Progress on wave physics in 1D waveguide cavity and cross cavity

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Target: Understanding level attraction

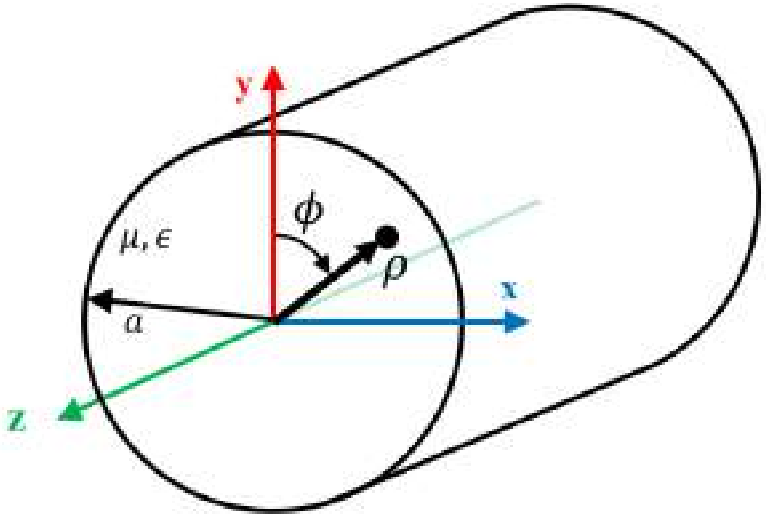
Method:

1. Maxwell equation + cavity perturbation
2. Experiment
3. Simulation from CST software

Scenario:

1. 1D waveguide cavity
2. Planar cross cavity

Maxwell equations



Vector wave equation

$$\nabla \times \vec{e} = -\vec{M} - j\omega\mu\vec{h},$$

$$\nabla^2\vec{e} + k^2\vec{e} = \nabla \times \vec{M} + j\omega\mu\vec{J} + \frac{1}{\epsilon}\nabla q_e,$$

$$\nabla^2\vec{h} + k^2\vec{h} = -\nabla \times \vec{J} + j\omega\mu\vec{M} + \frac{1}{\mu}\nabla q_m,$$

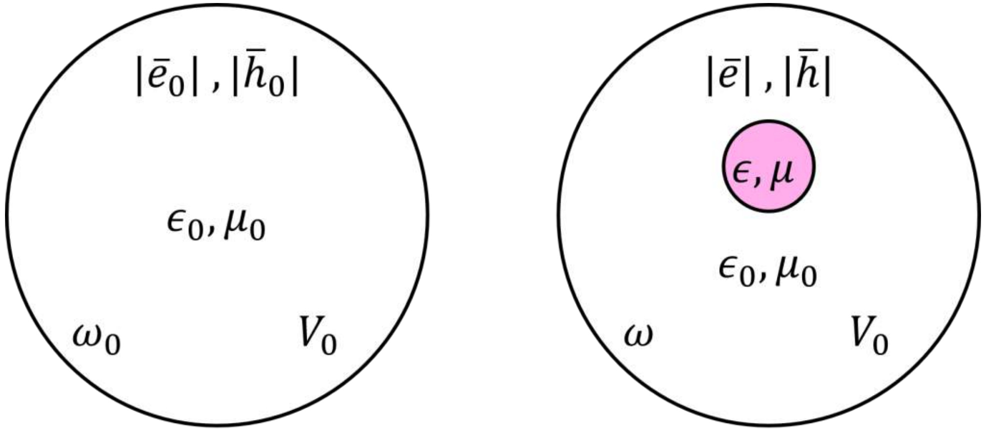
$$\nabla \cdot \vec{h} = \frac{\ }{\mu},$$

We assume $\vec{M} = \vec{J} = q_e = q_m = 0$, In a source free region $\rightarrow \vec{e}, \vec{h}$

Cavity perturbation theory

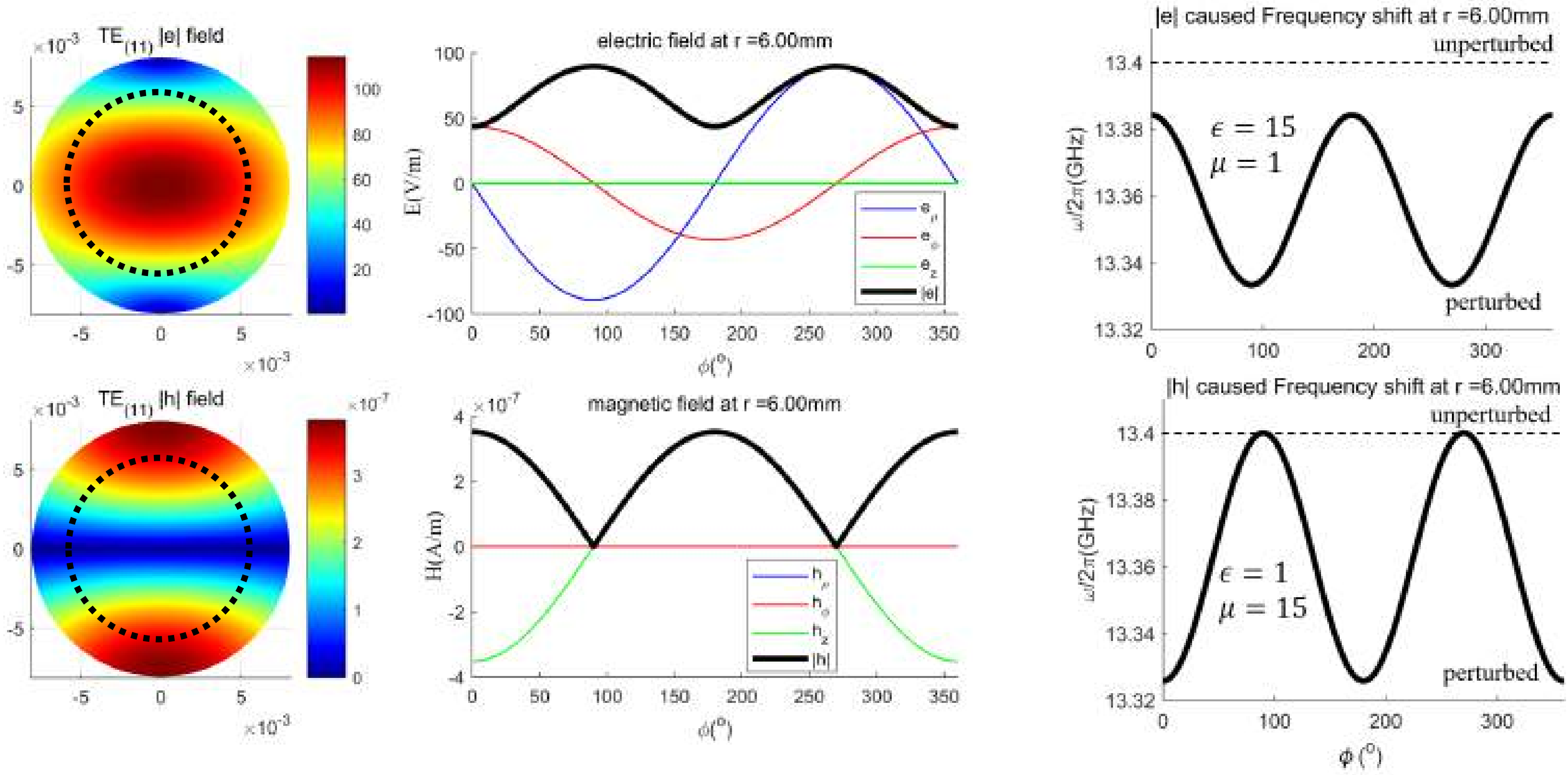
$$\frac{\omega - \omega_0}{\omega} = -\frac{\iiint_v (\Delta\epsilon\bar{e} \cdot \bar{e_0}^\star + \Delta\mu\bar{h} \cdot \bar{h_0}^\star)dV}{\iiint_v (\epsilon\bar{e} \cdot \bar{e_0}^\star + \mu\bar{h} \cdot \bar{h_0}^\star)dV},$$

$$\frac{\omega - \omega_0}{\omega_0} \approx -\frac{\iiint_v (\Delta\epsilon\,|\bar{e_0}|^2 + \Delta\mu\,|\bar{h_0}|^2)dV}{\iiint_v (\epsilon\,|\bar{e_0}|^2 + \mu\,|\bar{h_0}|^2)dV}.$$

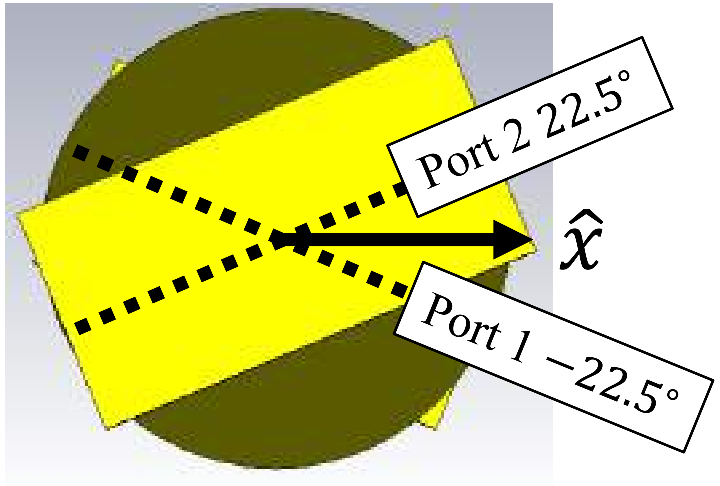


(a) (b)

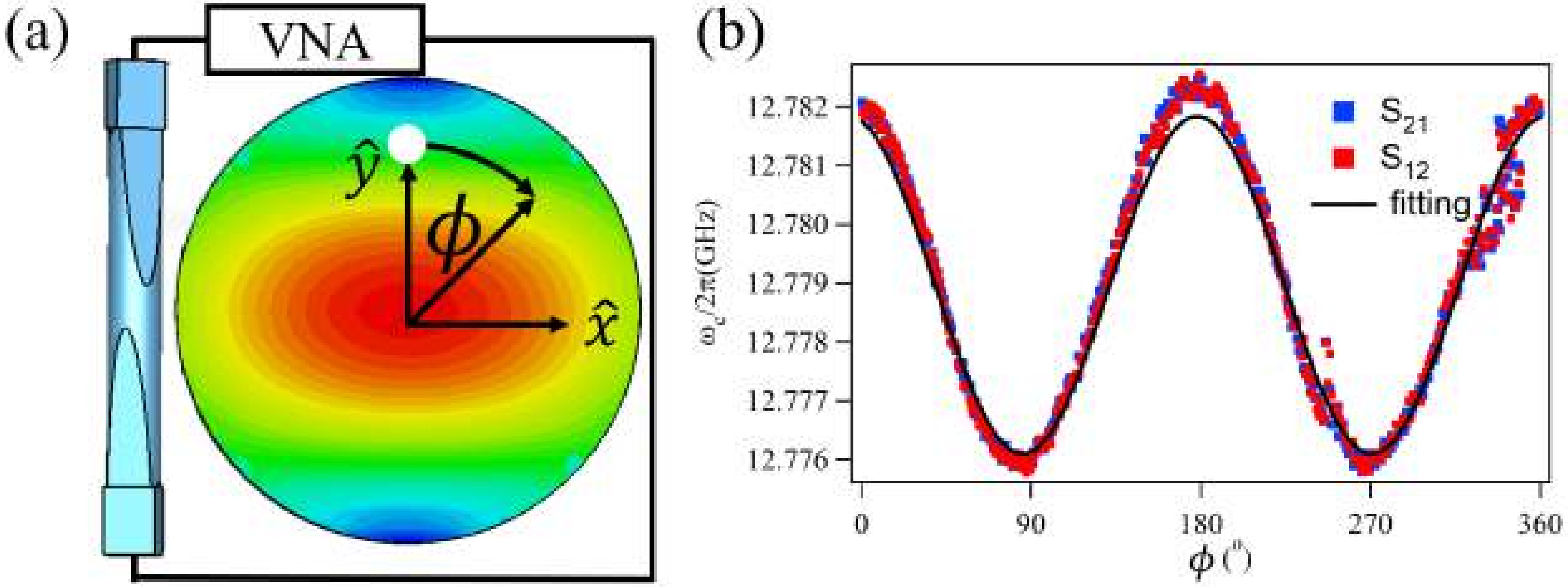
Calculations



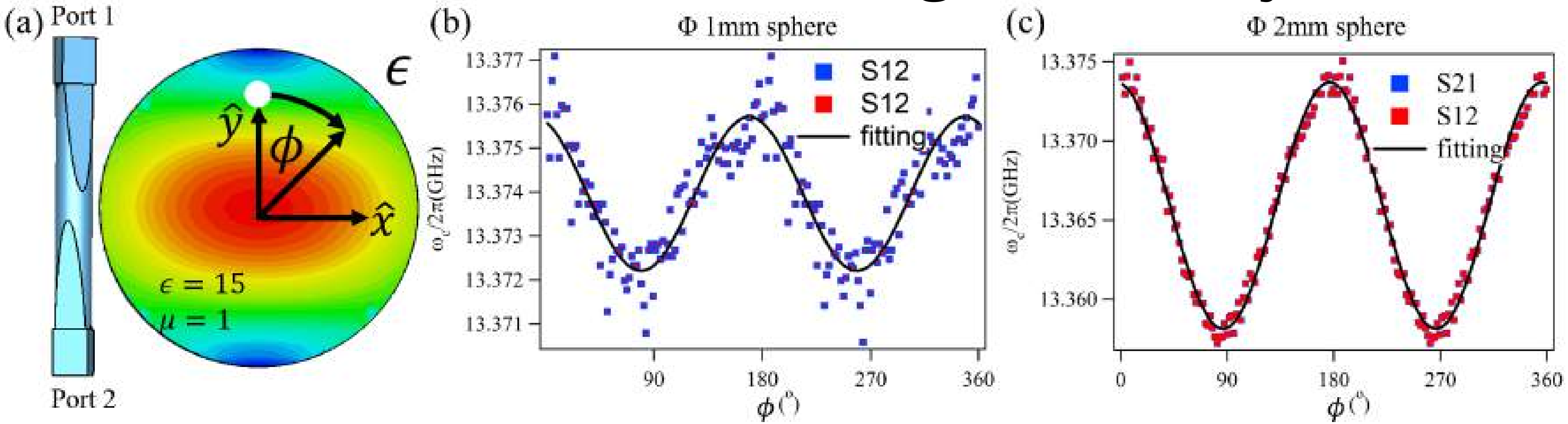
Experiment

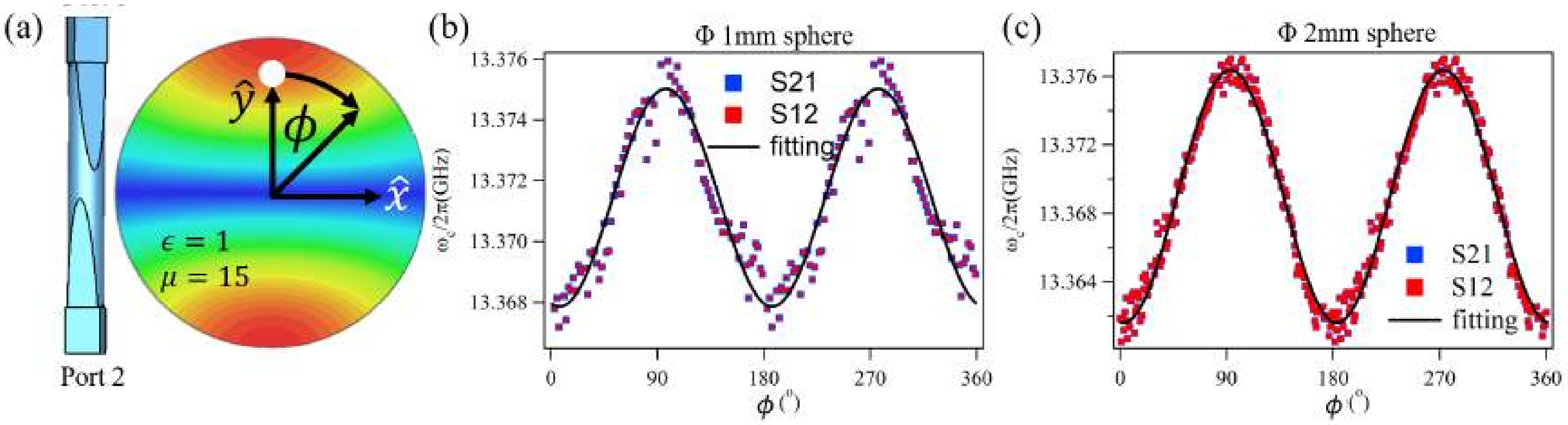


Current Front View



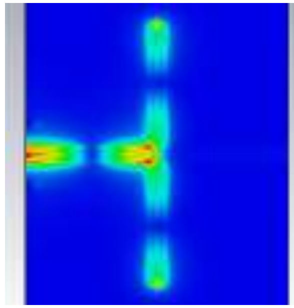
Simulations —— 1D waveguide cavity



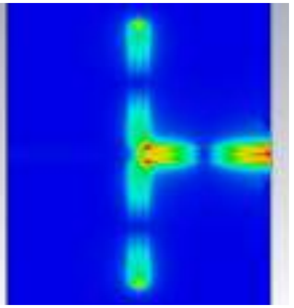


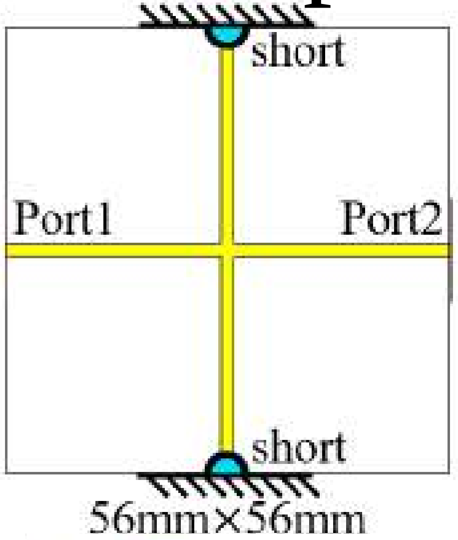
Simulations —— planar cross cavity

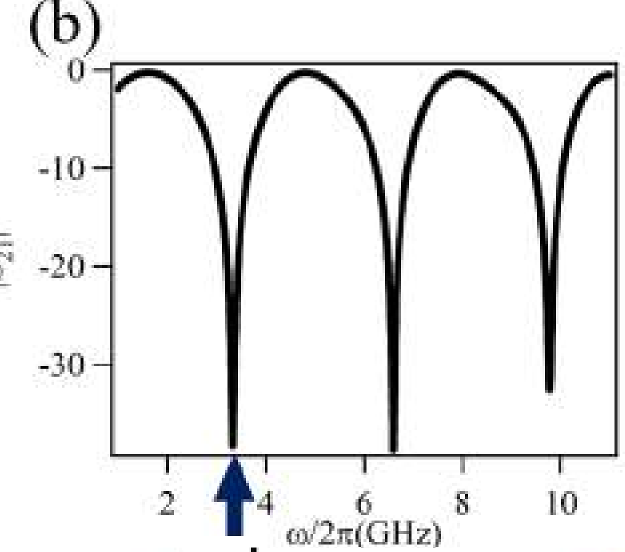
Port 1



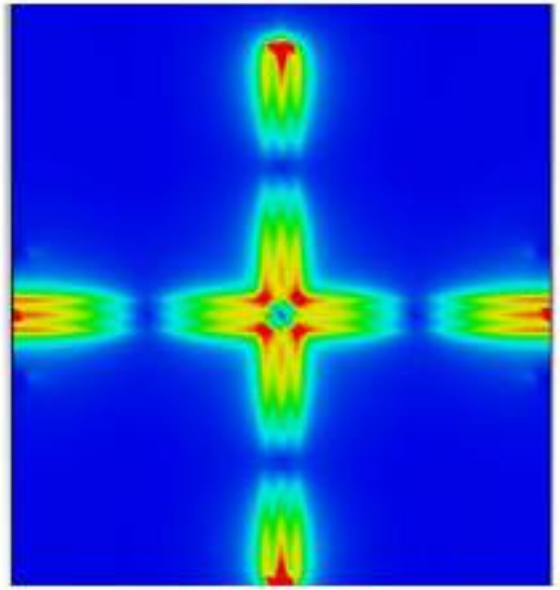
Port 2

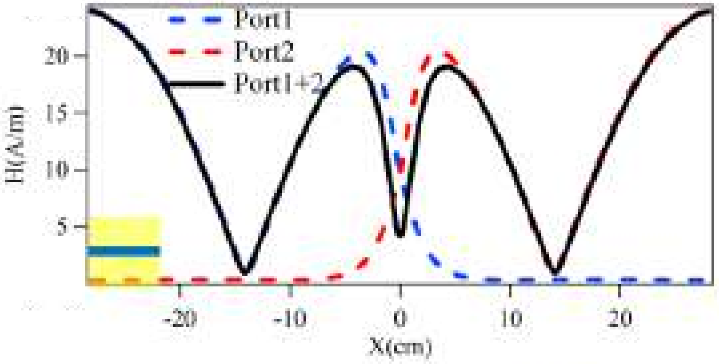


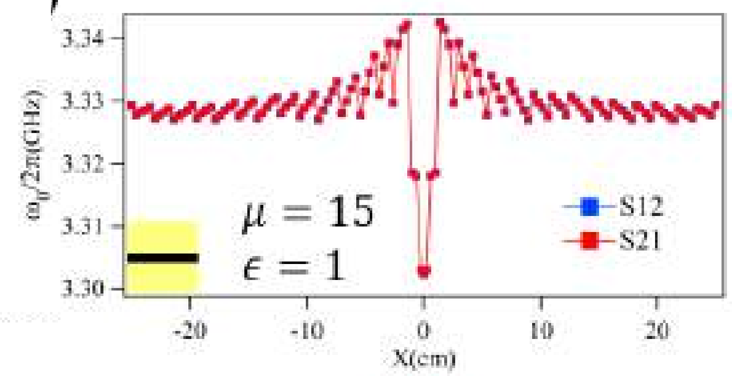


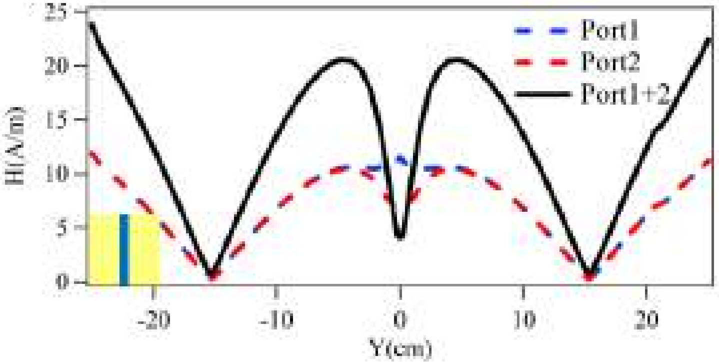


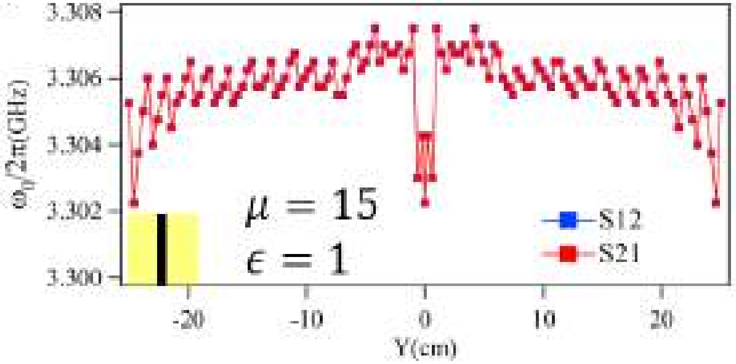
Port 1+2



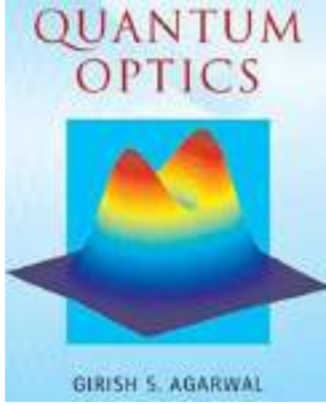


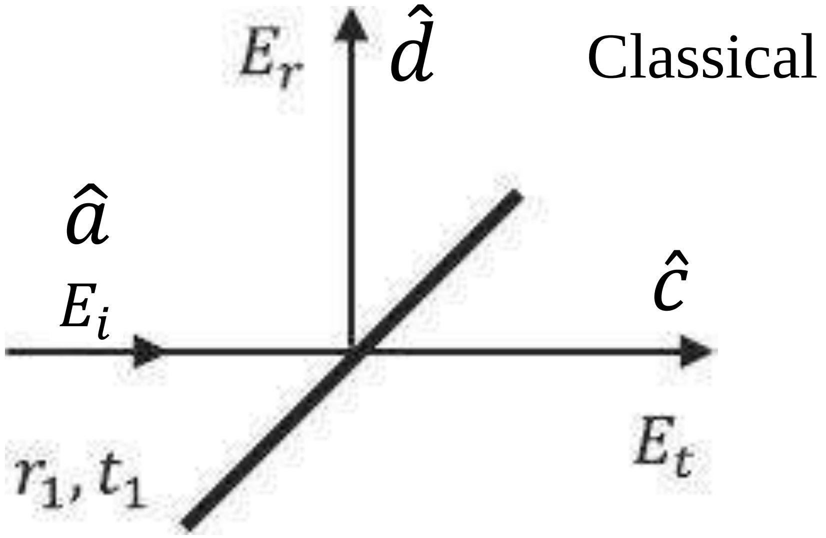


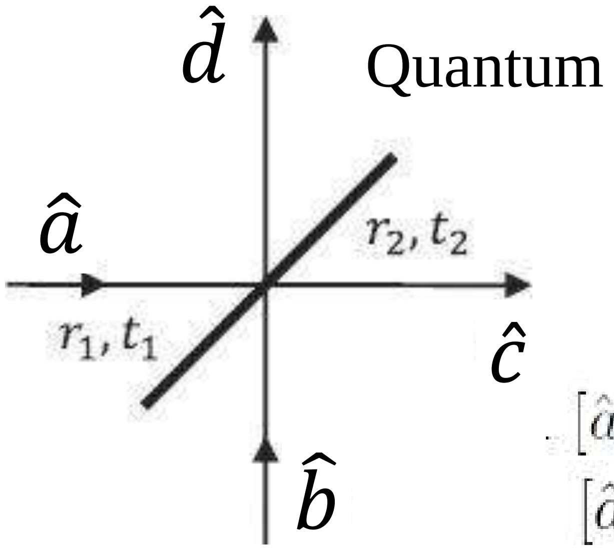




Possible explanation (need further study)

Citation: 





$$[\hat{a}, \hat{a}^\dagger] = [\hat{b}, \hat{b}^\dagger] = 1$$
$$[\hat{a}, \hat{b}^\dagger] = 0$$

$$E_t = t_1 E_i$$
$$E_r = r_1 E_i.$$

$$\hat{d} = t_1 \hat{a}$$
$$\hat{c} = r_1 \hat{a}.$$

$$\begin{pmatrix} \hat{c} \\ \hat{d} \end{pmatrix} = \begin{pmatrix} t1 & r2 \\ r1 & t2 \end{pmatrix} \begin{pmatrix} \hat{a} \\ \hat{b} \end{pmatrix}$$

This do not satisfy the following:

$$[\hat{c}, \hat{d}^\dagger] = 0.$$

In quantum theory vacuum fields are always present. Hence even if no field is sent from the other port of the beam splitter, the vacuum field enters from this port.

Next step on wave physics:

1. Further study on vacuum field.
2. Derive the coupling using LLG equation and Maxwell equation.

DRDC project (This week)

- Dielectric imaging using SSR sensor