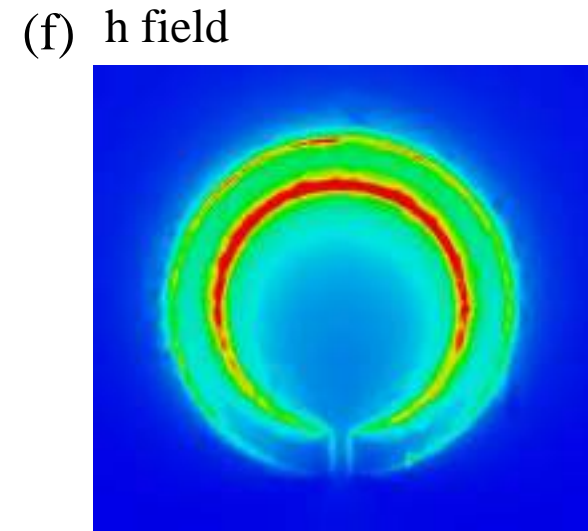
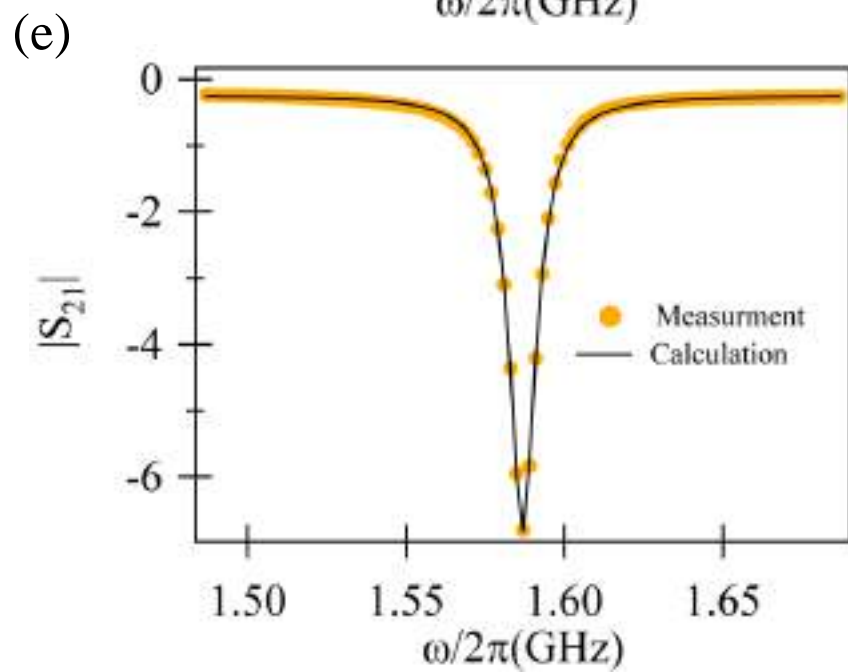
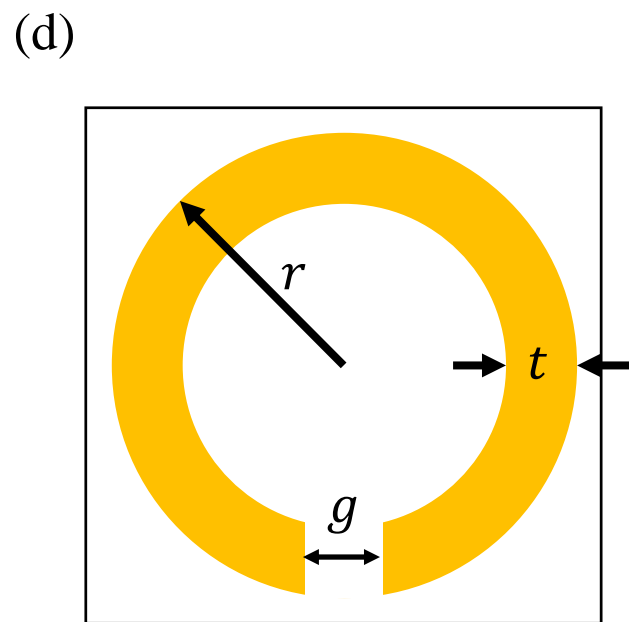
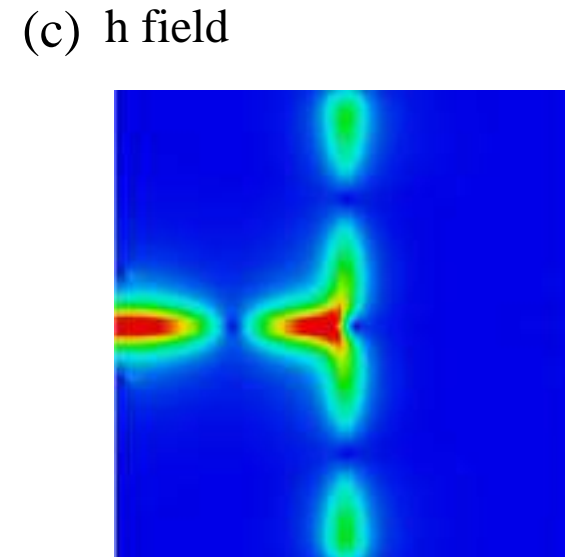
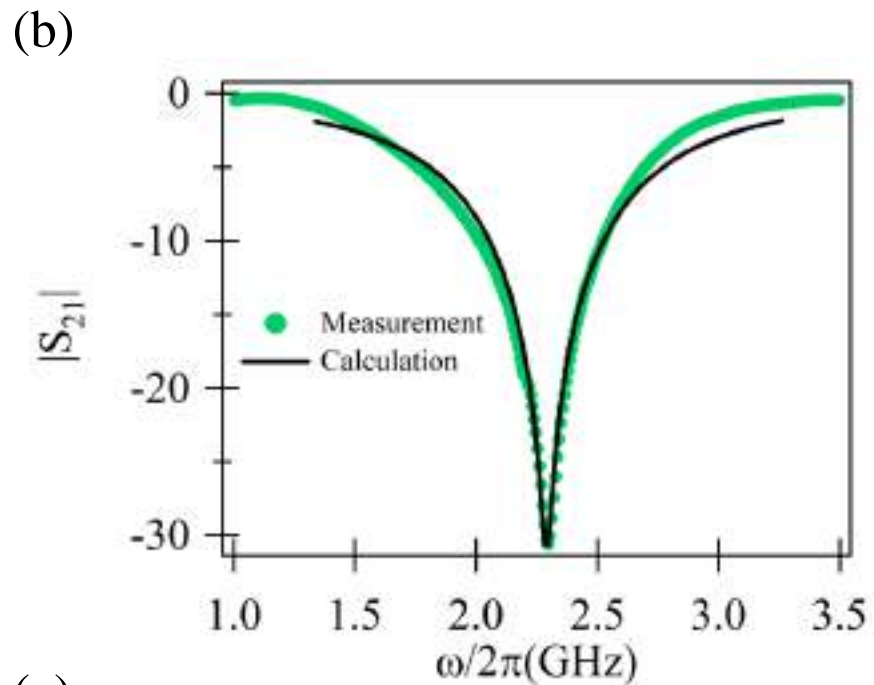
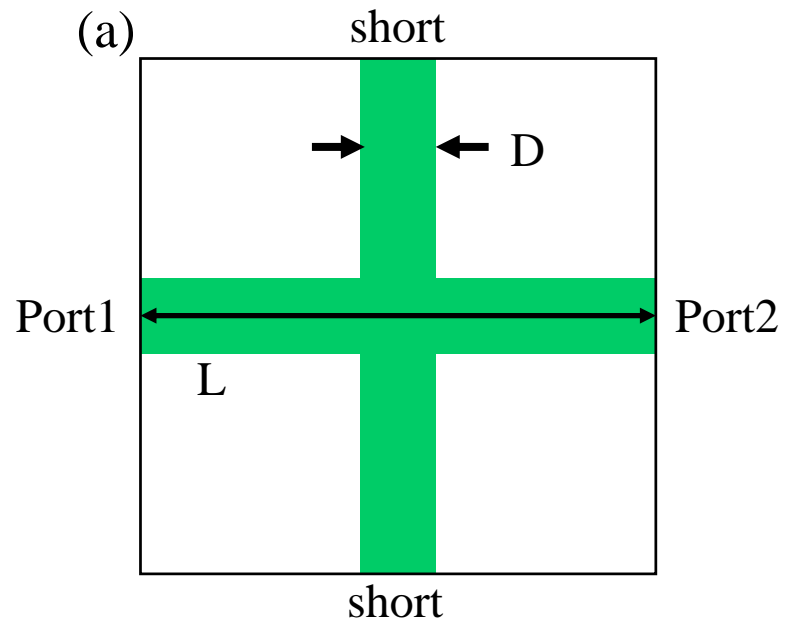


# Level attraction in metamaterials

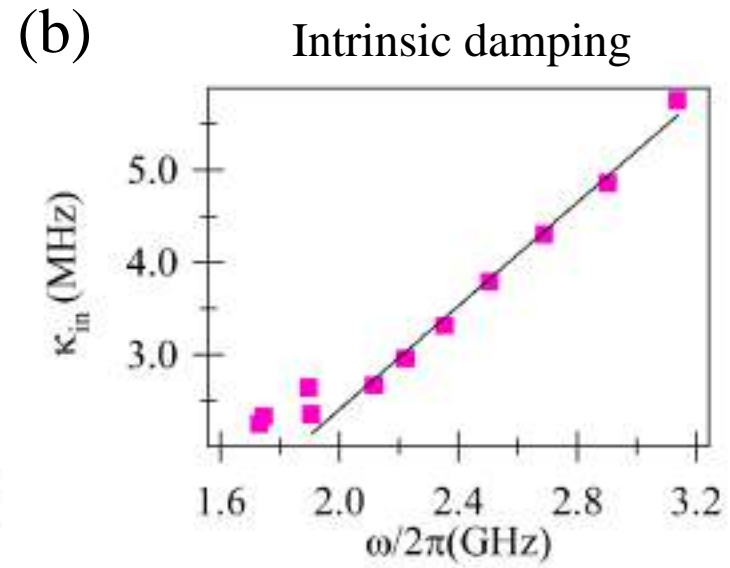
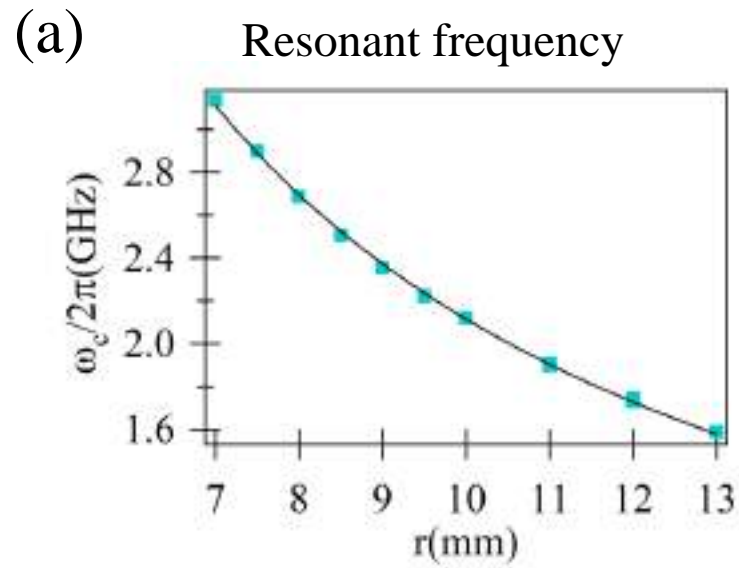
Yutong Zhao

March 4<sup>th</sup> 2019

# Characterize the cross cavity and Split Ring Resonator (SRR)



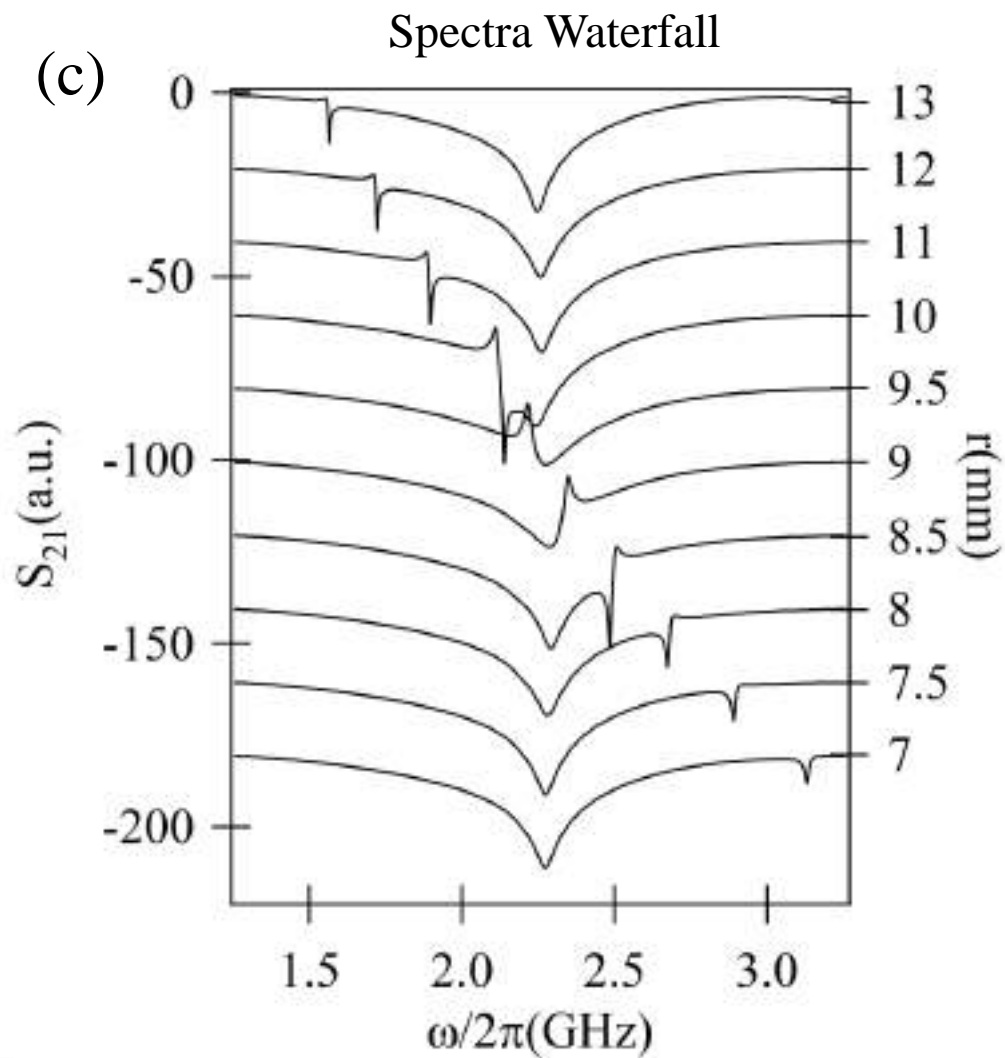
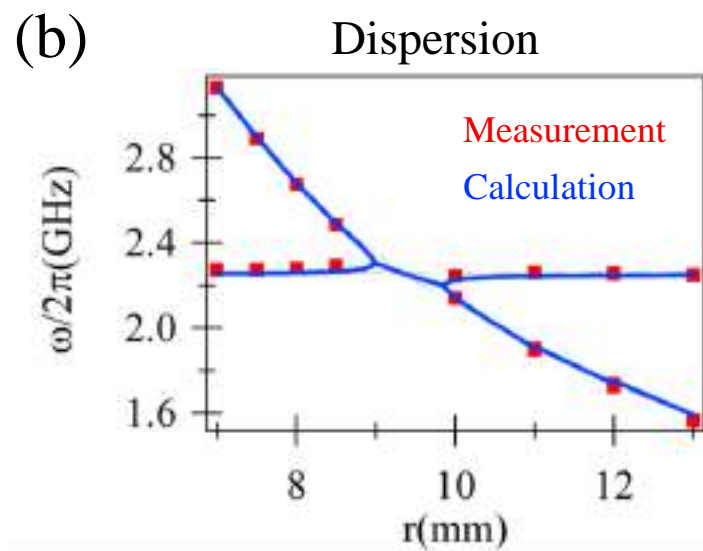
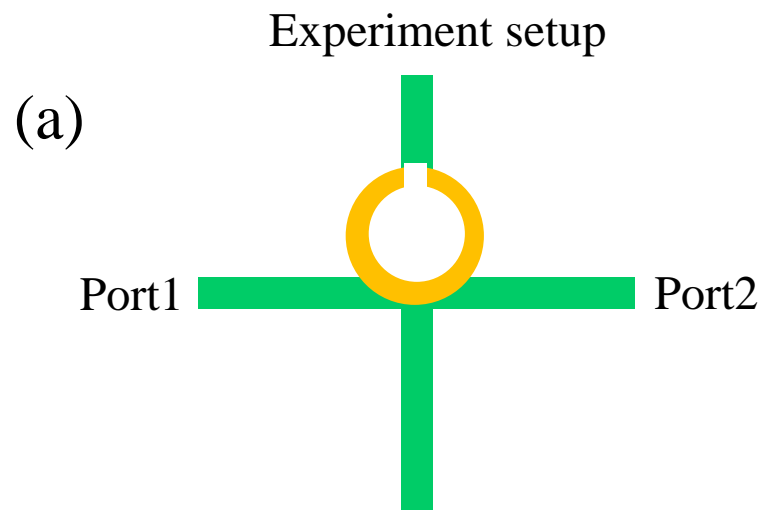
## Characterize SRRs with different radius



$$f_{SRR} = \frac{c'}{\lambda} = \frac{c'}{2\pi r} \propto \frac{a}{r}$$

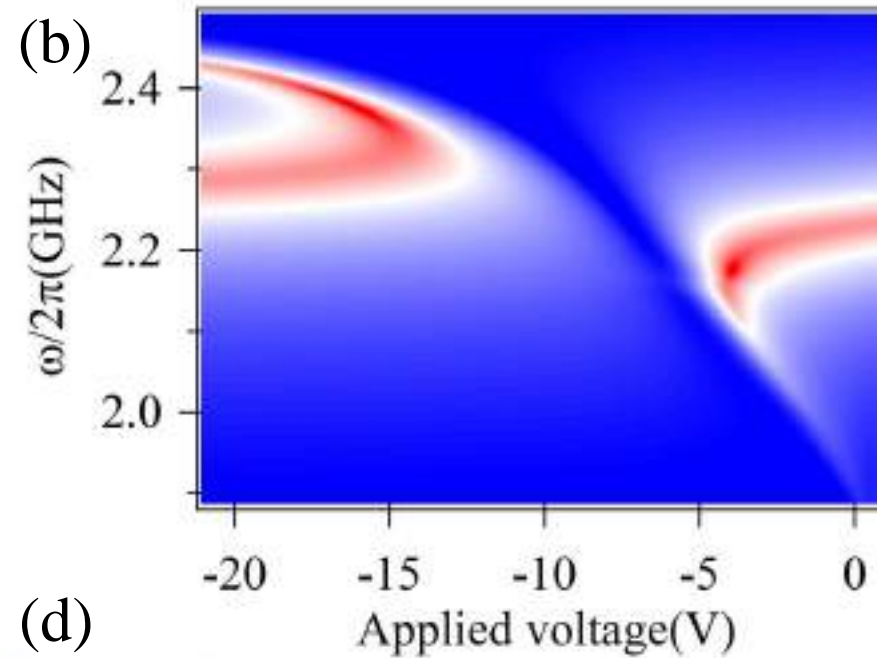
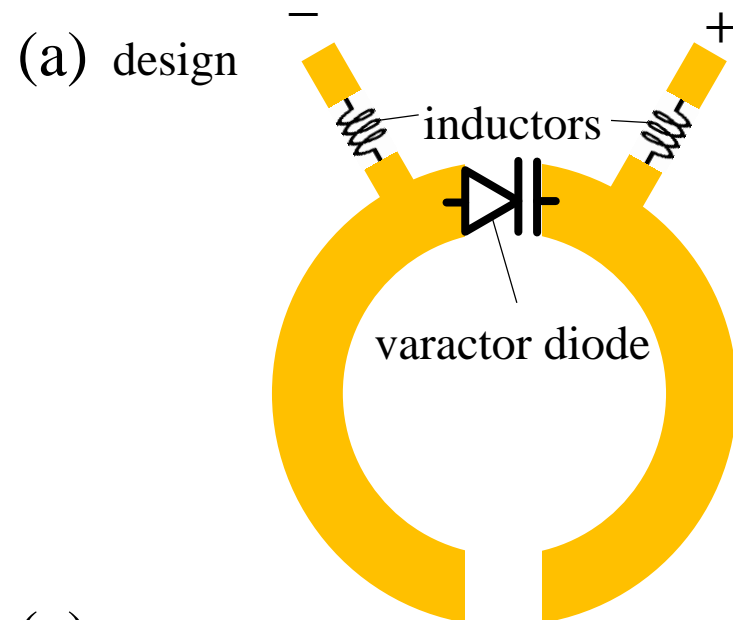
$$\Delta\omega_{in} = \frac{R}{2L} = \boxed{\frac{R}{2} \sqrt{\frac{C}{L}}} \times \frac{1}{\sqrt{LC}} \\ = \beta\omega_c$$

# Characterize SRRs with different radius

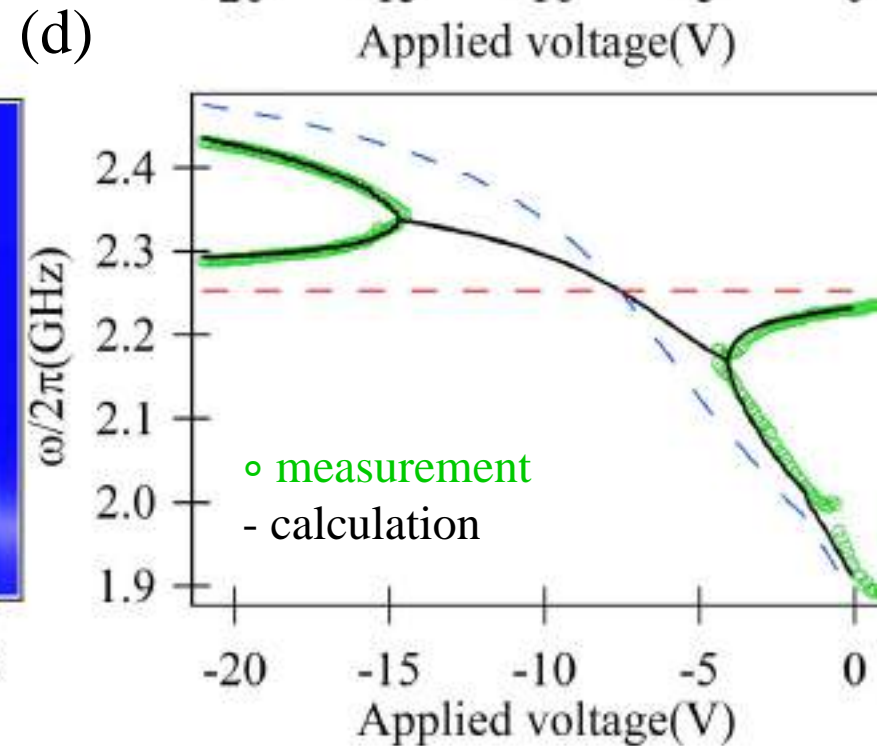
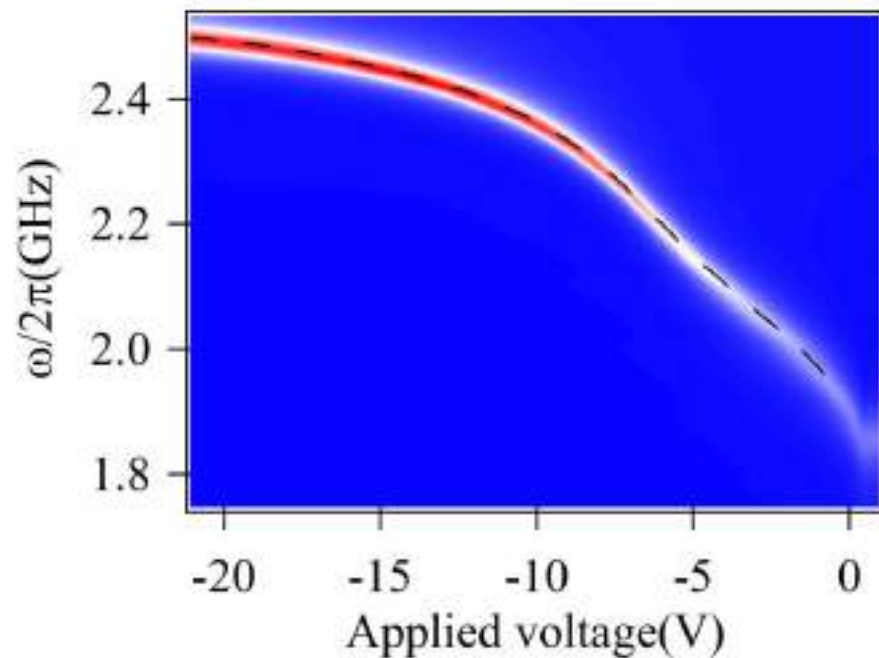


# Level attraction between Tunable SRR and cross cavity

Coupling dispersion



(c) Tunable SRR dispersion



- Conclusion

1. We have realized the level attraction in metamaterial.
2. The dispersion relation can be well descried by the model:

Fitting parameters:

$$\begin{aligned}\gamma_r &\sim 4MHz; \\ (\gamma_c)_{in} &= 20 MHz; (\gamma_c)_{ex} = 691 MHz; \\ g &= 85MHz; \phi = \pi;\end{aligned}$$

- Next step

1. Analysis the line shape of LA.
2. Try to develop coupling mechanism in this case.
3. Calculate effective  $\mu_r$  and  $\epsilon_r$  using S parameters.