

Amplification of a Broadband Signal. The transition between two energy levels exhibits a Lorentzian lineshape of central frequency $\nu_0 = 5 \times 10^{14}$ with a linewidth

 $\Delta \nu = 10^{12}$ Hz. The population is inverted so that the maximum gain coefficient $\gamma(\nu_0) = 0.1 \text{ cm}^{-1}$. The medium has an additional loss coefficient $\alpha_s = 0.05 \text{ cm}^{-1}$, which is independent of ν . Approximately how much loss or gain is encountered by a light wave in 1 cm if it has a uniform power spectral density centered about ν_0 with a bandwidth $2\Delta\nu$?

| γι | ر (۷ | is also | o Loi | entzi | an, | Yw |) = Y | Vo > (| (DV/2 V-V0)2+ |) ² (۵۷/2 | 2 | | | | |
|----|------|---------|--------|---------------------|---------|--------------------|--------------|--------|------------------|-------------------------|--------|------|--------|-----|--|
| | | g= - | 1102/c | <u>ıs dv</u> dv | , since | Zivi | = <u>l</u> o | for | Vo - DV | < V< | Vo+ DV | anol | . Icvs | = D | |
| | | => g = | TOV | <u>)(16)</u> 281 | | | | | | | | | | J | |
| | | | 7 Yw | | | | | | | | | | | | |
| | | gner = | 9-0 | الح = | 4.0.1 | cm ⁻¹ - | 0.05 | m = 0 | 7.0285 | > cm | -1 | | | | |
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The Two-Level Pumping System. Write the rate equations for a two-level system, showing that a steady-state population inversion cannot be achieved by using direct optical pumping between levels 1 and 2.

Hint: R2=-R1=R

Hint: R2=-R1=R

$$\frac{dN_1}{dt} = R_2 - \frac{N_2}{T_2}$$

$$\frac{dN_1}{dt} = -R_1 - \frac{N_1}{T_1} + \frac{N_2}{T_2}$$

$$\frac{dN_2}{dt} = -\frac{dN_3}{dt} \quad \text{suppose } N_2 \text{ is The higher level, } N_2 = \frac{g_1 T(\frac{C}{E} + 6\phi)N}{1 + (g_1 + g_2)(\frac{C}{E} + 6\phi)T}$$
Since $N_2 > N_1$, $N_2 + N_1 = N \Rightarrow N_2 > \frac{N}{2} \Rightarrow \text{let } A = T(\frac{C}{E} + 6\phi) \Rightarrow \frac{g_1 A}{H(g_1, g_2)A} > \frac{1}{2}$

$$\Rightarrow 2g_1 A > 1 + g_2 A$$

$$yhich cannot be achived.$$

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| Since | | | | | . coefficient be | ecomes | |
| | the syst | (em. js jn -(E:-E:)/KJ | -thermal | equlibrium | , we can | n get | |
| 3) | N2 = e | _ (2.48/0.036) | = 3.76 ×1 | -42 | | | |
| | | | | | | | |
| | 1/2 + 6 672 1/4 = 0 | × 10 N2)= 2.48/0.26 = | 83.105 | N3 & O. 1 | Vi= 10 ²³ | | |
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| $\frac{N_2}{T_{sp}} = \frac{8}{hV}$ | 1×10°° 1×10°°s | = 8.3×10 | 5-1 C | ,3 C ² | C, V | 3 703 | 125×10 ⁻¹⁹ |
| $\alpha = \frac{\pi}{c}$ | NiBn -N | (2 B ₂₄) | B1 = 2hv | 3A21 = 12hV | is = 11 C | | $= \frac{2 \times 6 \cdot 6 \times 10^{34} \times 3 \times 10}{2 \times 10^{34} \times 3 \times 10^{5}}$ |
| | 0 | < = 10 (9.9) | 8.32 - 8.3 | ×10 18 Bo1 | | | |
| | | = 6.6×10 | 7 x 3.15 x 10 ⁵ | · 9. 98×1033 | | | |
| | | = 4.6 | | | | | |
| | Also, // => | Also, $N_1 + N_2 = \frac{N_2 + \frac{1}{2} \cdot 67}{N_1 = e}$ $\Rightarrow N_1 + 8.$ $\Rightarrow N_1 = \frac{N_2}{7 \cdot 6} = \frac{8.3 \times 10^{18}}{1 \times 10^{3}}$ $\alpha = \frac{hV}{C} (N_1 B_{12} - N_2)$ | Also, $N_{1}+N_{2}=N_{0}=10^{33}$ $N_{2}+\frac{1}{12}.67\times10^{-40}.N_{2}=10^{33}$ $N_{3}+\frac{1}{12}.67\times10^{-40}.N_{2}=10^{33}$ $N_{1}=\frac{N_{2}}{N_{1}}=\frac{1}{12}.48/0.36=10^{33}$ $N_{1}+\frac{1}{12}.8.3\times10^{33}.N_{1}=10^{33}$ $N_{2}=\frac{1}{12}.10^{33}.N_{2}=\frac{1}{12}.3\times10^{33}$ $N_{3}=\frac{1}{12}.10^{33}.N_{2}=\frac{1}{12}.N_{2}.N_{2}.N_{2}.N_{3}$ $N_{3}=\frac{1}{12}.N_{3}.N_{2}.N_{3}.N_{3}.N_{3}$ $N_{4}=\frac{1}{12}.N_{4}.N_{2}.N_{3}.N_{3}.N_{4$ | Also, $N_{1}+N_{2}=N_{2}=10^{33}$ $N_{2}+6.67\times10^{-42}N_{2}=10^{33}$ $N_{3}+6.67\times10^{-42}N_{2}=10^{33}$ $N_{4}=0$ $N_{5}=0$ N | Also, $N_{1}+N_{2}=Na=10^{3\frac{1}{2}}$ $N_{2}+(3.67\times10^{-40^{2}}N_{2})=10^{3\frac{1}{2}} \implies N_{3} \approx 0.$ $N_{1}=e^{-2.48/0.36}=8.3\times10^{-5}$ $N_{1}+8.3\times10^{5}N_{1}=Na=10^{2\frac{3}{2}}$ $N_{1}=9.99\times10^{2^{2}}, N_{2}=8.3\times10^{18}$ | Also, $N_{17}N_{2} = Na = 10^{33}$ $N_{2} + \frac{1}{2} \cdot $ | $N_{2} + \frac{1}{4} \cdot 67 \times 10^{-10} N_{2}) = 10^{\frac{3}{2}} \implies N_{3} \approx 0, N_{1} = 10^{\frac{3}{2}}$ $\Rightarrow N_{1} = e^{-3.48/0.36} = 8.3 \times 10^{-5}$ $\Rightarrow N_{1} = 9.99 \times 10^{\frac{3}{2}}, N_{2} = 8.3 \times 10^{\frac{18}{2}}$ $\Rightarrow N_{1} = 9.99 \times 10^{\frac{3}{2}}, N_{2} = 8.3 \times 10^{\frac{18}{2}}$ $\Rightarrow N_{1} = \frac{8.3 \times 10^{\frac{18}{2}}}{1 \times 10^{\frac{3}{2}}} = 8.3 \times 10^{\frac{3}{2}} = \frac{C^{3}}{2h \times 10^{\frac{3}{2}}} = \frac{C^{3}}{2h \times 10^{\frac{3}{2}}} = \frac{hv}{2h} \frac{1}{2h} = \frac{hv}{2h} = \frac{hv}{2h$ |

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| (b) | | V = - | VF | 2 | 0.15 G |)H3 = | 23. | 33 m | odes | | | | | | | |
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| | 4° | tsp : | $\frac{\nabla p}{n}$ $\frac{N_2}{n}$ $= \frac{N_2}{N_2}$ $= \frac{N_2}{N_2}$ | > \(\frac{1}{N_0} \) | | | | | | |
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| | | T1 = | 光 | | | | | | | |
| | | Tz | N2 N | | | | | | | |
| | | T21 | = (N) | -N1) | | | | | | |
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