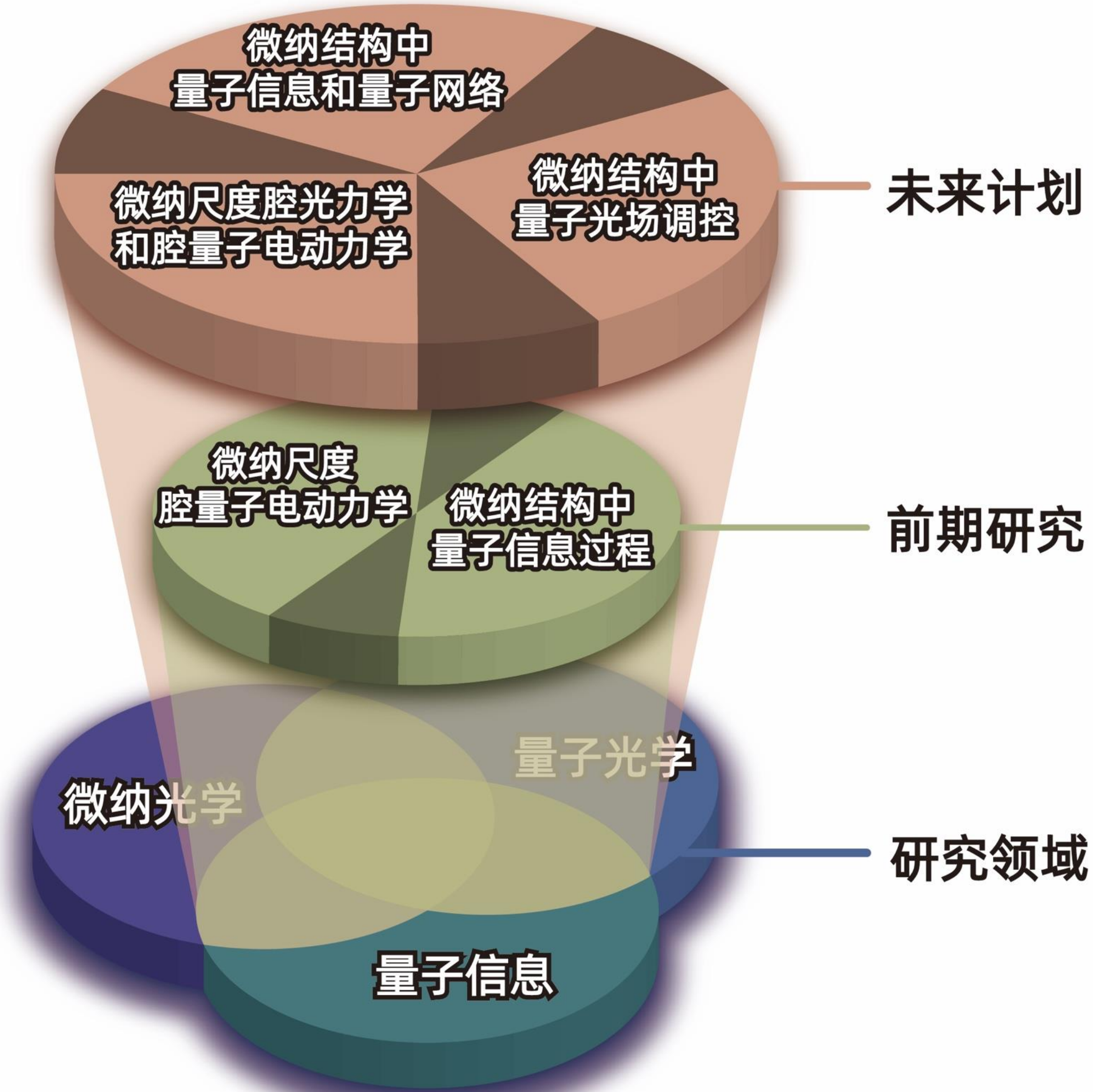
极端光学团队午餐会

微纳尺度量子光学与量子信息

古 英

2025年 5月

研究领域

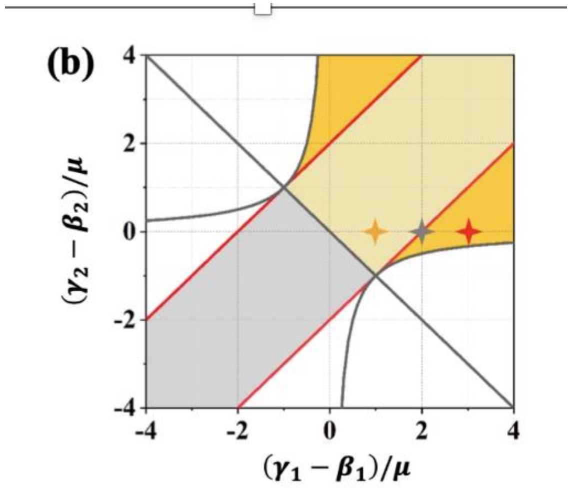


目前在研方向:

1. 微纳波导中量子态及其应用
2. 基于超表面的量子分束及应用
3. 拓扑结构中的腔量子电动力学及量子分束
4. 基于微纳结构的量子光场整形

1.微纳波导中量子态及其应用

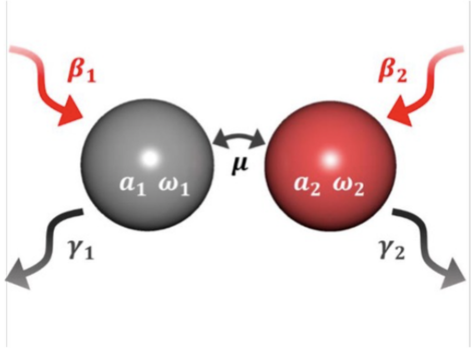
a. 量子PT相图及量子态制备 （PRA（2024））



- The existence of quantum jumping term
- In classical, there is an average effect in gain and loss

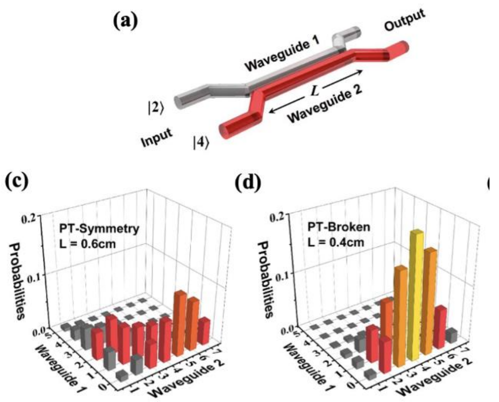
  But in quantum, the role of loss and gain is different:

  The gain will bring the noise, but the loss can not decrease the noise



$$\hat{H} = \hbar\omega_1\hat{a}_1^\dagger\hat{a}_1 + \hbar\omega_2\hat{a}_2^\dagger\hat{a}_2 + \hbar\mu(\hat{a}_1^\dagger\hat{a}_2 + \hat{a}_2^\dagger\hat{a}_1)$$

$$\frac{d\hat{\rho}}{dt} = -\frac{i}{\hbar}[\hat{H},\hat{\rho}] + \sum_{i=1,2}\gamma_i(2\hat{a}_i\hat{\rho}\hat{a}_i^\dagger - \hat{\rho}\hat{a}_i^\dagger\hat{a}_i - \hat{a}_i^\dagger\hat{a}_i\hat{\rho}) + \sum_{i=1,2}\beta_i(2\hat{a}_i^\dagger\hat{\rho}\hat{a}_i - \hat{\rho}\hat{a}_i\hat{a}_i^\dagger - \hat{a}_i\hat{a}_i^\dagger\hat{\rho})$$

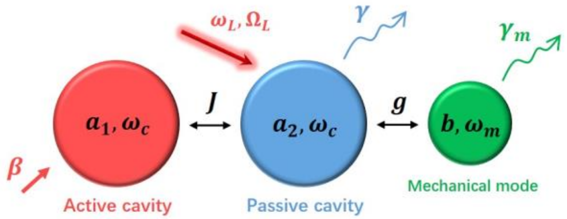


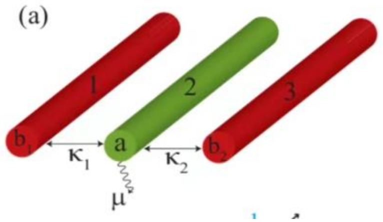
1. 微纳波导中量子态及其应用---其它工作

b. 基于波导结构的猫态制备 （目的：小猫变大猫，JOSAB（2025））

c. 基于波导结构的腔光力研究（高Fock态的确定性制备等））

d. 量子anti-PT结构的研究 （在研）





$$H_0 = H_{opt} + H_{mech} + H_{int},$$

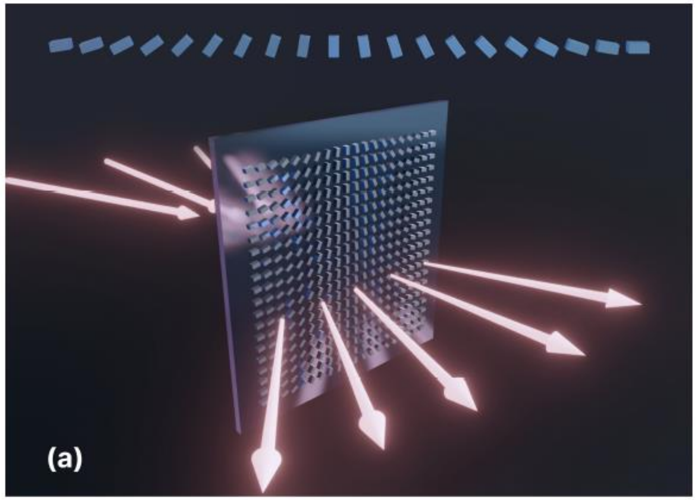
$$H_{opt} = \hbar\omega_1 a_1^{+} a_1 + \hbar\omega_2 a_2^{+} a_2 + \hbar J(a_1^{+} a_2 + a_2^{+} a_1),$$

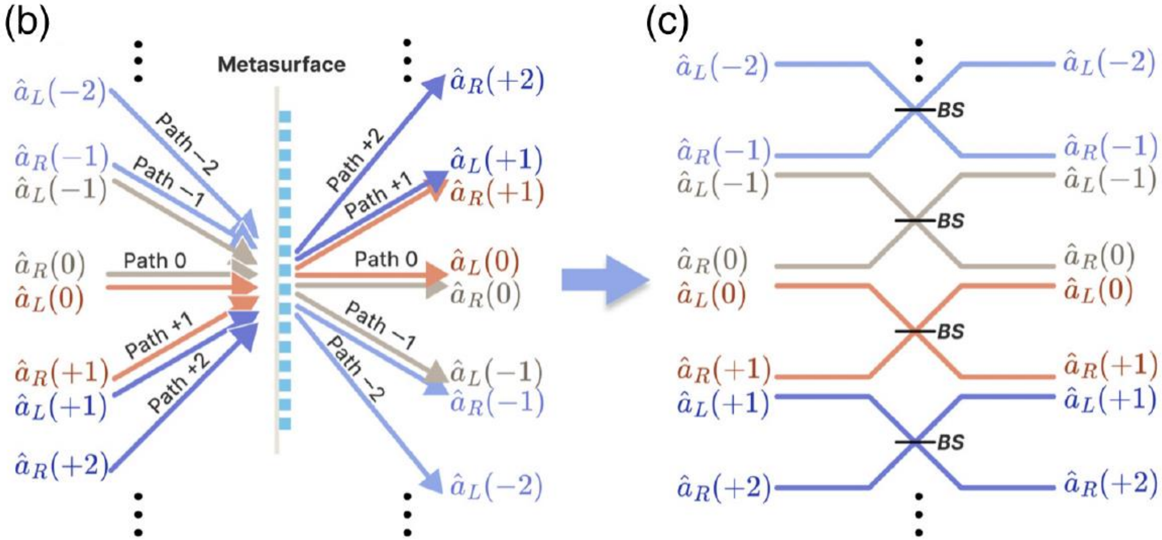
$$H_{mech} = \hbar\omega_m b^{+} b,$$

$$H_{int} = -\hbar g_0 a_2^{+} a_2 (b + b^{+}) + \hbar\Omega_L (a_2 e^{i\omega_L t} + a_2^{+} e^{-i\omega_L t})$$

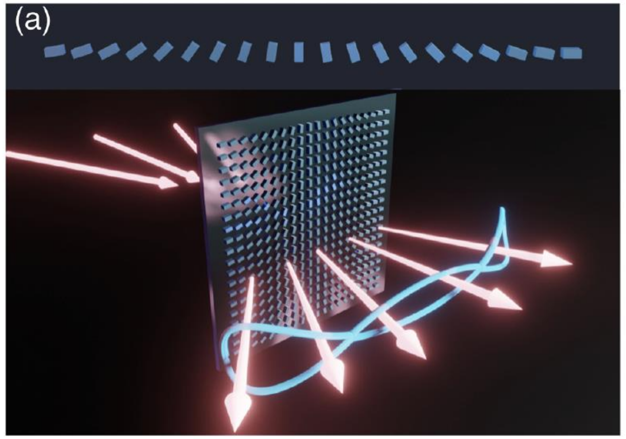
2. 基于超表面的量子分束及应用

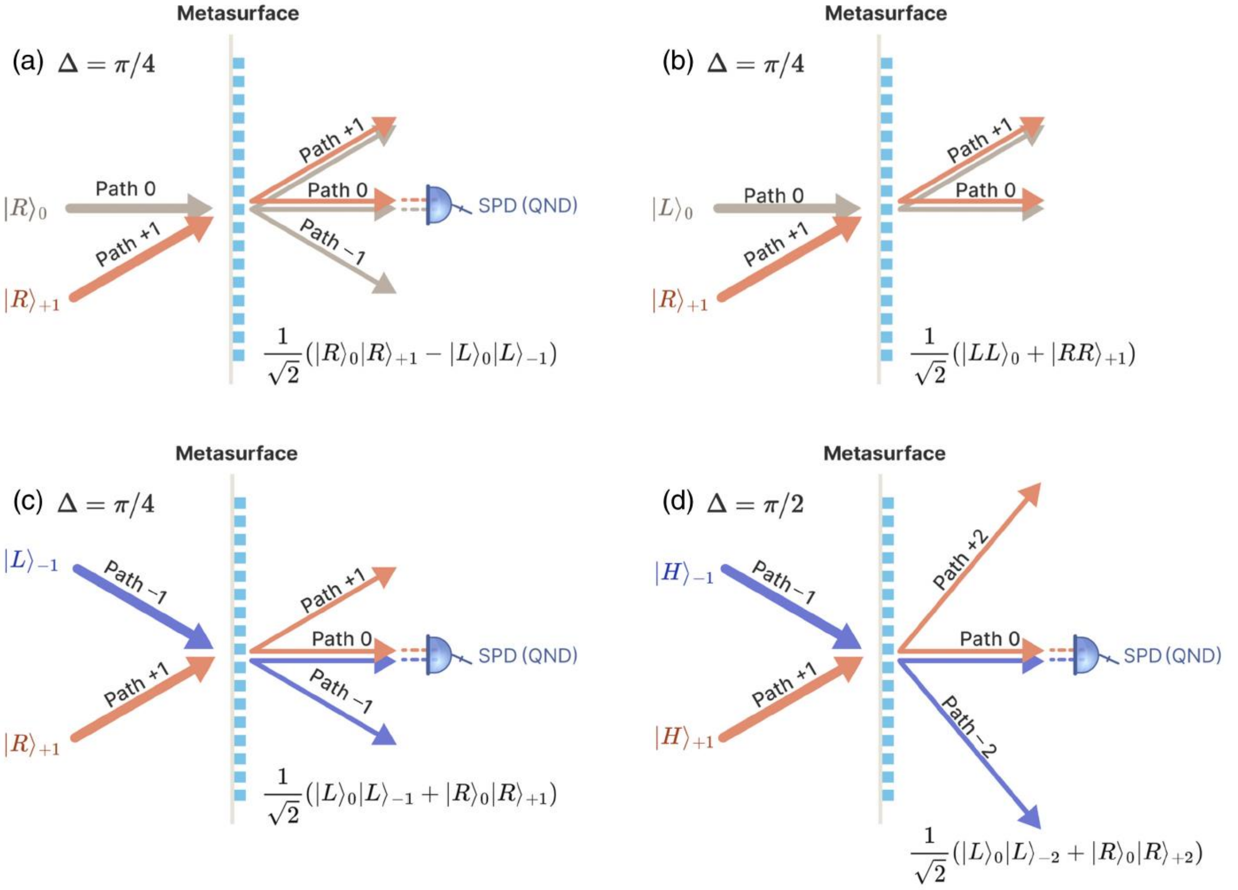
a. 基于超表面的并行分束，从经典到量子 （OE（2024））

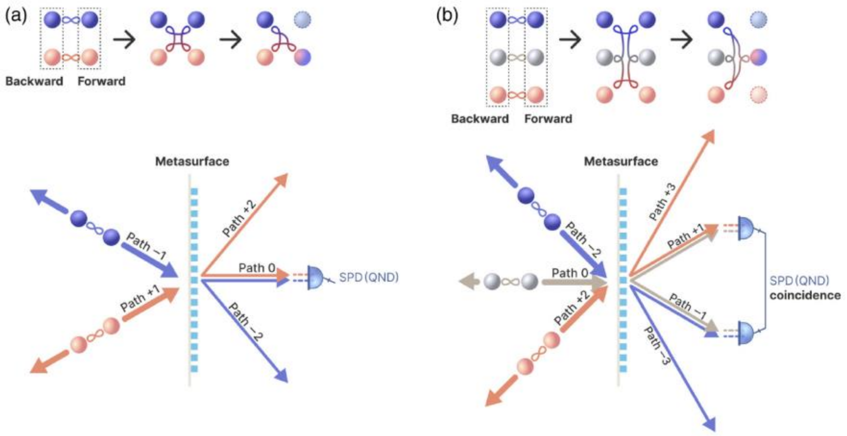




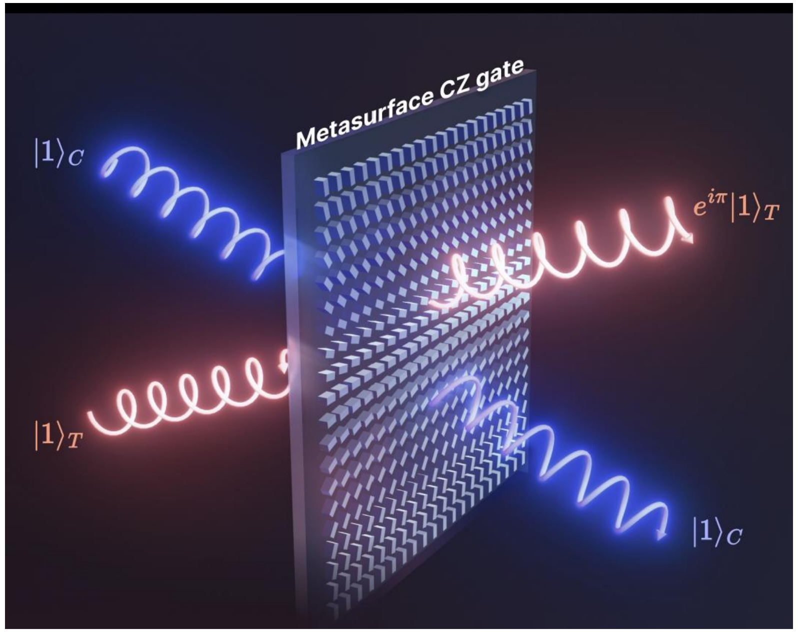
b. 基于超表面的纠缠制备、转换和融合 （Adv. Photon. Nexus（2025））

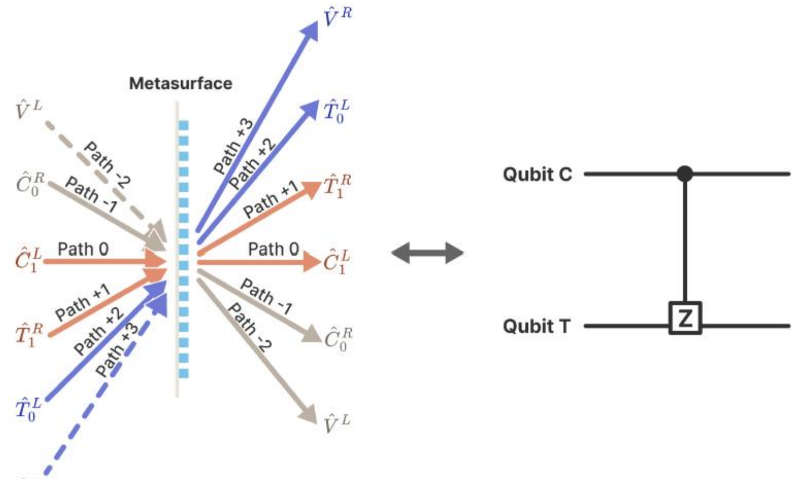


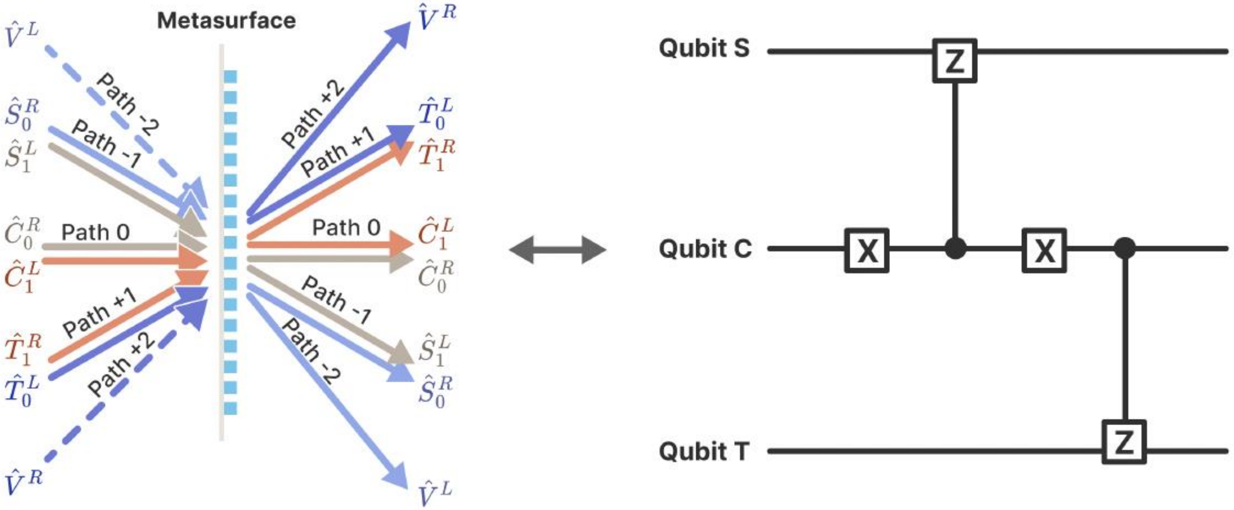




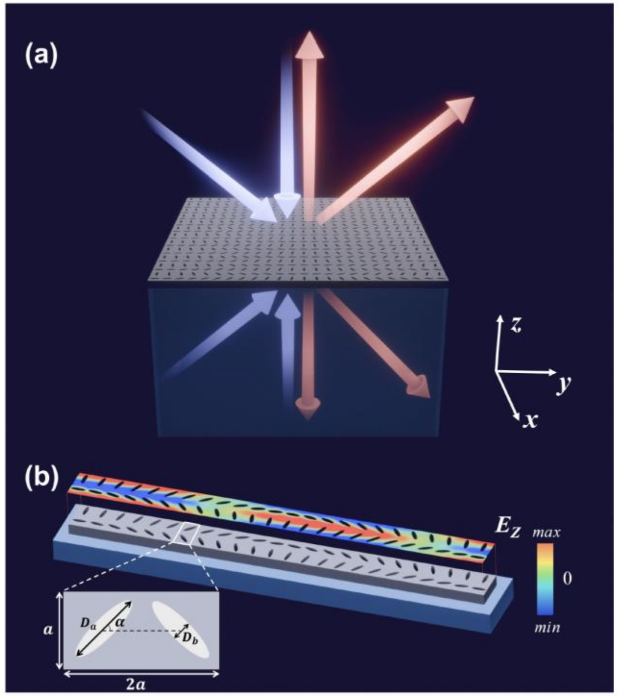
c. 单片超表面的CZ门（Light: Sci. Appl.（2025））



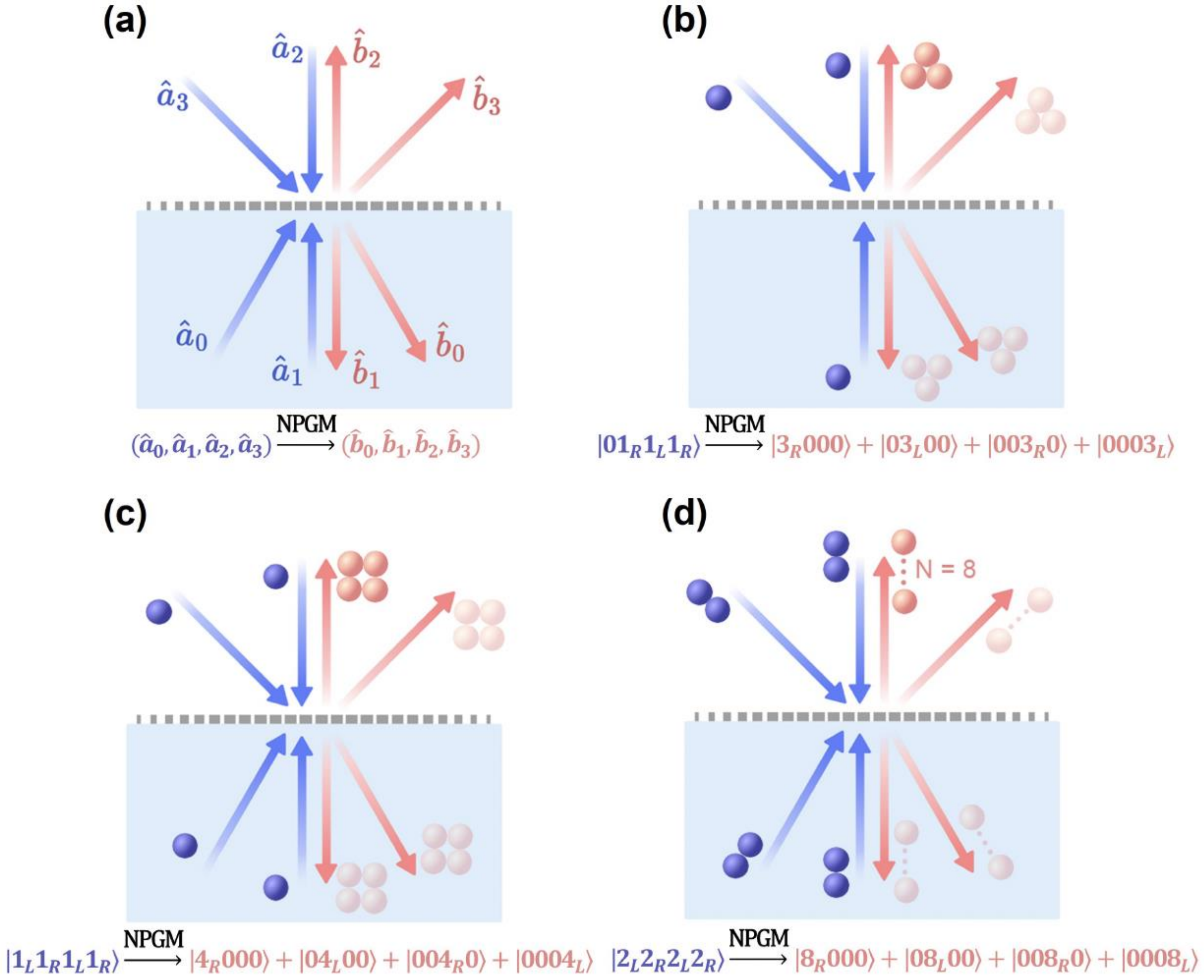




d. 基于非局域超表面的多端口近对称量子分束、NOON态制备（submitted）



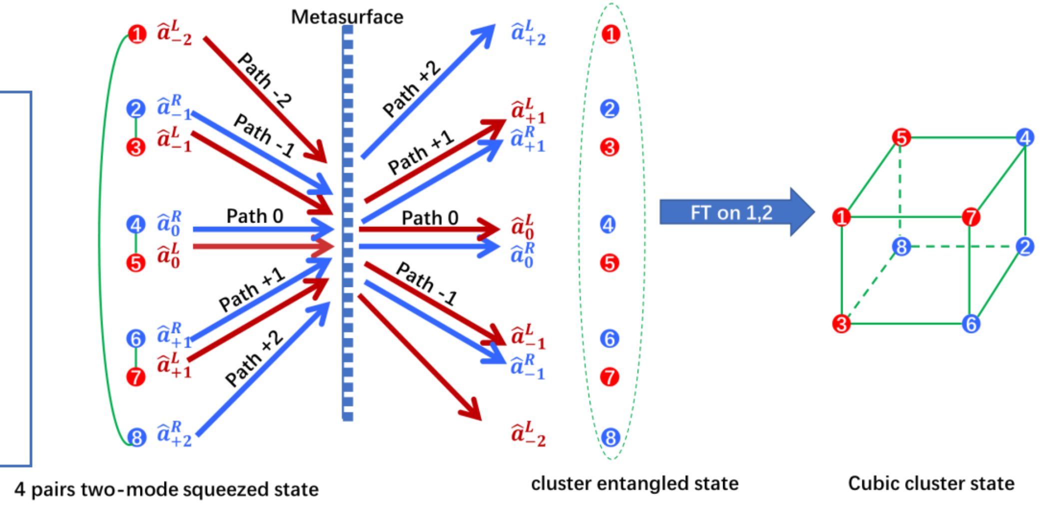
$$\begin{pmatrix}\hat{b}_0\\ \hat{b}_1\\ \hat{b}_2\\ \hat{b}_3\end{pmatrix} = \begin{pmatrix} J_{0,3}e^{i\varphi_{0,3}} & J_{1,4}e^{i\varphi_{1,4}} & J_{2,2}e^{i\varphi_{2,2}} & J_{3,1}e^{i\varphi_{3,1}} \\ J_{0,4}e^{i\varphi_{0,4}} & J_{1,3}e^{i\varphi_{1,3}} & J_{2,1}e^{i\varphi_{2,1}} & J_{3,2}e^{i\varphi_{3,2}} \\ J_{0,2}e^{i\varphi_{0,2}} & J_{1,1}e^{i\varphi_{1,1}} & J_{2,3}e^{i\varphi_{2,3}} & J_{3,4}e^{i\varphi_{3,4}} \\ J_{0,1}e^{i\varphi_{0,1}} & J_{1,2}e^{i\varphi_{1,2}} & J_{2,4}e^{i\varphi_{2,4}} & J_{3,3}e^{i\varphi_{3,3}} \end{pmatrix} \begin{pmatrix}\hat{a}_0\\ \hat{a}_1\\ \hat{a}_2\\ \hat{a}_3\end{pmatrix}$$



2. 基于超表面的量子分束及应用---其它工作

e. 用超表面的量子分束制备图态（在研）

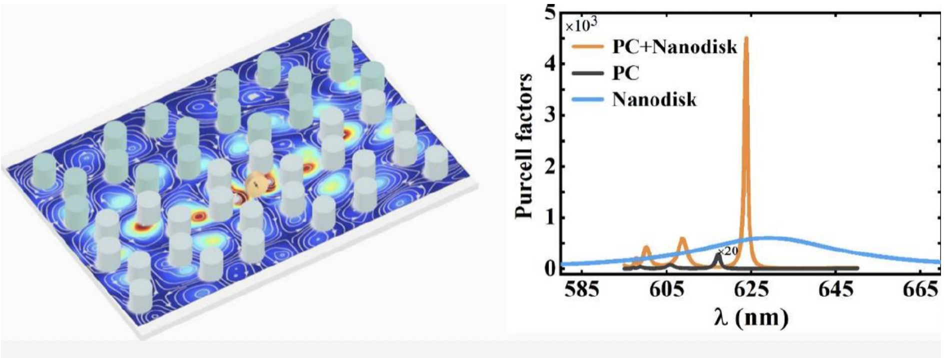
- 量子分束过程可以在两个单模压缩态之间确定性地建立连续变量量子纠缠
- 利用超表面并行分束中多个分束过程，可以在多个单模压缩态之间建立多模式量子纠缠，即产生图态

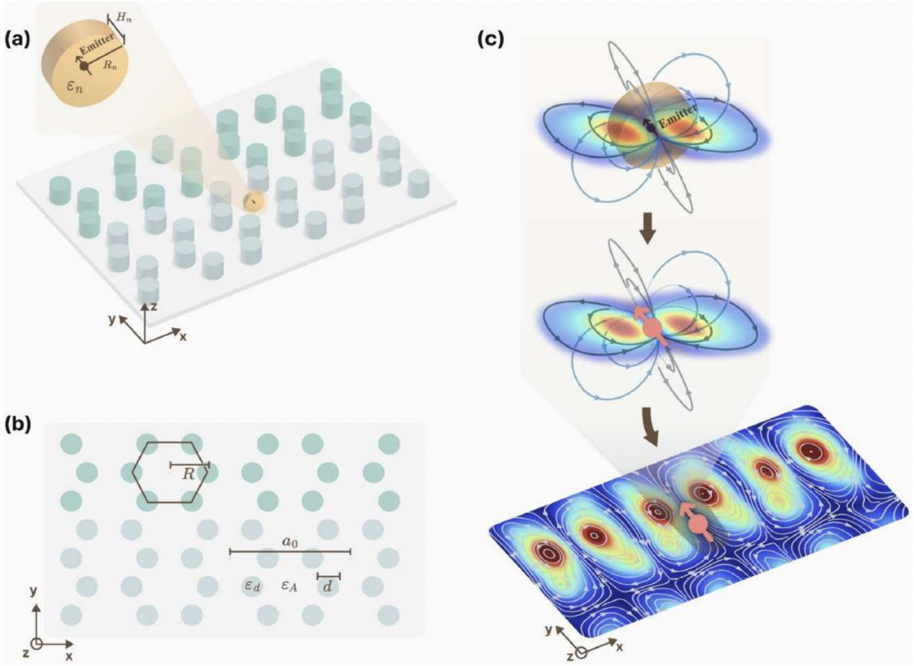


f. 基于非局域超表面量子分束的四波混频研究（在研）

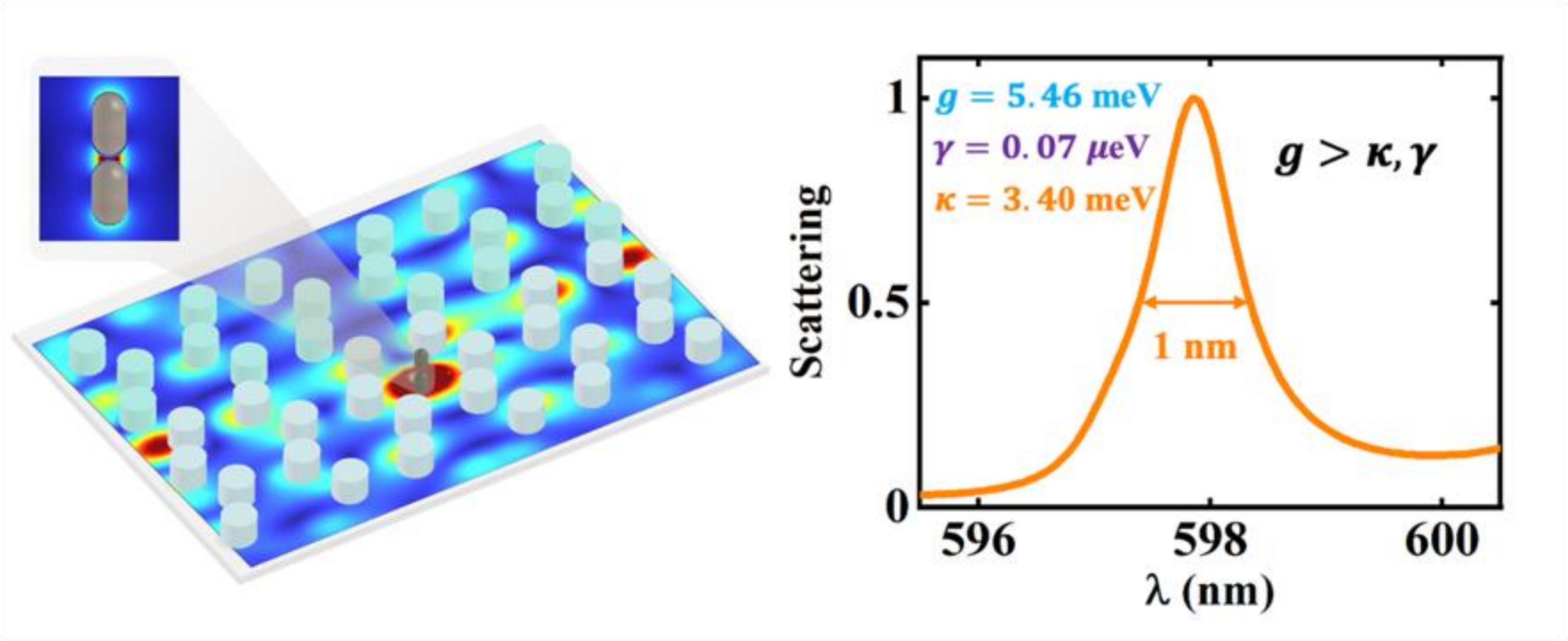
3. 拓扑结构中的腔量子电动力学及量子分束

a. 蜂窝状拓扑光子结构中的珀塞尔系数级联增强（Nano Lett. (2024)）

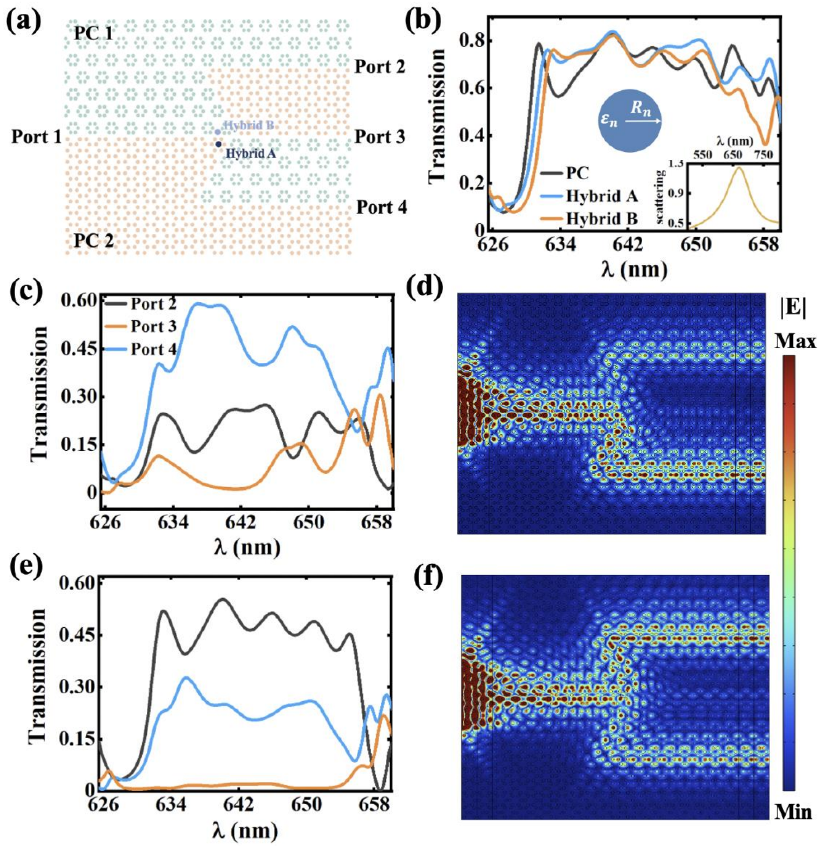


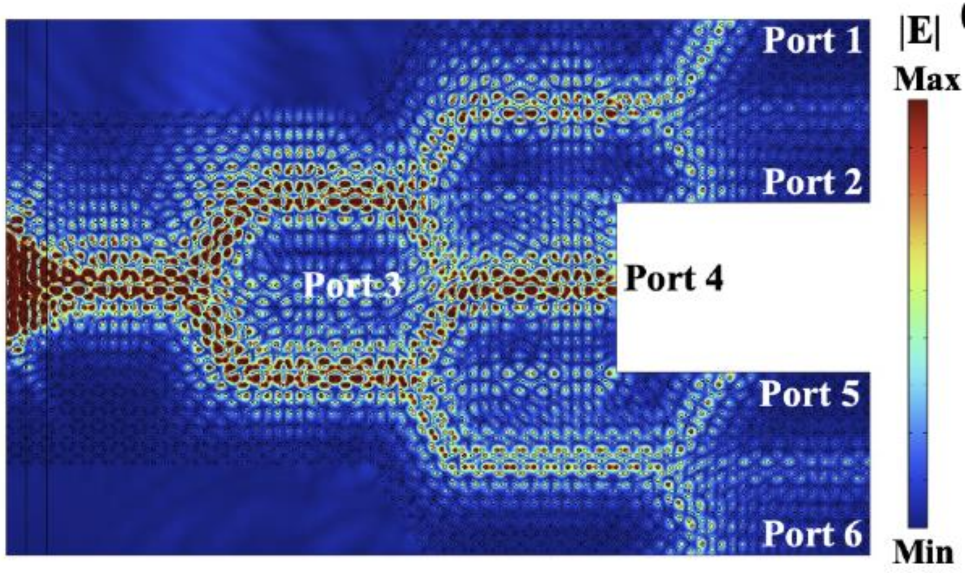


b. 蜂窝状拓扑光子结构中的强耦合 (submitted)



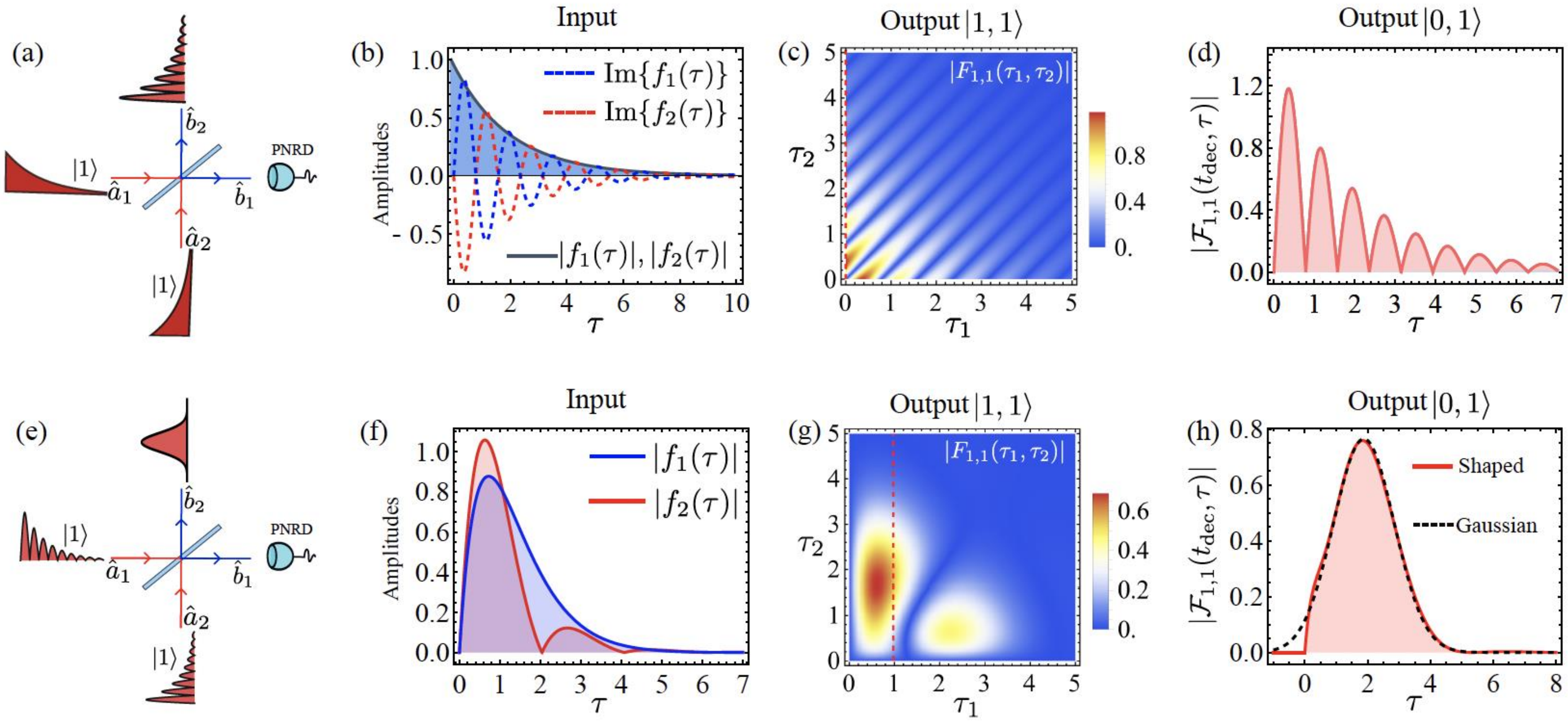
c. 拓扑光子结构中的量子分束及用于量子行走 (submitted)





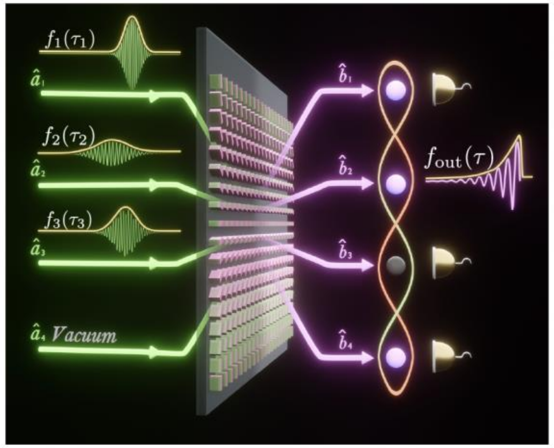
4. 基于微纳结构的量子光场时域整形

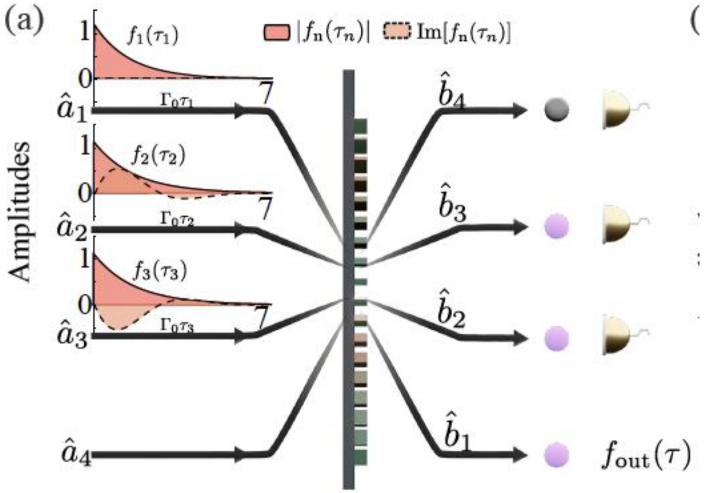
a. 基于量子分束的量子光场时域整形（JOSAB （2025））



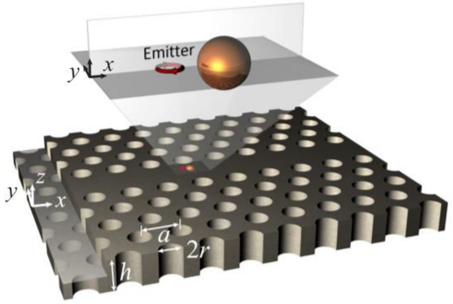
4. 基于微纳结构的量子光场时域整形---其它工作

b. 基于超表面的量子光场时域整形（Laser &Photonics Reviews (2025)）



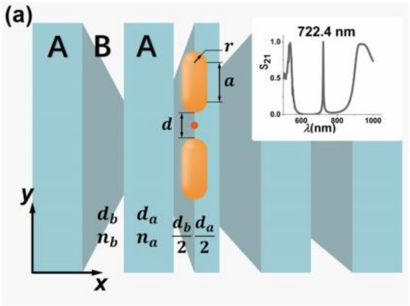


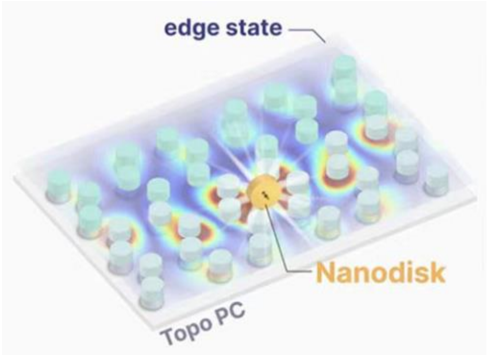
总之：微纳和量子的结合，但是落脚于量子

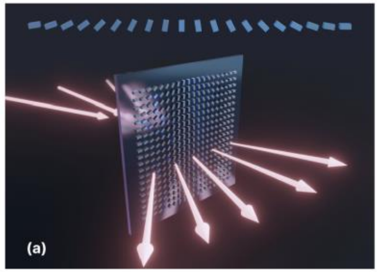


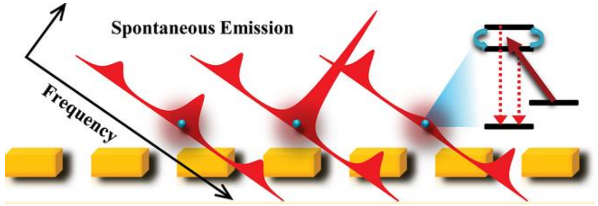
三个层次：

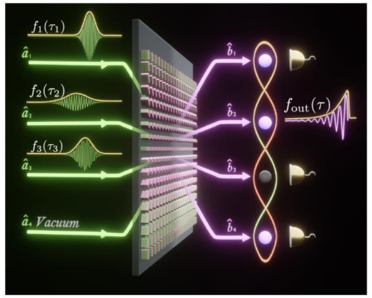
1. 研究多种微纳结构及其组合
2. 量子光场传输以及光子和其它量子的相互作用过程
3. 基本原理以及用于具体体的芯片上量子信息过程












谢谢大家！ 欢迎批评指正、沟通讨论！