequency, and wavelength conversion.

GENERAL DESCRIPTION OF LASERS, 22

5. The Laser, 22

Maiman's ruby laser. Fluorescence and stimulated emission in three- and four-level systems. Light amplification and generation.

ANALYTICAL PROBLEMS, 29

6. Threshold Condition, 29

Lorentz line shape. Peak and integrated absorption and their relation to the population of atomic levels. Threshold condition for oscillations. Rate equations and their solution for ruby. Calculation of pumping power.

7. Cavity Problems, 36

Escape of radiation by diffraction and by transmission through the reflectors. Cavity modes. The self-reproducing modes of Fox and Li. Confocal, spherical interferometer. The results of Boyd and Gordon. Excitation of oscillatory modes by the atomic systems. Frequency pulling. Multimode oscillations. Off-axial modes.

8. Linewidth Problems, 46

The oscillator as a noise amplifier. Power spectrum. Derivation of the Townes-Schawlow formula for line width of a single mode oscillation. Applications to Javan's observations on He-Ne lasers.

SOLID-STATE LASERS, 52

9. The Ruby Laser of Maiman, 52

Properties of ruby, exciting lamp, and reflectors. Irregular pulsations. Variation of output with temperature. Polarization. Coherence. Beamwidth. Peak power. Efficiency.

10. Control of Pulsations. The Giant Pulse of Hellwarth and McClung, 59

Use of shutter to prevent early start of oscillations. Kerr cell as shutter. Rise time, power, and energy of giant pulses. Regular pulsations.

11. Improvements of the Ruby Laser, 64

Sapphire-coated ruby cylinder. The cw ruby laser of Nelson and Boyle.

12. Ruby Lasers Operating at Unconventional Frequencies, 69

The R_2 (6929 Å), N_1 (7041 Å) and N_2 (7009 Å) line ruby lasers.

13. Solid State Lasers Other Than Ruby, 70

Uranium (2.613, 2.50, 2.24 μ), Samarium (7083 Å), Neodymium (1.06 μ), Thulium (1.917 μ), Holmium (2.046 μ).

FLUID-STATE LASERS, 79

14. Exploration of Liquids as Laser Materials, 79

Advantages of fluids. Transfer of excitation in organic compounds.

15. Negative Absorption of Optical Radiation in Gases, 80

Energy exchange processes in gases. Optical excitation. Schawlow's calculations for optical excitation in K vapor. Excitation of Cs with a He lamp. Excitation by electron collision and by resonant transfer of energy. The He-Ne mixture.

16. Conditions for Population Inversion through Excitation by Electron Collision, 86

Electron collisions of the first and second kind. Ratios of lifetimes. Departures from Boltzmann distribution in an atomic ensemble in contact with a hot electron gas. Possibility of population inversion in a single gas. Resonant transfer of energy in gaseous mixtures. The conditions of Basov and Krokhin.

17. The Helium-Neon Laser, 91

Detailed description of Javan's laser. The gas laser with external spherical reflectors. Measurements of beamwidth and frequency stability.

APPLICATIONS AND DEVELOPMENT, 100

18. Laser Applications, 100

Scientific experimentation: Light harmonics, mixing, two quantum experiments. Communications. Ranging. Local heating and destruction. Photochemical and biological applications.

19. Current Problems of Laser Development, 103

Exploration of new laser materials. Requirements of different applications and methods of satisfying these.

REFERENCES, 107

TABLES, 115

SUPPLEMENT, 119

AUTHOR INDEX, 121

SUBJECT INDEX, 123