Assign 5.

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Problem 1.

Consider an optical cavity that is 2 meters long and is filled with a gain medium with a peak gain of 35% per pass. The total round trip cavity loss is 5%. The gain is Doppler broadened and consists of argon gas (atomic weight = 39.95 AMU) with gain peak at 534.1 nm and gas temperature is 450 K. The upper state lifetime is 100 nsec.

Calculate the number of cavity modes that will produce laser action assuming that one of the cavity modes lines up exactly at the line center of the gain.

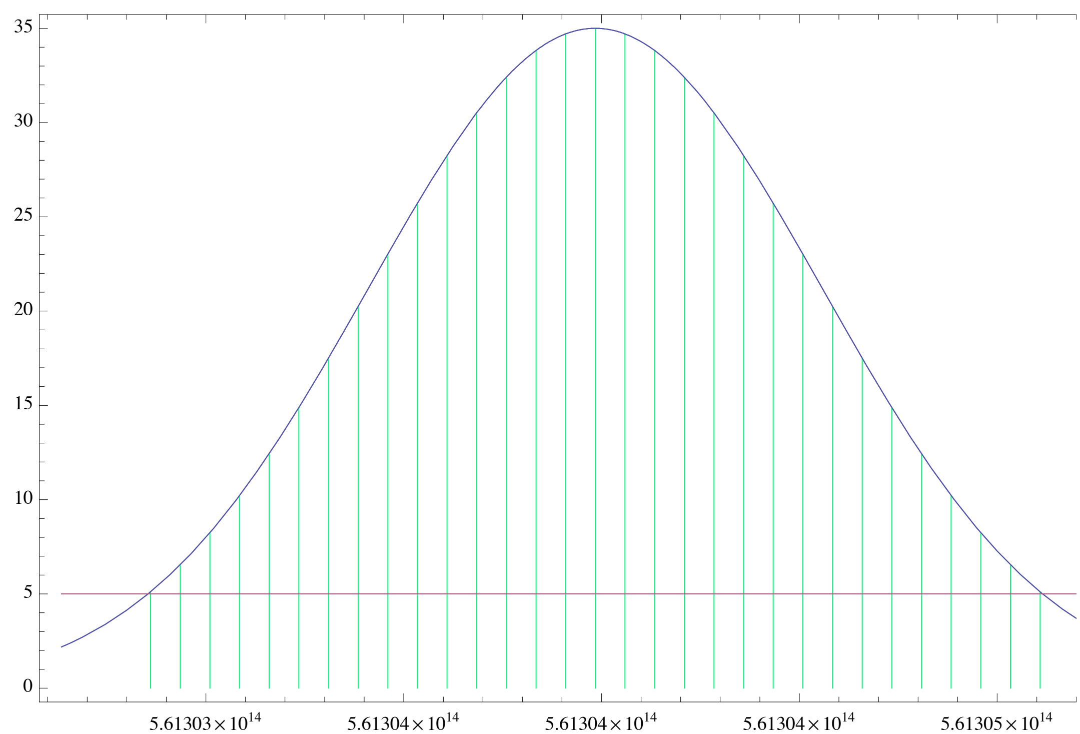
pg 27. only consider those frequencies above the loss line: $2\, g(\nu)\, L > \delta_c$.
So we have a loss line at 5%, and the Professor's idea was to compare it against a gain peak of 35%. As the problem reads 35% "per pass" I give credit for that as well, (or interpreting the 5% as "per pass").

Using: $\alpha(\nu) = \alpha_0 \,\mathrm{Exp}\left[-\left(2\, \frac{(\nu-\nu_0)}{\Delta\nu_D} \sqrt{\ln(2)}\right)^2\right]$, with $\Delta\nu_D = \frac{2\sqrt{2\, k \ln 2}}{c}\, \nu_0 \sqrt{\frac{T}{M}} = 1.34927\times 10^9$ Hertz ,

$\nu_0 = c/\lambda_0 = 5.61304\times 10^{14}$ Hertz, and $\alpha_0 = 35$, with δ=5.

Line spacing is $\frac{c}{2L} = \frac{c}{4\,\mathrm{Meter}} = 7.49481\times 10^7$ Hertz, giving me the following plot:

Out[31]=



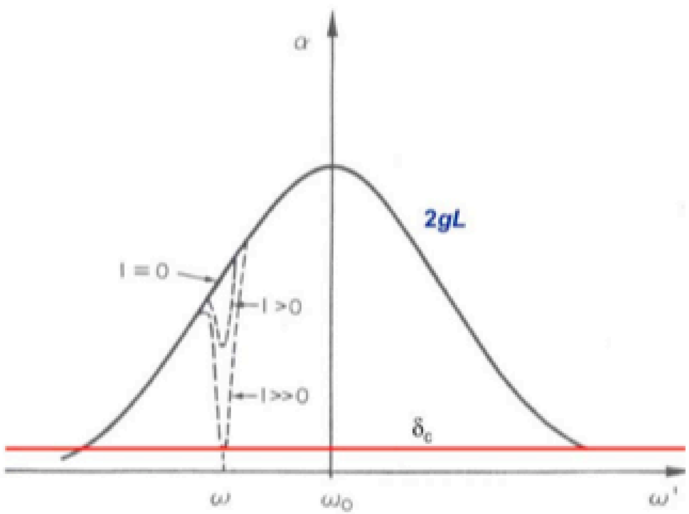
Which by my count has 31 modes activated.

- **scratch**

Problem 2.

Estimate the relative power output on each of the modes (take the strongest mode output as 1)

My interpretation was it could just be the difference between 95% at peak, scaled by the relative wait of g(ν)-loss, based upon the following plot. On further contemplation I realized that the power is really given by:
$I(\nu) \propto I_0\, e^{g(\nu)-\delta}$*, so it should be the ratio of* $I(\nu)/I(\nu_0)$*. I gave credit for well-reasoned answers.*



From my numbers in Problem 1, I got:

	ν_n	$\frac{\alpha(\nu)-\delta}{\alpha(0)-\delta}=\frac{g(\nu)-\delta}{g(\nu_0)-\delta}$	$\frac{I[\nu]}{I[\nu_0]}$
-15	5.61303×10^{14}	0.00355314	1.04102×10^{-13}
-14	5.61303×10^{14}	0.0514822	4.38449×10^{-13}
-13	5.61303×10^{14}	0.108164	2.40115×10^{-12}
-12	5.61303×10^{14}	0.1737	1.71505×10^{-11}
-11	5.61303×10^{14}	0.247713	1.57972×10^{-10}
-10	5.61303×10^{14}	0.329262	1.82418×10^{-9}
-9	5.61303×10^{14}	0.416791	2.52041×10^{-8}
-8	5.61303×10^{14}	0.508124	3.90331×10^{-7}
-7	5.61303×10^{14}	0.600515	6.23992×10^{-6}
-6	5.61304×10^{14}	0.69076	0.0000935323
-5	5.61304×10^{14}	0.775364	0.00118373
-4	5.61304×10^{14}	0.850758	0.0113646
-3	5.61304×10^{14}	0.913546	0.0747493
-2	5.61304×10^{14}	0.960753	0.308078
-1	5.61304×10^{14}	0.990062	0.742198
0	5.61304×10^{14}	1.	1.
1	5.61304×10^{14}	0.990062	0.742198
2	5.61304×10^{14}	0.960753	0.308078
3	5.61304×10^{14}	0.913546	0.0747493
4	5.61304×10^{14}	0.850758	0.0113646
5	5.61304×10^{14}	0.775364	0.00118373
6	5.61304×10^{14}	0.69076	0.0000935323
7	5.61305×10^{14}	0.600515	6.23992×10^{-6}
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15	5.61305×10^{14}	0.00355314	1.04102×10^{-13}

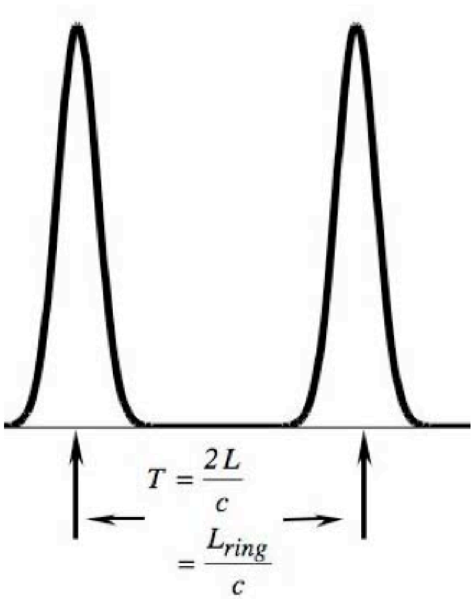
- **scratch**

Problem 3

If all the oscillating modes were to be phase locked together, what would the lasewr output look like? Continuous wave or pulses? If pulses, estimate the pulse width and the pulse repetition frequency.

from pg. 49-51

It's going to be pulses with pulse repitition frequency given by: Pulse width= $\tau_p = \frac{T}{2N+1} = \frac{2\pi}{\Omega(2N+1)}$, with pulse modulation frequency: $\Omega = \frac{2\pi c}{2L}$, reptition time T = $\frac{c}{2L}$. Repetition frequency,
is therefore given by 1/T.


$T = \frac{2L}{c}$
$= \frac{L_{ring}}{c}$