Solutions:

1

(a)

Homog	Inhomog
Nd:YAG	Nd:glass fiber
Ti:Sapphire	Er:glass fiber
Yb:YAG	He-Ne
GaAs	Ar^{+} ion plasma
Alexandrite	CO_2
Ruby	

(b) Nd:YAG collisional phonon, Ti:Sapphire collisional phonon (vibronic), He-Cd Doppler, isotope, Nd:glass local field, collisional.

(c)

$$\tau_{sp} = \frac{3h\varepsilon_0 c^3}{16\pi^3 n \nu_0^3 |\mu|^2}$$

$$g(0) = \frac{2}{\pi \Delta \nu_0}$$

$$\sigma(0) = \frac{2\pi^2 |\mu|^2}{3n\varepsilon_0 ch} \nu_0 g(0)$$

$$\tau_{sp} = \frac{\lambda_0^2}{4\pi^2 n^2 \sigma(0)} \frac{1}{\Delta \nu_0}$$

2.

(a) Whole line in homogeneous medium, spectral hole burning in inhomogeneous medium.

(b)Partly-forbidden – longer lifetime.

(c) Calculate G_0 , Γ_s, then use

$$\Gamma(l) = \Gamma_s \ln(1 + (\exp\left(\frac{\Gamma_{in}}{\Gamma_s}\right) - 1)G_0)$$

3.

(a) all except $KTiOPO_4$. Inversion symmetry.

(b)no. No accumulation of energy.

(c) 1064/2. 1319/2. 1319/3

Task 4

(a) Monochromaticity, Coherence, Directionality, Brightness

(b) When a laser beam scattered from a rough surface, the scattered light is seen to consist of a random collection of alternately bright and dark spots.

(c) $d_g=2\lambda L/D$, so L=237 cm.

(d) 1.67 mm.

Task 5.

(a) …

(b)

$$\omega' = \left[\omega^2 - \left(\frac{1}{t_0}\right)^2\right]^{1/2}$$

$$t_0 = \frac{2\tau}{x}$$

$$\omega = \left[\frac{(x-1)}{\tau_c \tau}\right]^{1/2}$$

$$\tau_c = \frac{L_e}{\gamma c}$$

τ=230 μs, τ_c=34 ns, x=2, ω=355 KHz, t_0=230 μs, so ω' is 355 KHz.

(c) Homogenously broadened,

$$\Delta\tau_p \cong \frac{0.45}{(\nu_m \Delta\nu_0)^{1/2}}$$

ν_m=c/2L=750 MHz, $\Delta\tau_p$=37 ps.

Inhomogenously broadened,

$$\Delta\tau_p \cong \frac{0.441}{\Delta\nu_0^*}$$

$\Delta\tau_p$=2.3 ps.

(d) $E = \int_{-\infty}^{+\infty} P(t)dt$

$P_{av}=\nu_m E$, so P_p=442.5 W, E=5 nJ.

Task 6

(a) $$P_{th} = \left(\frac{\gamma}{\eta_p}\right)\left(\frac{h\nu_p}{\tau}\right)\left(\frac{\pi a^2}{\sigma_e\{1-\exp[-(2a^2/w_0^2)]\}}\right)$$, 54.25 W

(b) $$P_{th} = \left(\frac{\gamma}{\eta_p}\right)\left(\frac{h\nu_p}{\tau}\right)\left[\frac{\pi(w_0^2 + w_p^2)}{2\sigma_e}\right]$$, 24.77 W (The pumping efficiency $\eta_p = \eta_a T_p = [1-\exp(-\alpha l)]T_p$)