Artificial atom in a transmission line

- What if there's many artificial atoms?

Master equation: N artifical atoms

H_0

$$\dot{\rho} = \boxed{\frac{-i}{\hbar}\left[H_{Qs},\rho\right]} - i\left[\sum_j D_j(t)\sigma_x^j,\rho\right]$$

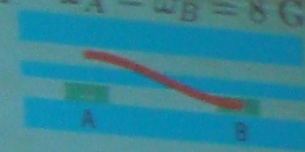
$$- i\sum_{k\neq j}\Omega_{kj}^{+}\left(\sigma_+^k\rho\sigma_-^j - \sigma_+^j\rho\sigma_-^k - \sigma_-^j\sigma_+^k\rho + \rho\sigma_-^k\sigma_+^j\right)$$

$$- i\sum_{k\neq j}\Omega_{kj}^{-}\left(\sigma_-^k\rho\sigma_+^j - \sigma_-^j\rho\sigma_+^k - \sigma_+^j\sigma_-^k\rho + \rho\sigma_+^k\sigma_-^j\right)$$

$$+ \sum_{kj}\frac{\gamma_{kj}}{2}\left(\sigma_-^k\rho\sigma_+^j + \sigma_-^j\rho\sigma_+^k - \sigma_+^j\sigma_-^k\rho - \rho\sigma_+^k\sigma_-^j\right).$$

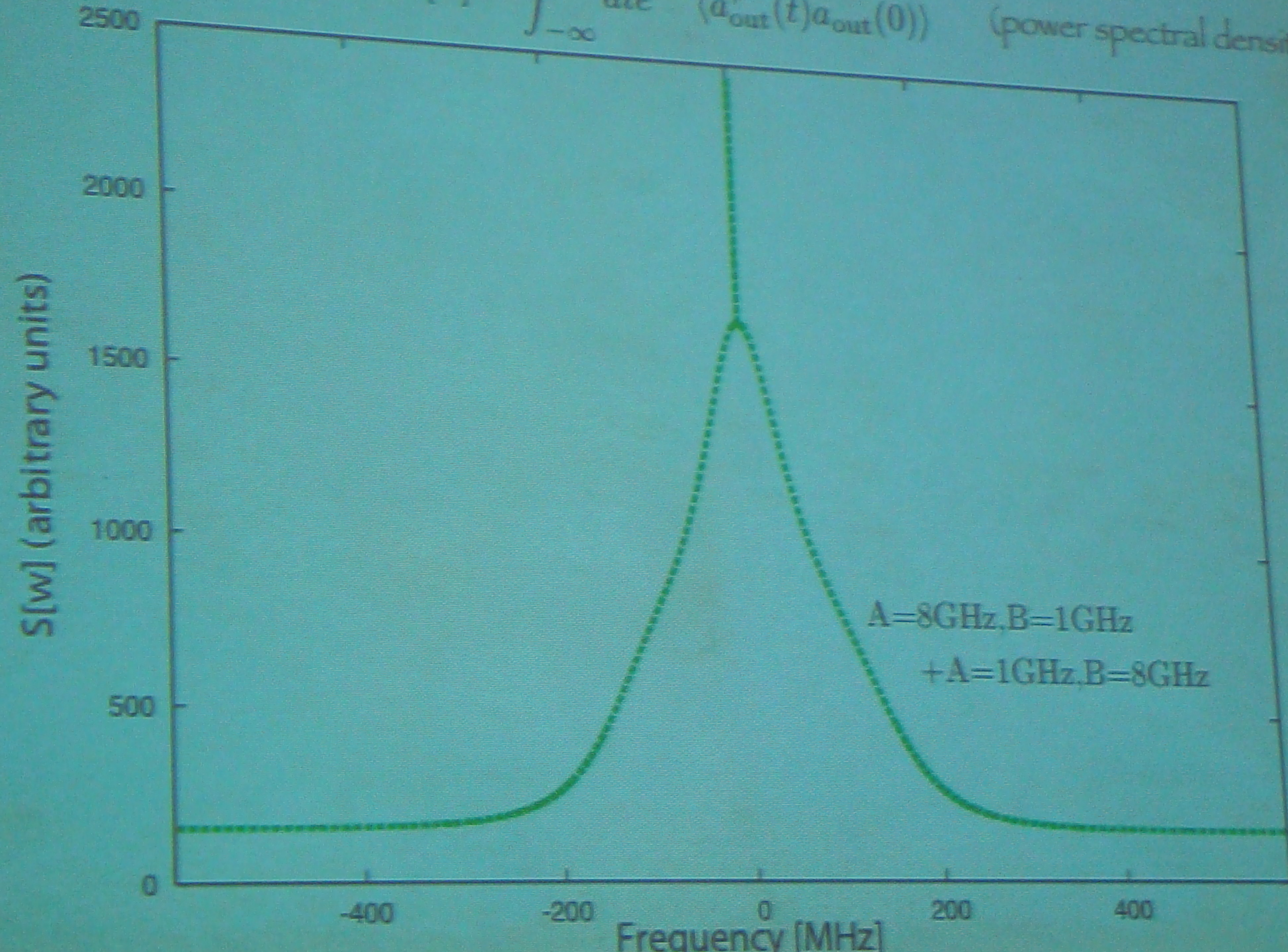
nλ/2 mode spectrum

$\omega_d = \omega_A = \omega_B = 8$ GHz



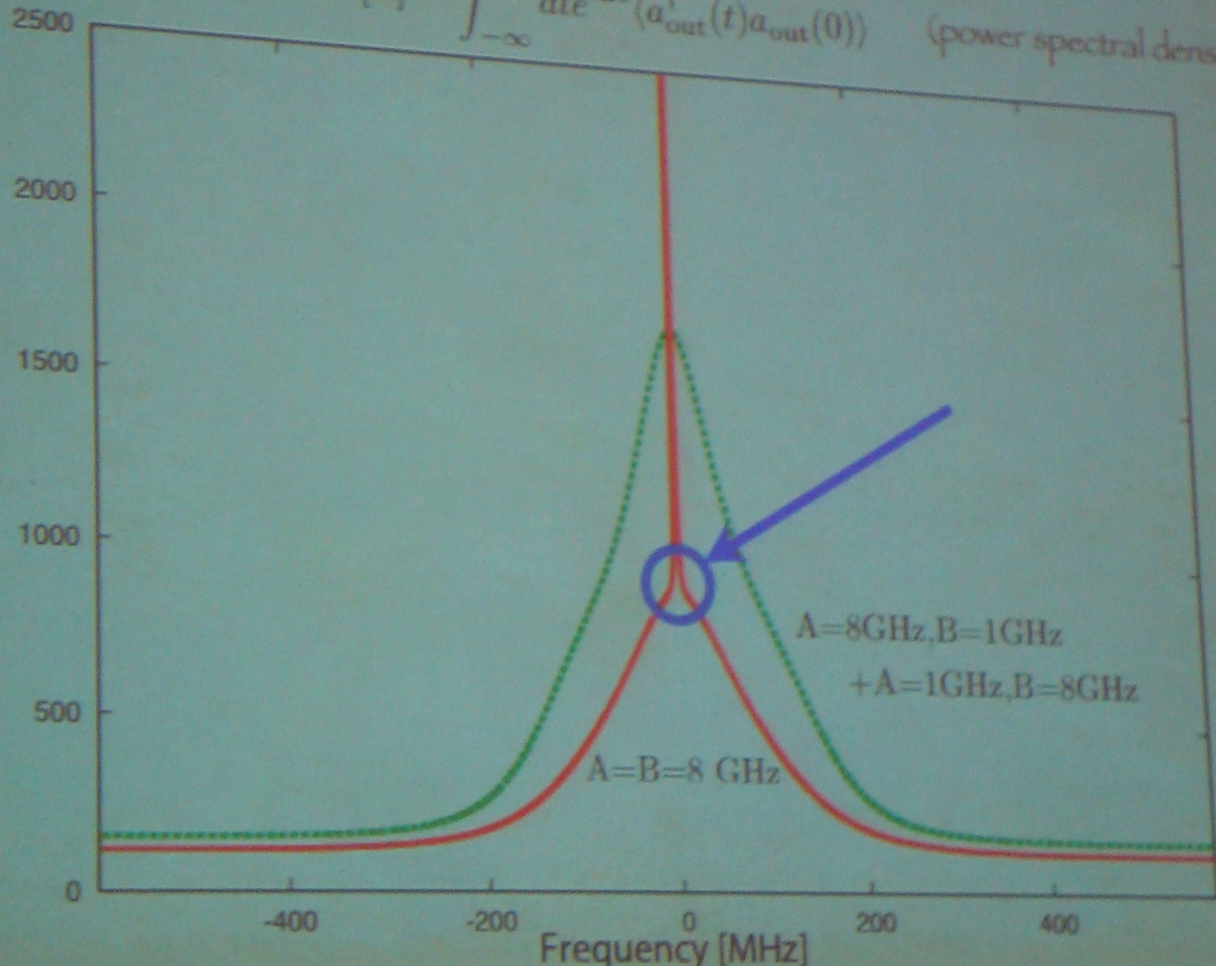
$$S[\omega] = \int_{-\infty}^{\infty} dt e^{i\omega t} \langle a^{\dagger}_{\mathrm{out}}(t) a_{\mathrm{out}}(0) \rangle$$

(power spectral density)

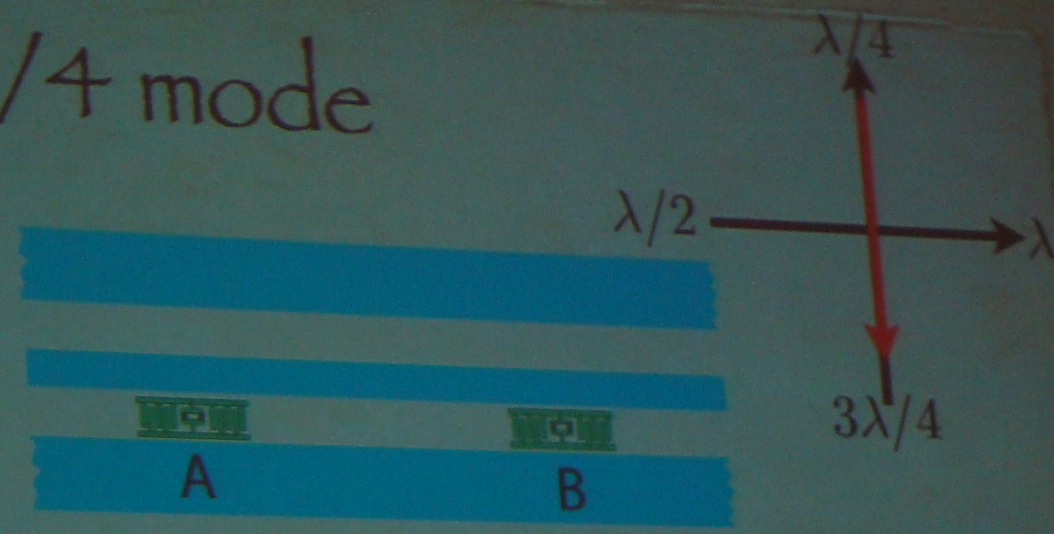


nλ/2 mode spectrum

$$S[\omega] = \int_{-\infty}^{\infty} dt e^{i\omega t} \langle a_{out}^{\dagger}(t) a_{out}(0) \rangle$$ (power spectral density)

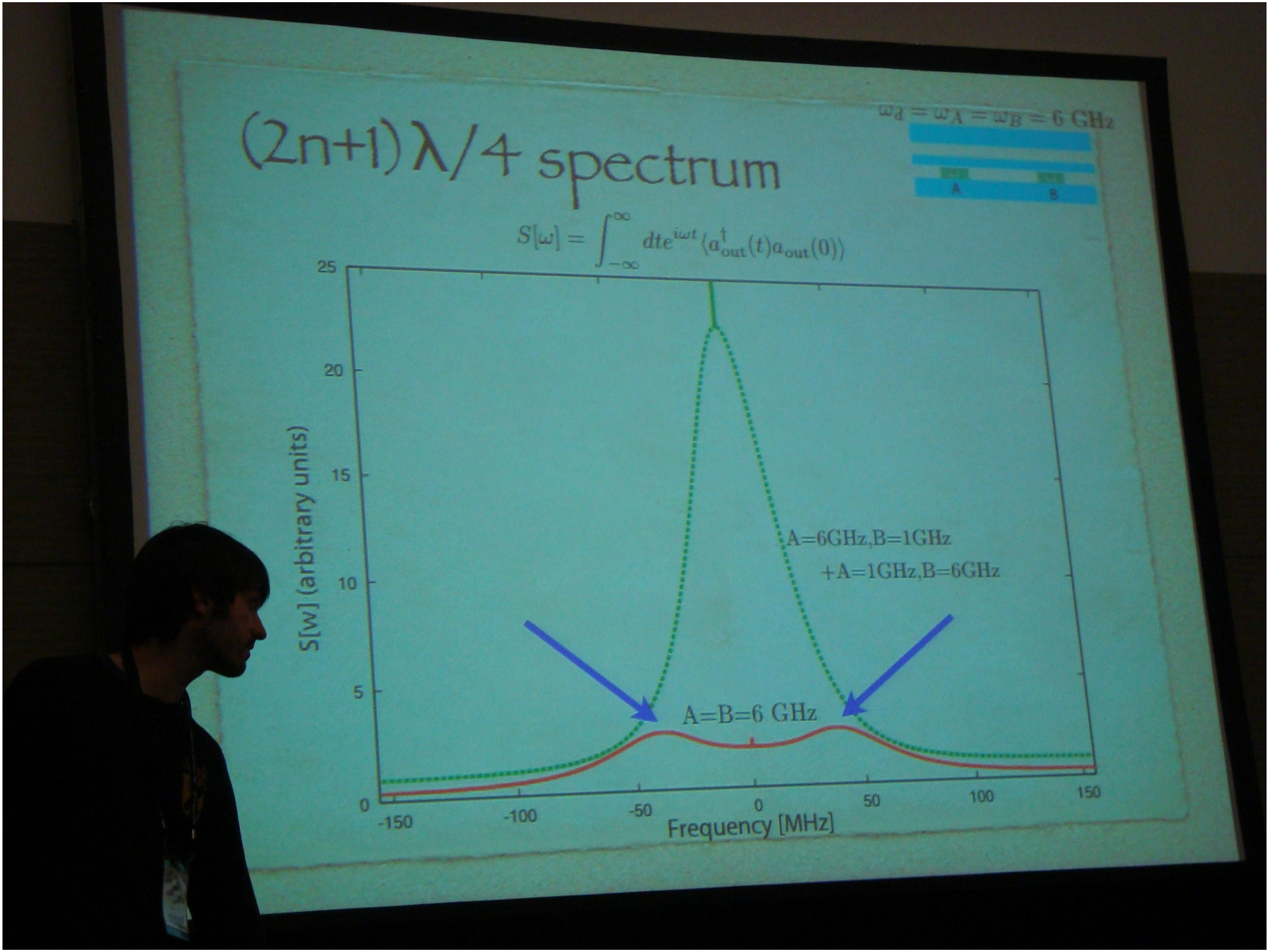


(2n+1)λ/4 mode



$$-iJ\left[\sigma_-^A\sigma_+^B + \sigma_-^B\sigma_+^A, \rho\right] + \sum_j \gamma_{jj}\mathcal{D}\left[\sigma_-^j\right]\rho$$

- No standing mode => No interaction through resonant photons
- Virtual interaction through the other modes!


(2n+1)λ/4 spectrum
$\omega_d = \omega_A = \omega_B = 6$ GHz
A
B
$S[\omega] = \int_{-\infty}^{\infty} dt e^{i\omega t} \langle a_{out}^{\dagger}(t) a_{out}(0) \rangle$
S[w] (arbitrary units)
Frequency [MHz]
A=6GHz,B=1GHz
+A=1GHz,B=6GHz
A=B=6 GHz
0
5
10
15
20
25
-150
-100
-50
0
50
100
150