

Self-induced manipulation of biphoton entanglement in topologically distinct modes

Jizhou Wu

Quantum Science Center of Guangdong–Hong Kong–Macao Greater Bay Area (Guangdong)

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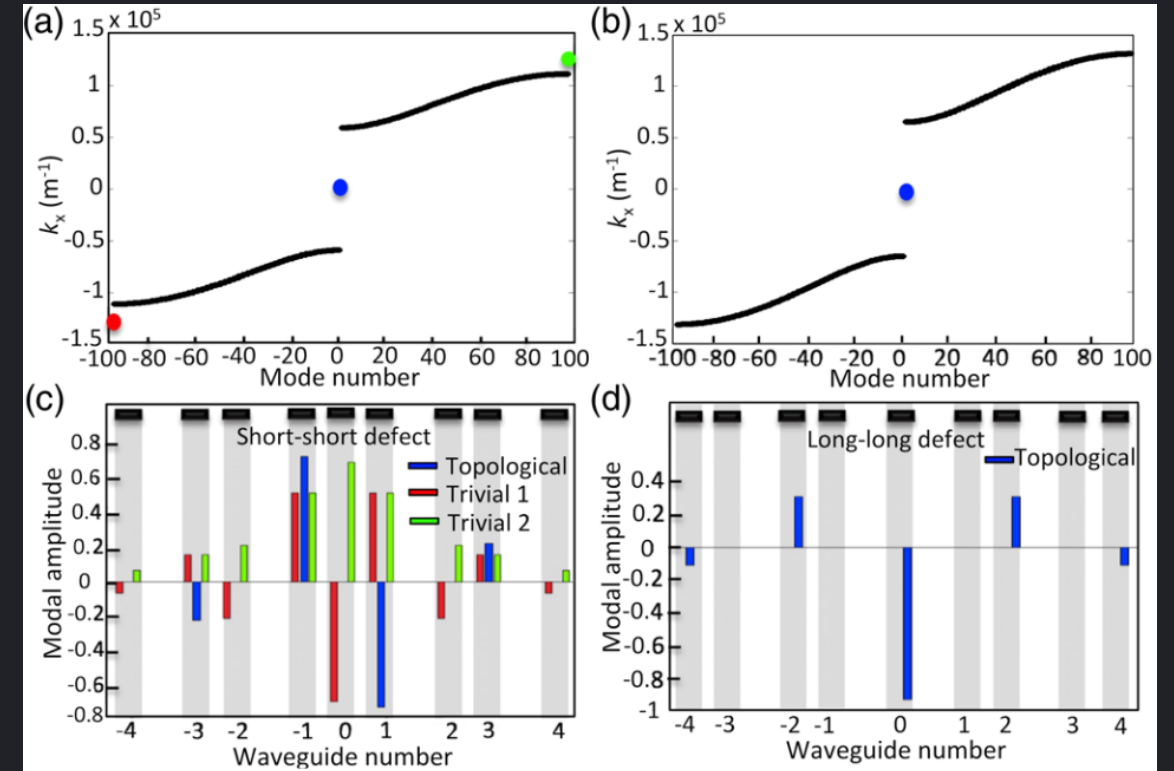
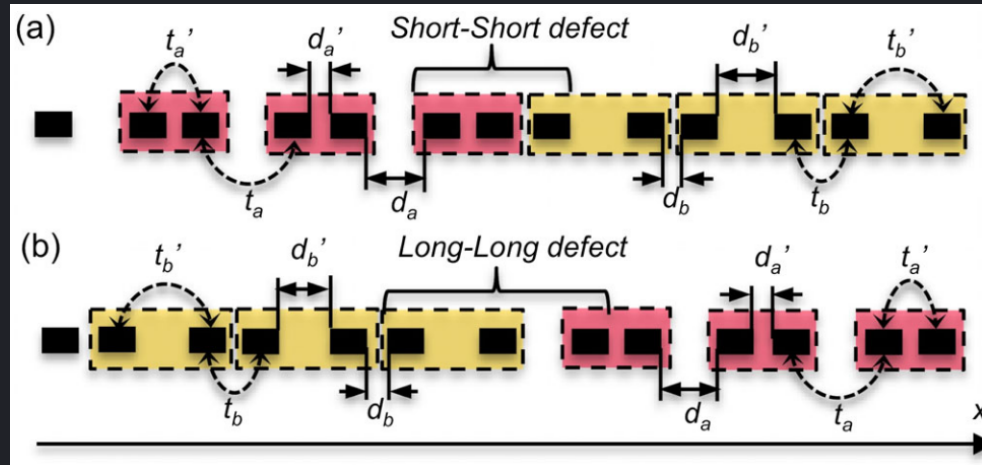
Background: Su-Schrieffer-Heeger model



$$H = \sum_{i=0}^{n-1} \left(u a_{2i+1}^{\dagger} a_{2i} + \text{H.c.} \right) + \sum_{i=1}^{n-1} \left(v a_{2i}^{\dagger} a_{2i-1} + \text{H.c.} \right)$$

- $u < v$: topologically nontrivial
- $u > v$: topologically trivial

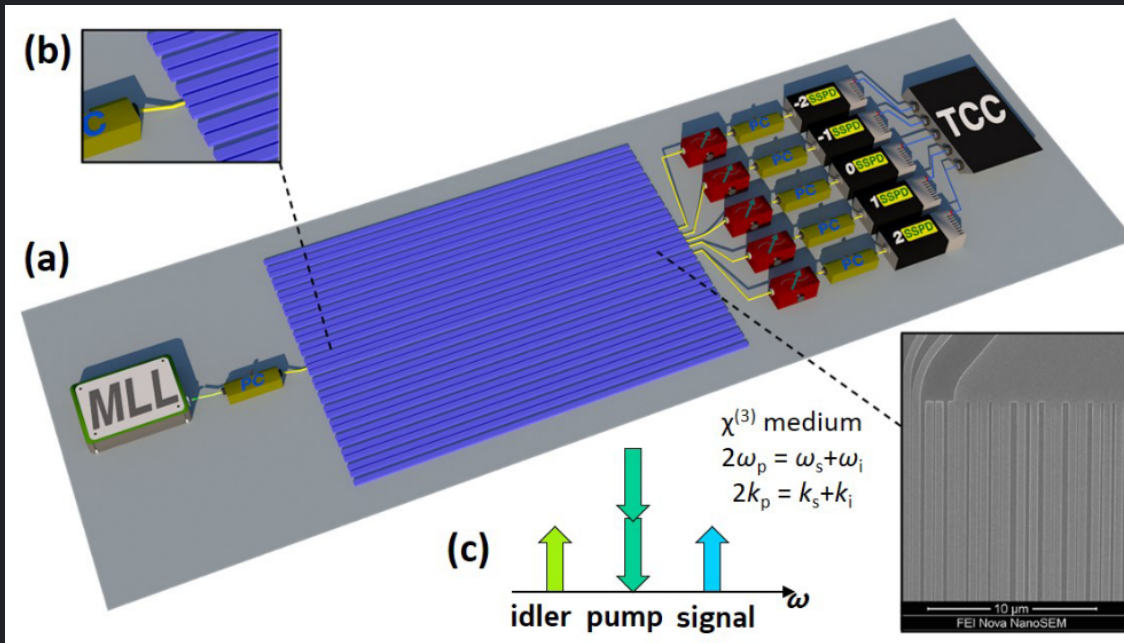
Background: Different defects of two SSH chains



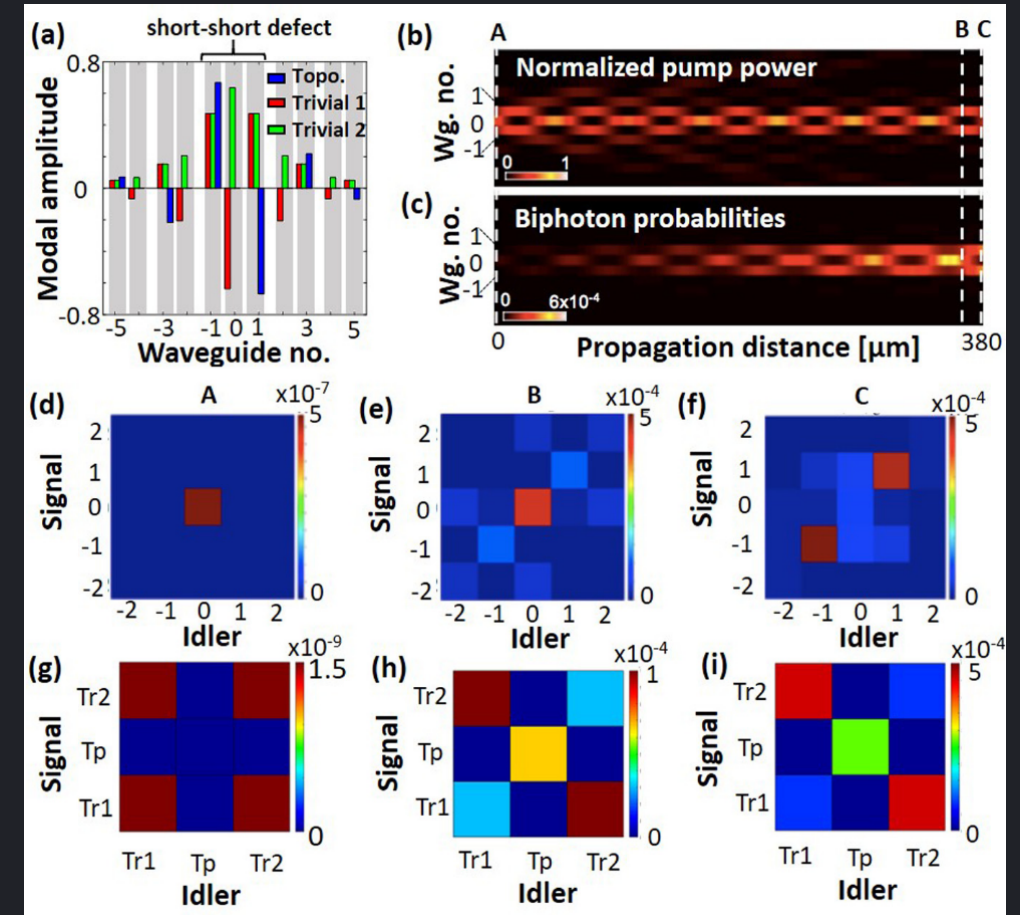
A. Blanco-Redondo, I. Andonegui, M. J. Collins, G. Harari, Y. Lumer, M. C. Rechtsman, B. J. Eggleton, M. Segev

Phys. Rev. Lett. 116, 163901 (2016).

Background: Topological biphoton generation

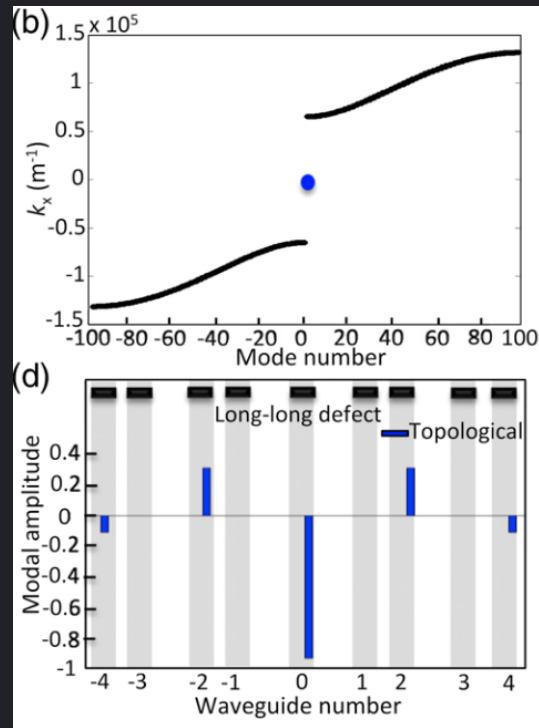


$$H_{\text{SFWM}} = \gamma \sum_{n=1}^N (a_n^p)^2 a_n^{s\dagger} a_n^{i\dagger} + \text{H.c.}$$



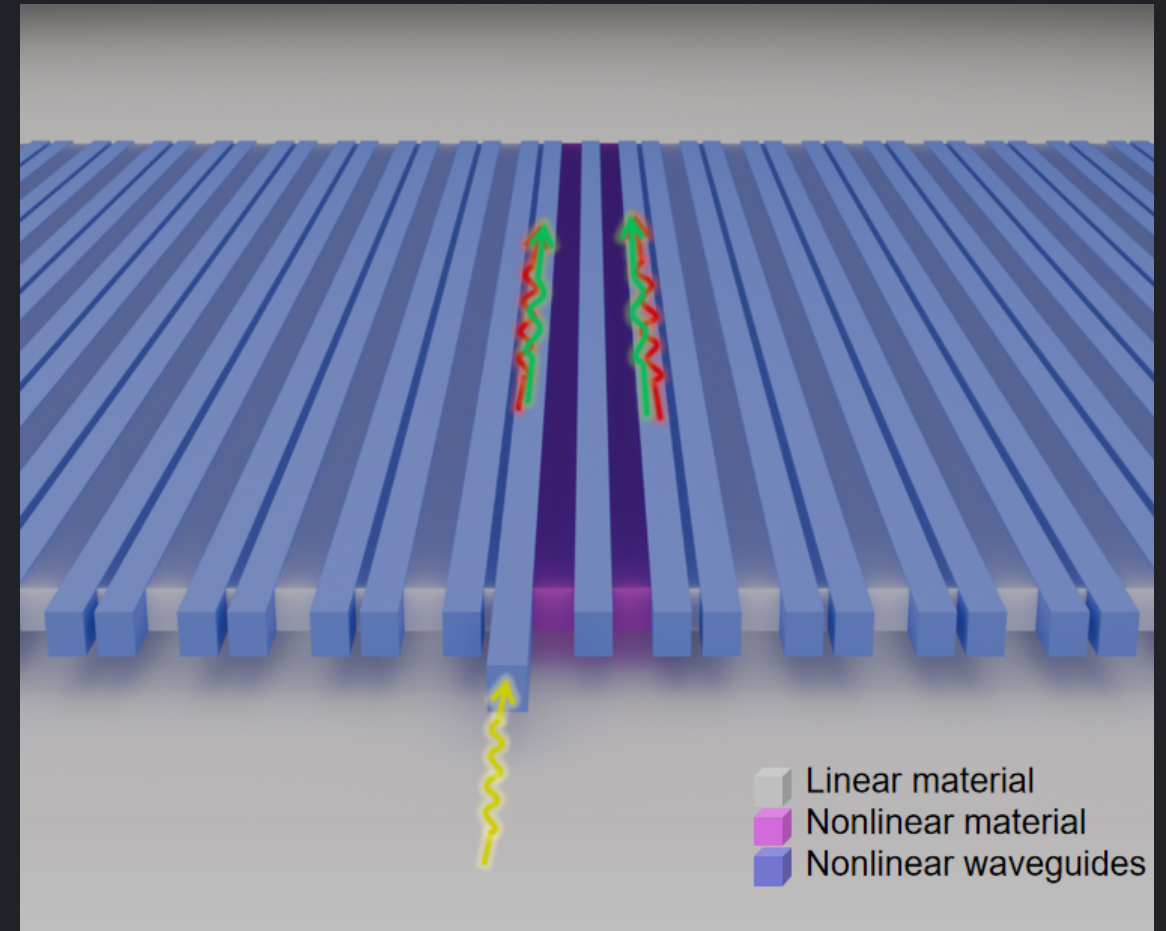
C. Doyle, W.-W. Zhang, M. Wang, B. A. Bell, S. D. Bartlett, A. Blanco-Redondo
 Phys. Rev. A 105, 023513 (2022).

Motivation: Introducing Kerr-like nonlinearity



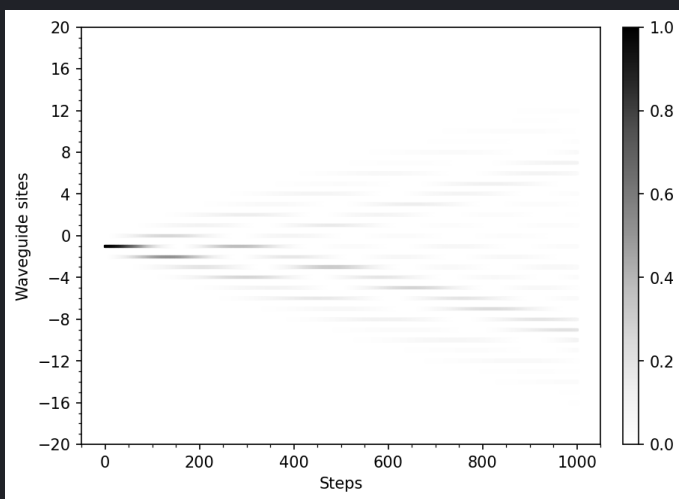
Phys. Rev. Lett. 116, 163901 (2016).

$$v \rightarrow v(|\psi_n|^2 + |\psi_{n+1}|^2)$$

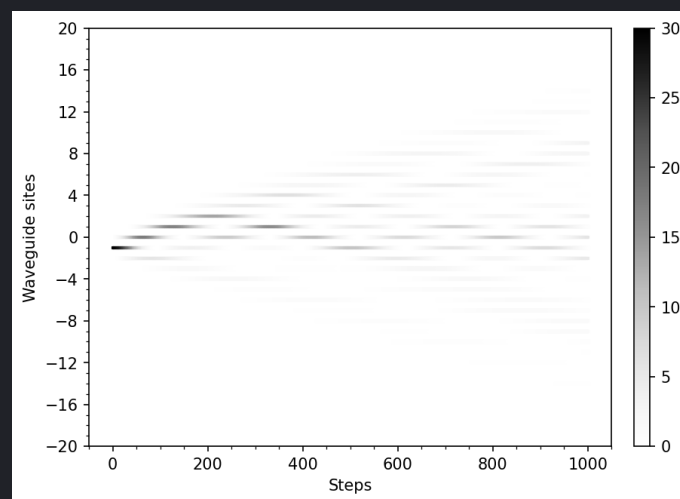


Entanglement of spatial distinct modes in long-long coupling?

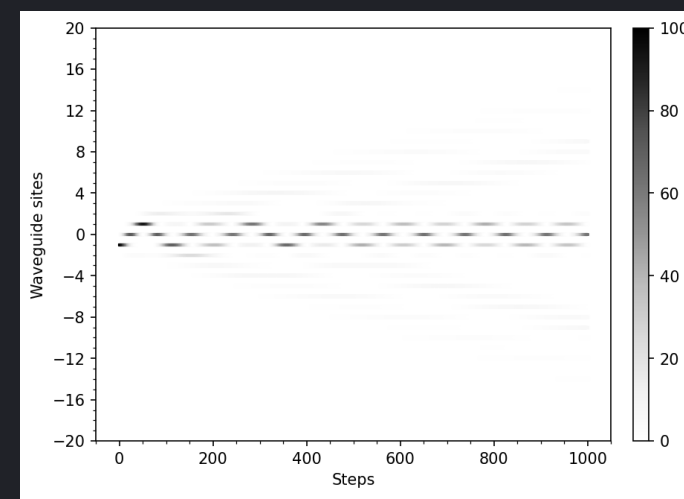
Pump evolution



1W

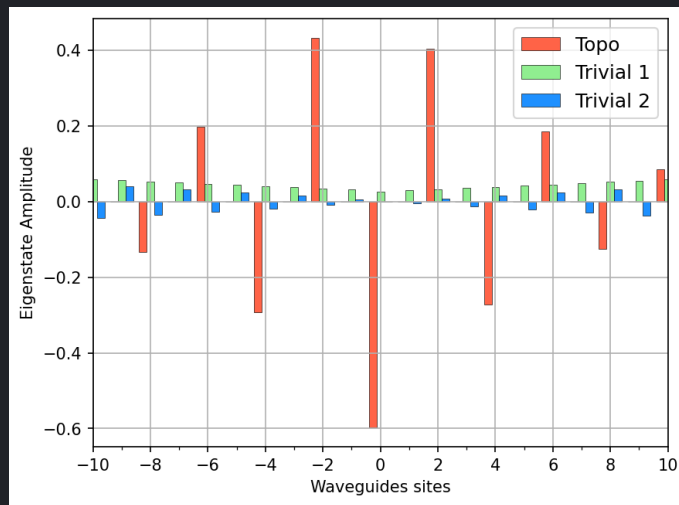
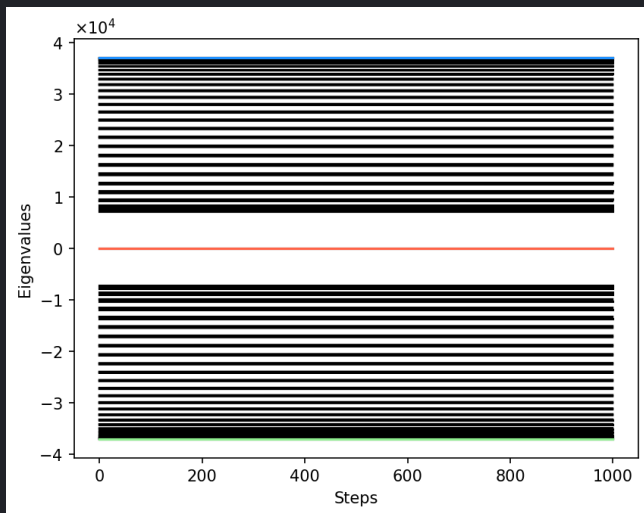


30W

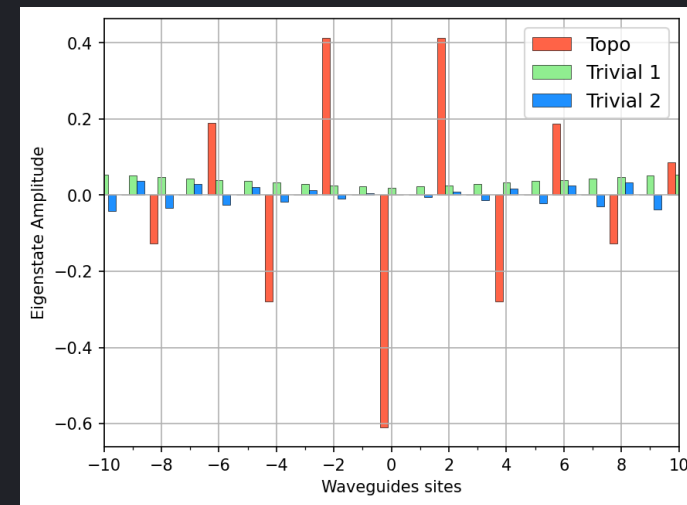


100W

Eigenstates for initial pump being 1W

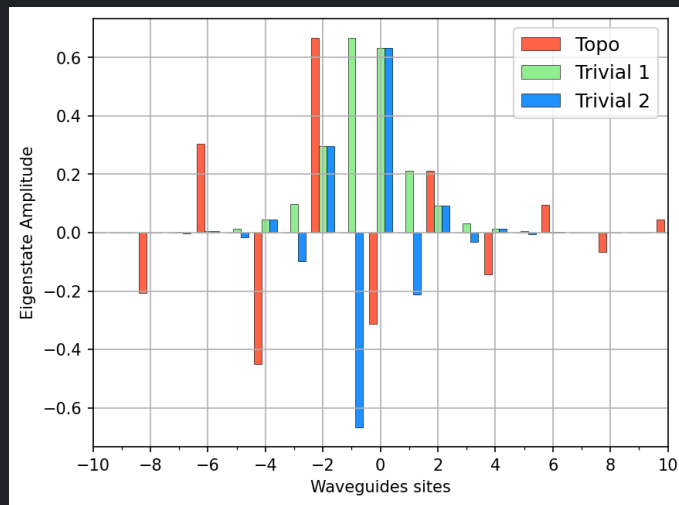
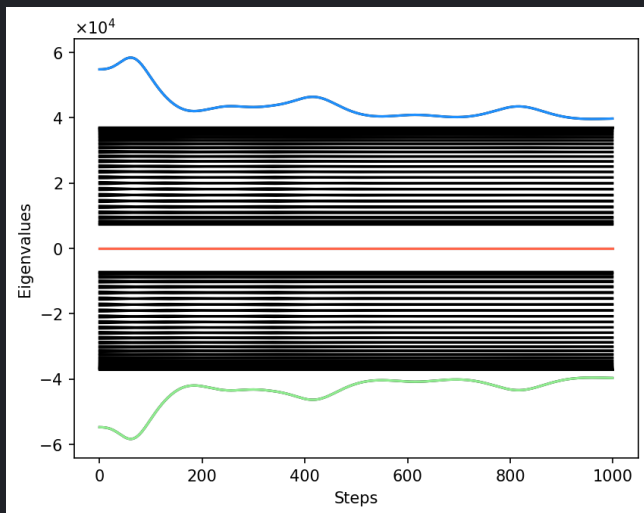


$$t = \delta t$$

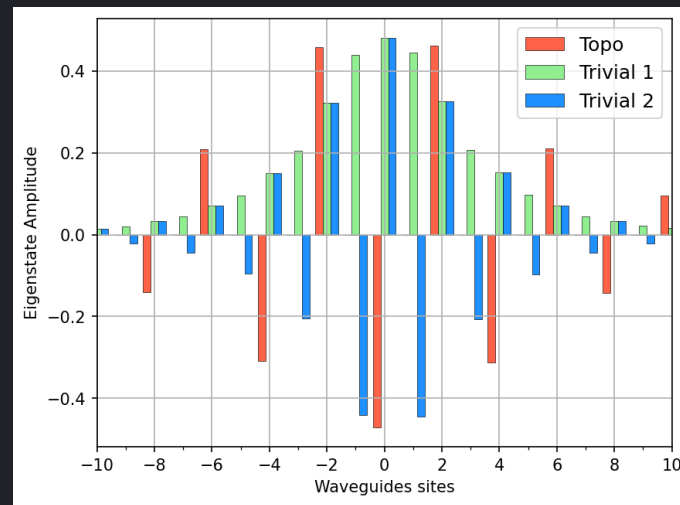


$$t = 1000\delta t$$

Eigenstates for initial pump being 30W

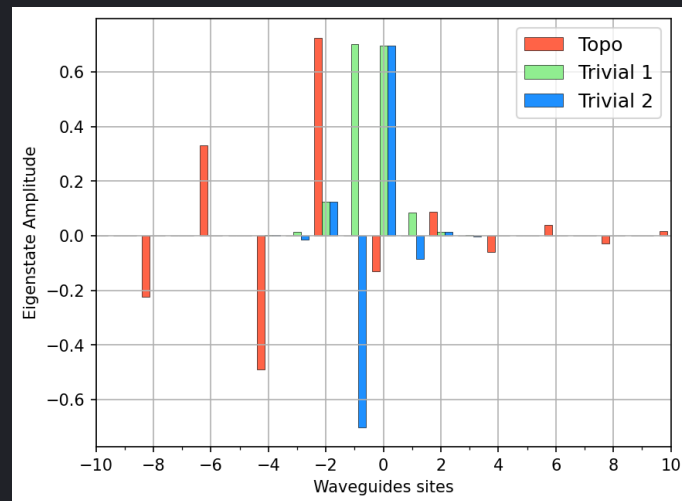
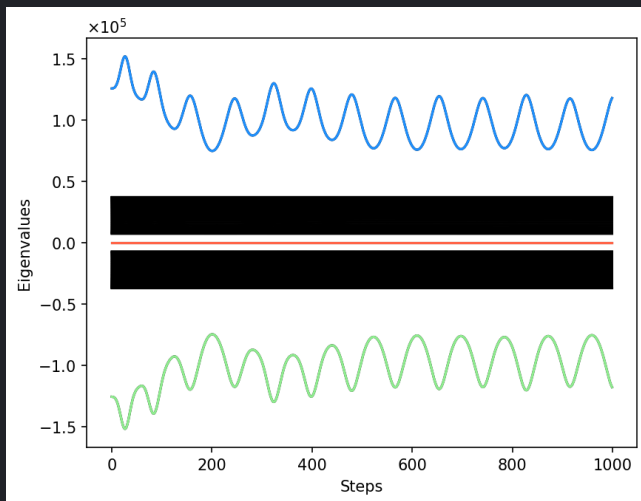


$$t = \delta t$$

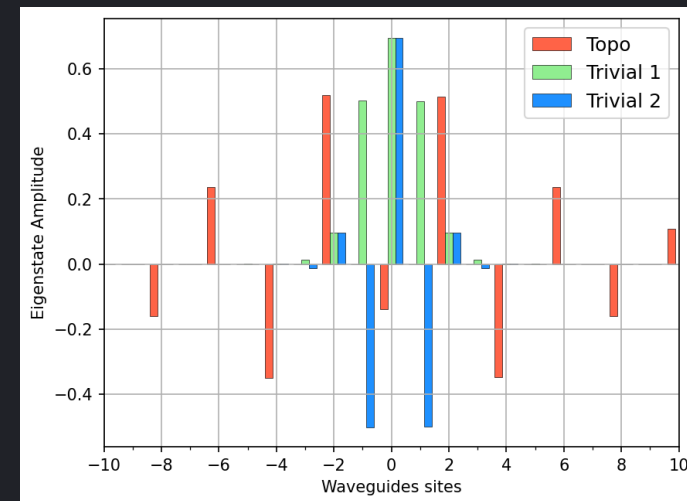


$$t = 1000\delta t$$

Eigenstates for initial pump being 100W

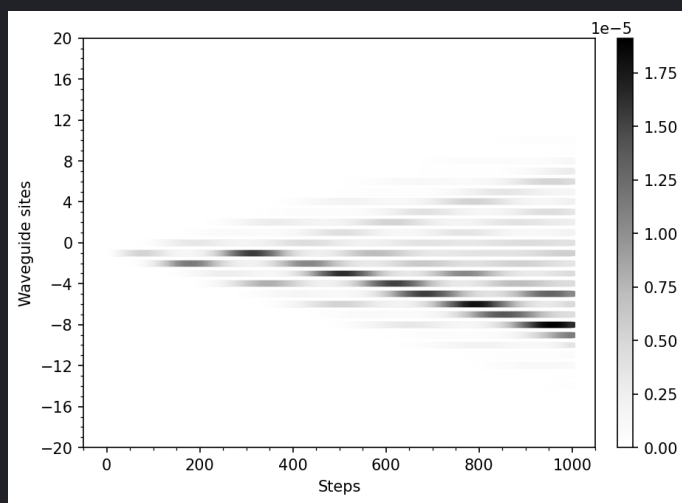


$$t = \delta t$$

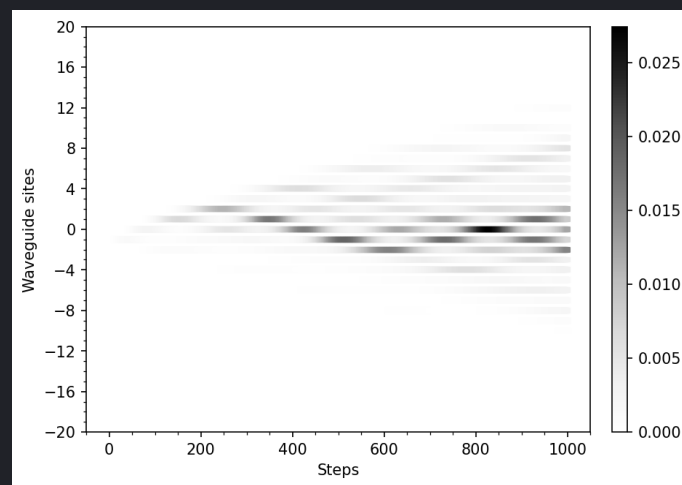


$$t = 1000\delta t$$

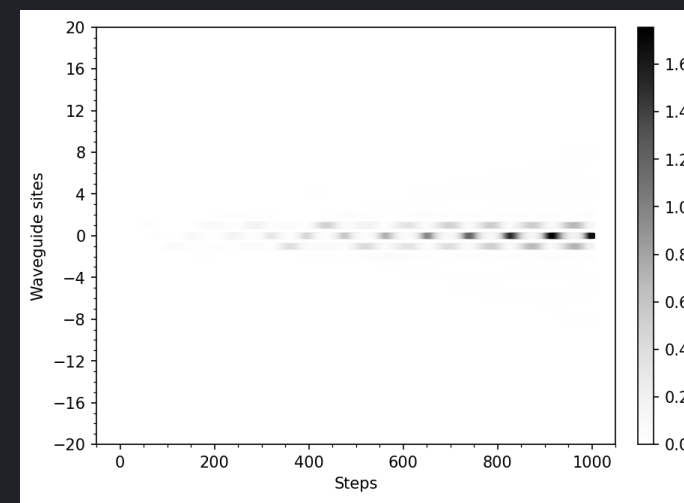
Biphoton evolution



1W

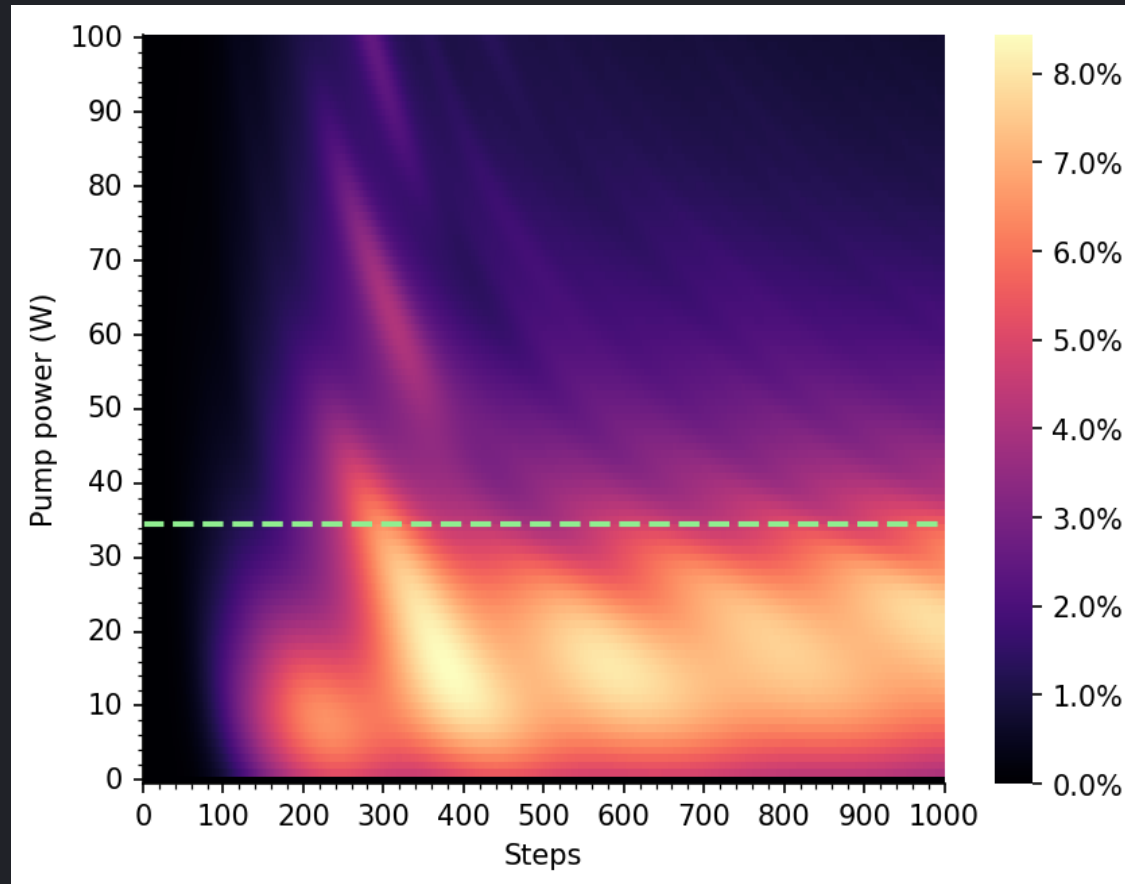


30W

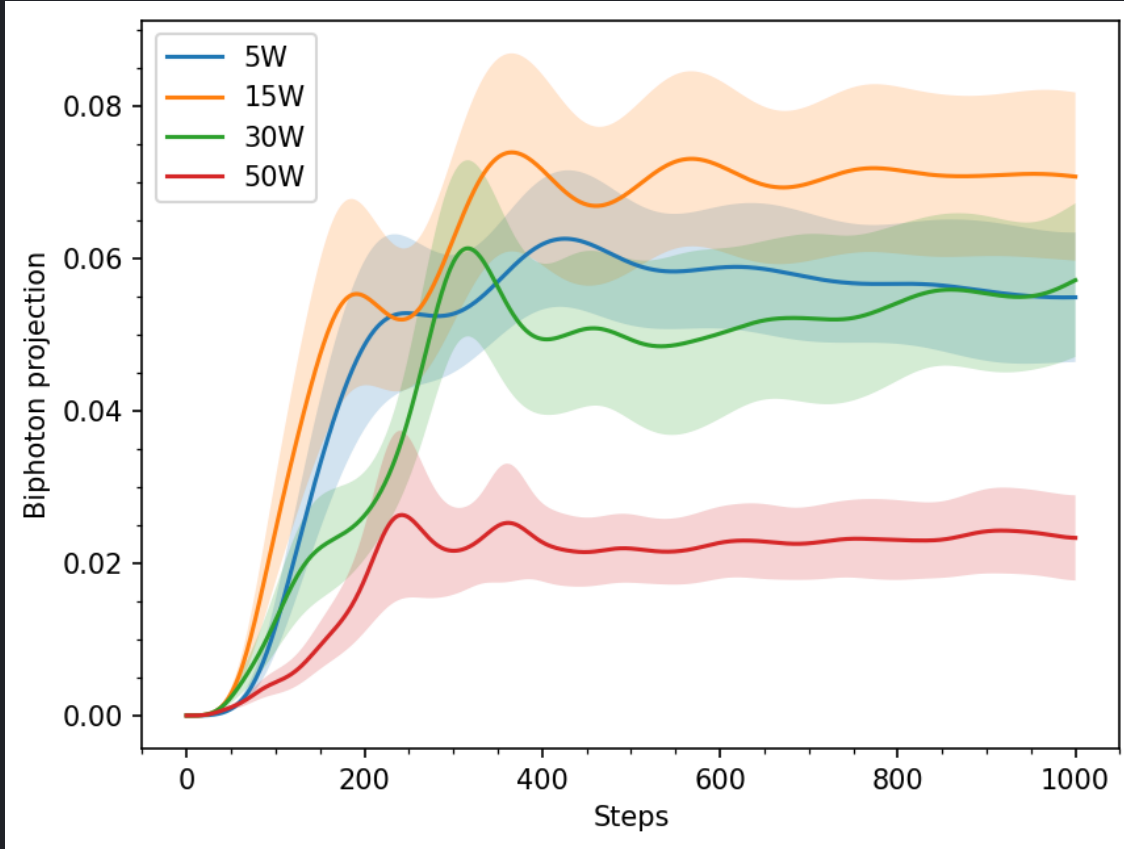


100W

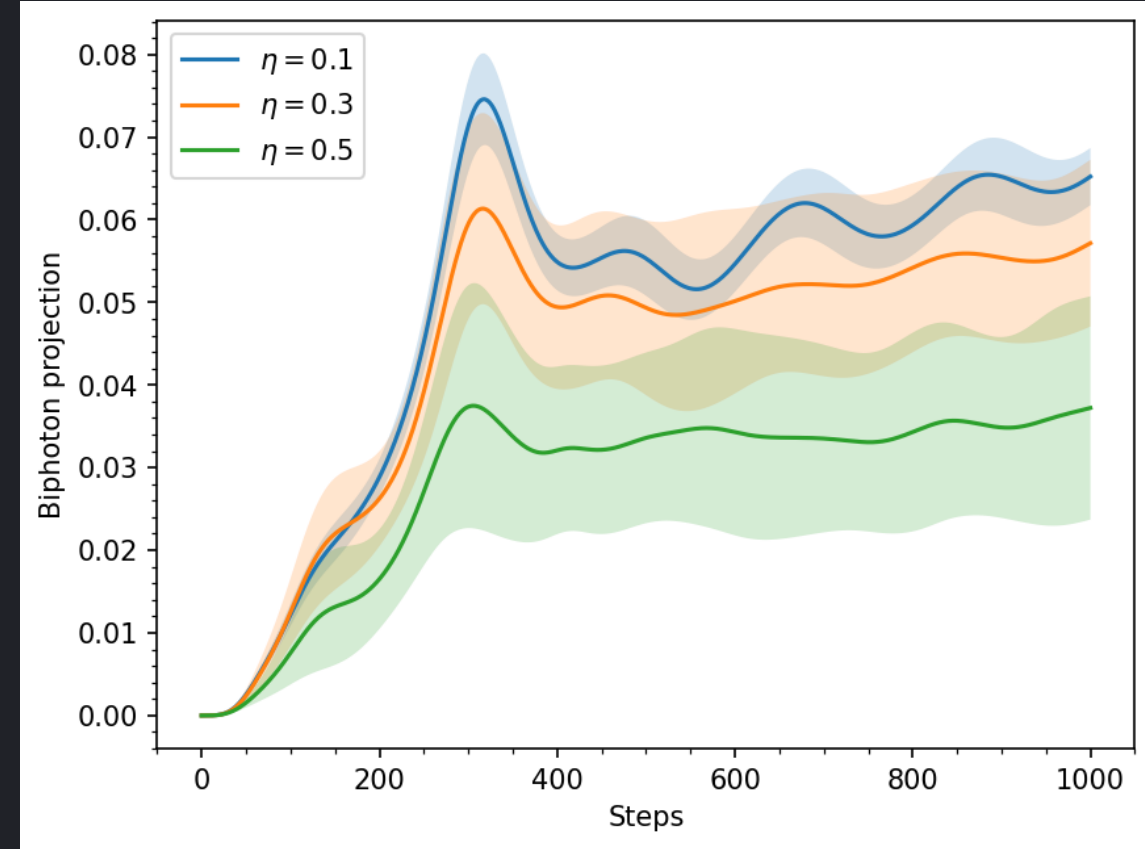
Weight of topological biphoton states



Disorder effect $v \rightarrow (1 + \eta)v, \eta \in [-1, 1]$



$\eta = 0.3$



pump = 30W

Summary

- **Aim:** To generate topologically protected spatial biphoton in long-long coupled SSH chains
- **Claim:** By introducing the self-induced nonlinear hopping, we analyze the weight change of the generated biphoton states and the disorder effect on it.
- **Importance:** Nonlinear topology + quantum photonics
→ external manipulation of the waveguide chips



Wei-Wei Zhang
@Northwestern Polytechnical University