Lasers: EPL 334

Major, 29th April, 2008. 8:00am

Attempt all questions

Full Marks: 35 Time: 2hr.

1. (a) Explain in brief the basic mechanism for Doppler broadening. Name and explain a broadening effect in solid state gain medium which gives similar lineshape function as the Doppler broadening. [2]

(b) What is amplified spontaneous emission and how does it affect a laser amplifier? [1]

(c) A He-Ne laser has a gain region of length 0.2m, mirrors of reflectivity 99% and scattering losses per pass of 0.5%. What is the threshold gain required to make a laser? What would be the population difference ΔN_{ul} required to reach that threshold?
If the population difference were increased by a factor of 10 from those required from the threshold condition, what intensity would be required in the cavity (compared to I_{sat}) to reduce the gain to its steady state value.
A_{ul} = 3.4 x 10^6/s, refractive index = 1.0, $\Delta\nu$ = 1.5 x 10^9 Hz. [4]

2. (a) What is spectral and spatial hole-burning? [2]

(b) State a method for selecting a particular longitudinal mode without shortening the length of the gain medium. [1]

(c) A resonator is made of a convex mirror (radius of curvature R_1) and a concave mirror (radius of curvature R_2) with a separation L between them. Find the value of L for which the resonator is stable. Consider both cases $|R_1| > R_2$ and $|R_1| < R_2$. [4]

3. (a) What is the importance of optimum output coupling of a laser cavity? [1]

(b) Derive a relationship between optimum output coupling with small signal gain coefficient and other cavity parameters. [4]

(c) Explain carrier and phonon confinement effects in a semiconductor laser? [2]

4. (a) Explain self focusing mechanism and its use in Kerr lens modelocking. [3]

(b) A 10-fs unchirped Gaussian pulse with central wavelength λ_0 = 800 nm enters a 1mm thick fused silica plate with a group delay dispersion of 36.16 fs^2 at 800nm. Calculate the pulse broadening at the output of the plate due to dispersion. [3]

(c) Explain with sketch how a positively chirped pulse can be compensated for in a cavity. [1]

5. (a) Sketch, label and indicate the importance of the relevant energy levels of
(i) Ar ion laser
(ii) Ti-sapphire laser. [4]

(b) Sketch and label an Ar ion laser cavity and explain the importance of the tungsten disk and the off centre holes in the cavity. [2]

(c) How a dye laser is affected by excited state absorption? [1]

k_B = 1.3806 × 10^{-23} J / K; h = 6.626 × 10^{-34} J . sec