Mobility of localized solutions in a nonlinear graphene ribbon

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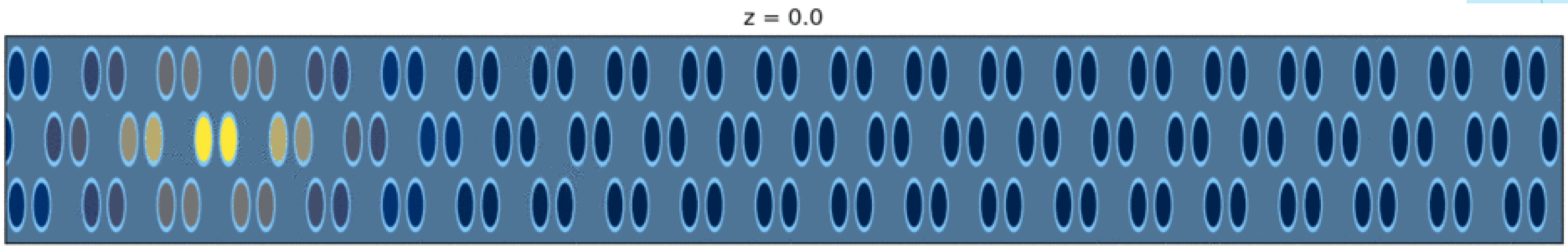
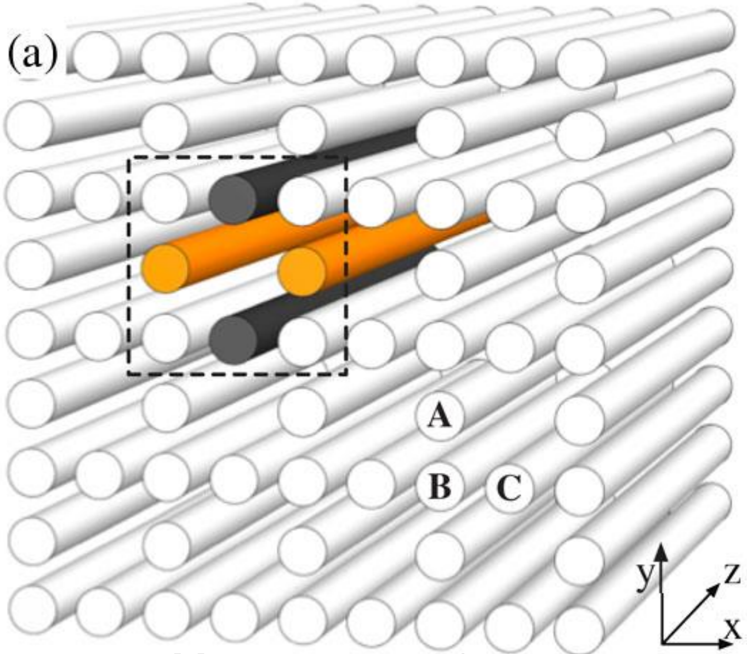


Photonic Lattices

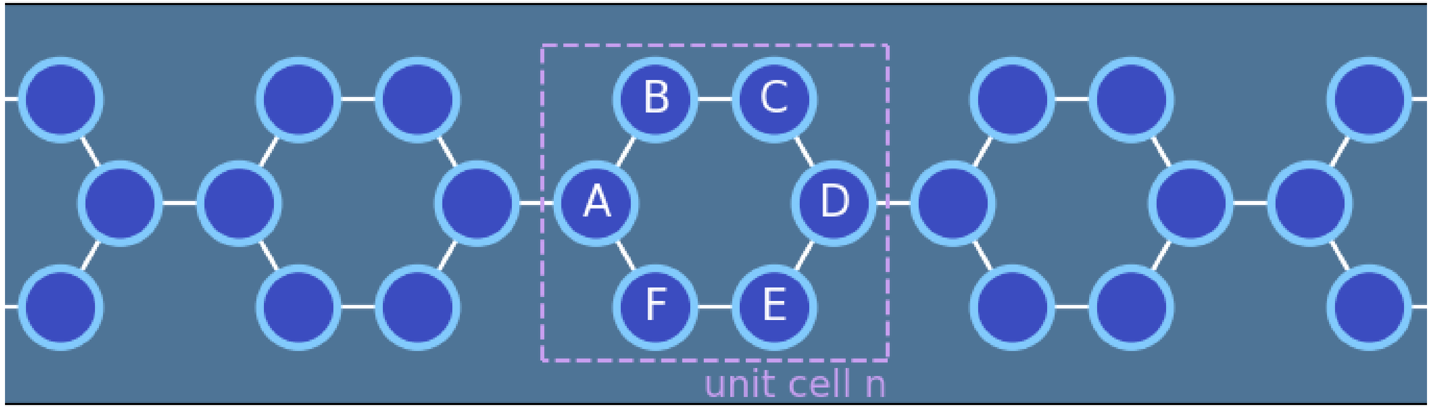
- Solid state physics uses atom lattice as main framework to explore electronic properties [1] but the experimental study of those systems is indirect.
- Photonic lattices allows to study those systems with relatively simple experimental techniques because of the analogy between Schrödinger's equation and the paraxial wave equation [2].
- Also, there are potential applications in security devices [3], quantum computing [4] and quantum metrology [5].



[3] Vicencio, R. A. et al. (2015).

Nonlinear graphene ribbon

- We consider a quasi-1D graphene ribbon with Kerr-type nonlinearity



- The amplitude of the field in each waveguide can be described by a discrete nonlinear Schrödinger equation:

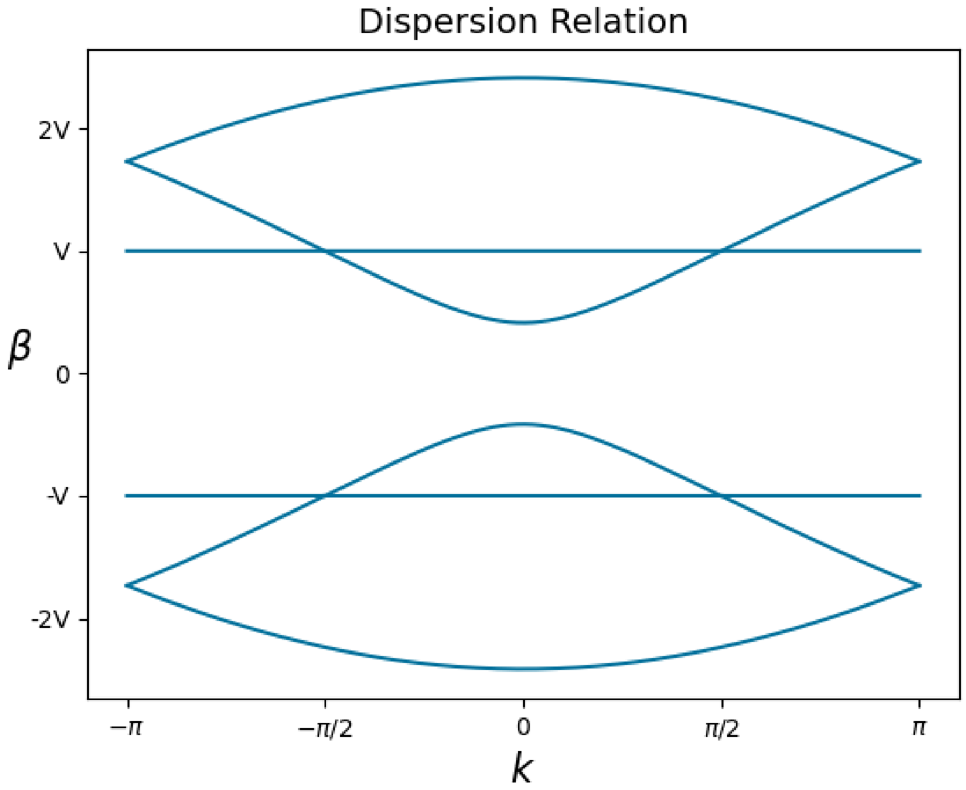
$$-i\frac{\partial \psi_{\vec{n}}}{\partial z} = \sum_{\vec{m}\neq\vec{n}} V_{\vec{m},\vec{n}}\psi_{\vec{m}} + \gamma|\psi_{\vec{n}}|^2\psi_{\vec{n}}$$

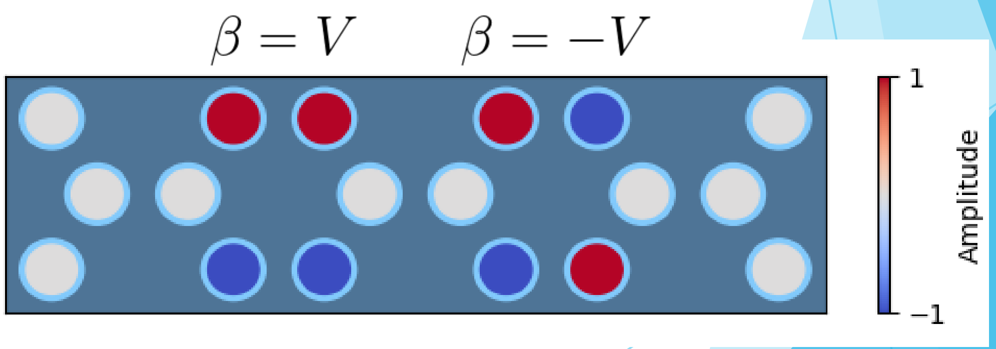
Linear Spectrum

- When choosing stationary solutions of the form

$$\{a_n, b_n, c_n, d_n, e_n, f_n\} = \{A, B, C, D, E, F\}e^{i\beta z}e^{ikn}$$

we find the dispersion relation consisting in two flat bands and two dispersive bands.

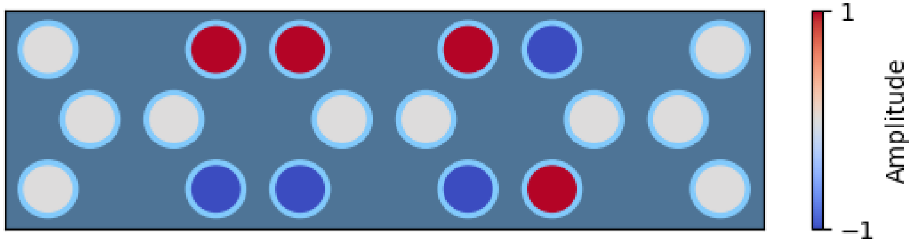




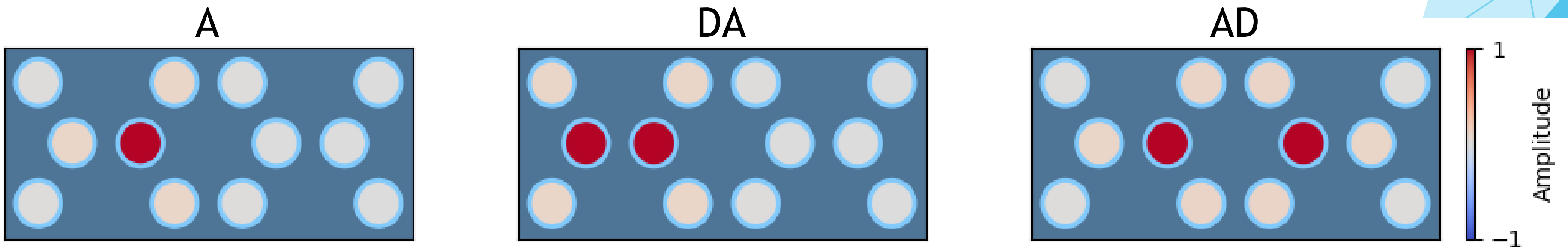
Nonlinear localized modes

- We study the focusing case (γ>0), and without loss of generality we set V = γ = 1.
- The two flat band solutions continues existing as exact solutions with no power threshold.

$$\beta = V \qquad \beta = -V$$

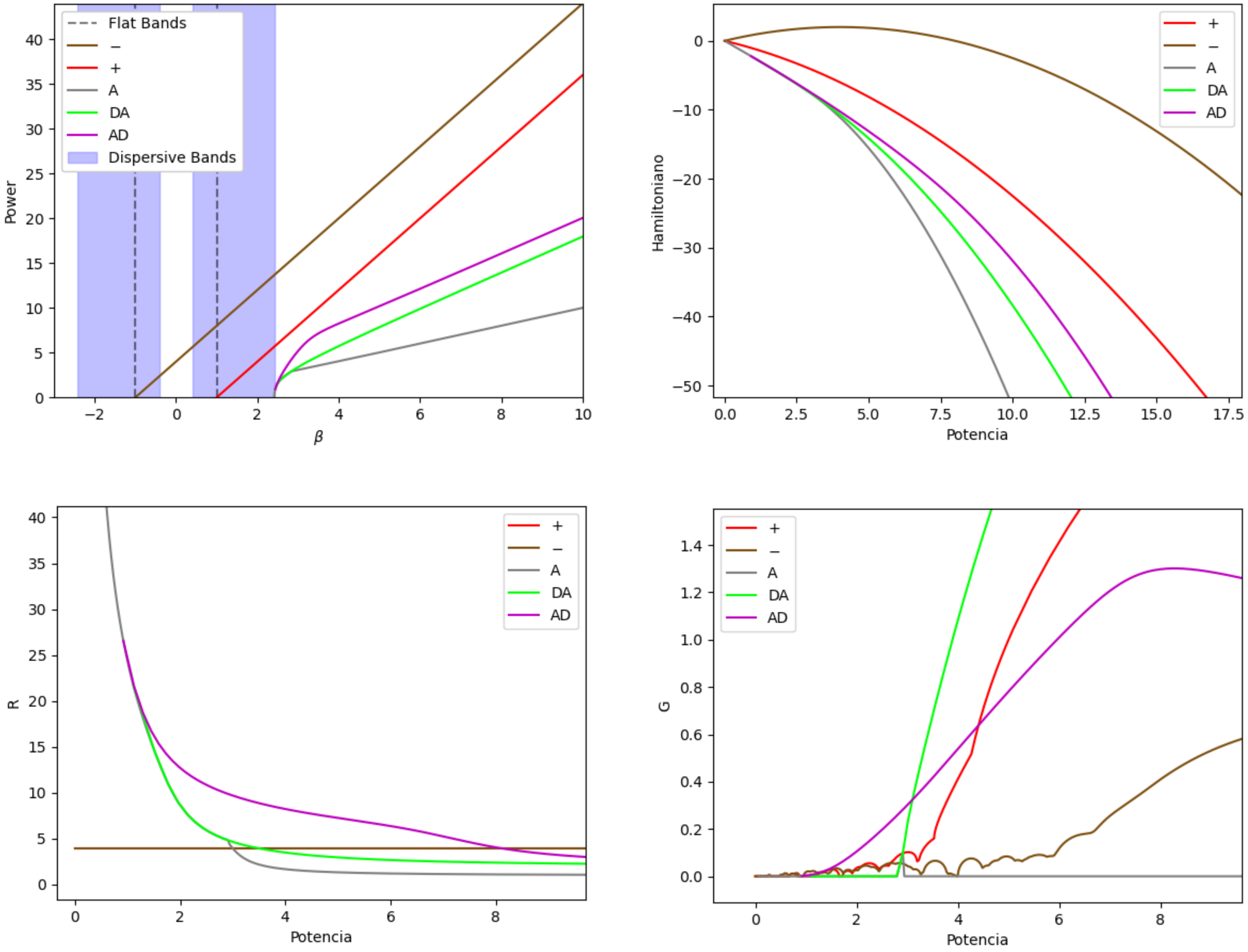


- We look for other localized families of solutions using a multidimensional Newton Raphson method, starting from the anticontinuum limit (β>>1 or P>>1), and then approaching to the linear bands



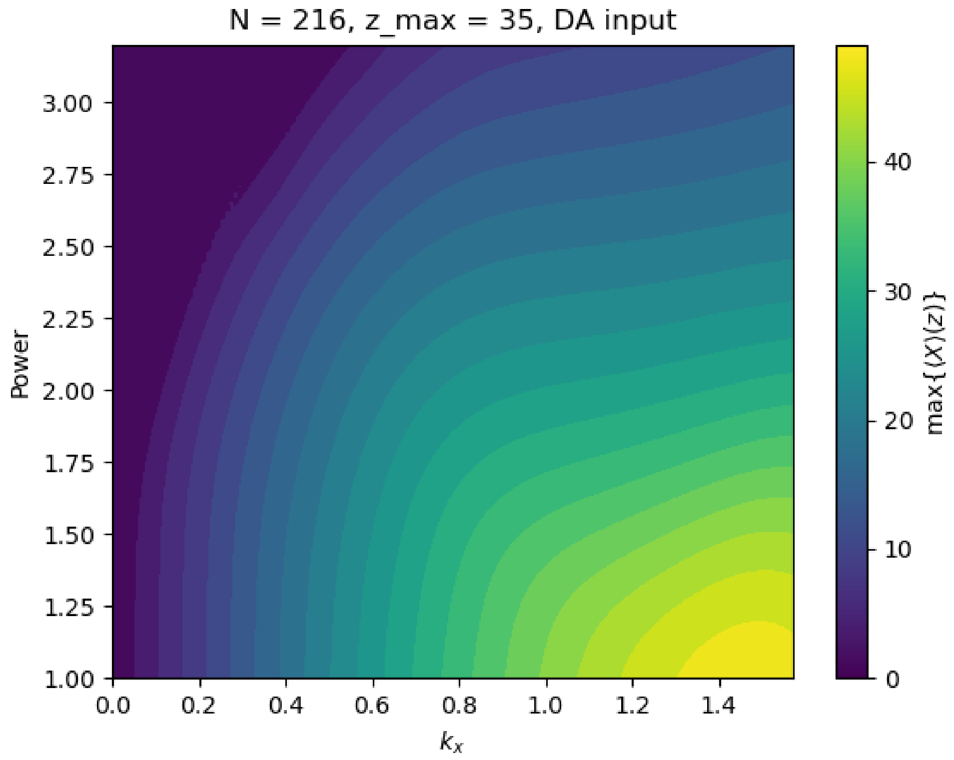
Nonlinear localized modes

- We characterize these families by their Frequency (β), Power (P), Hamiltonian (H), Participation Number (R) and Stability Index (G)



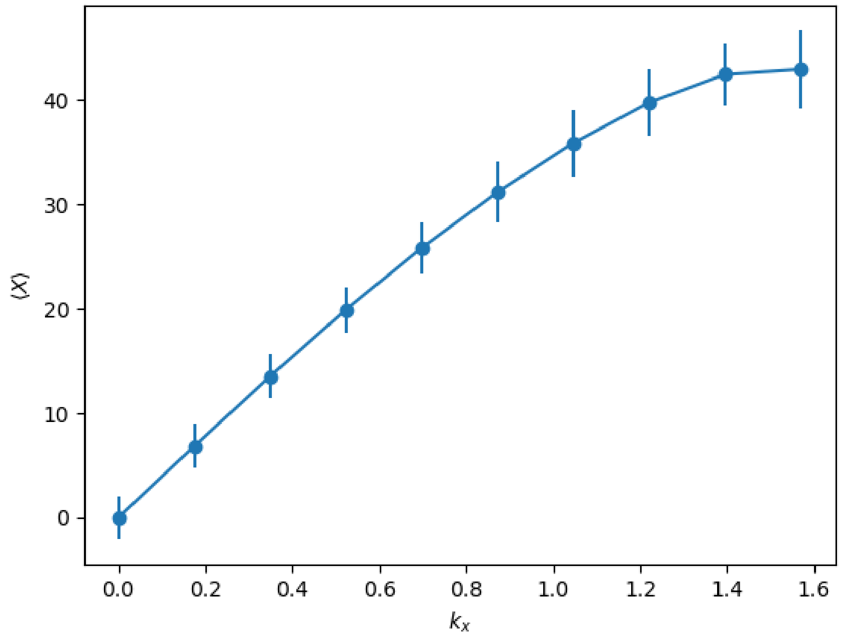
Mobility

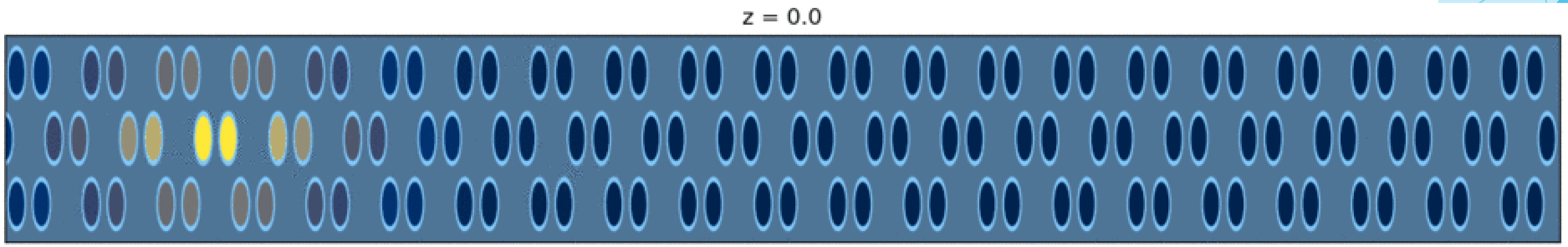
- Numerical simulations of DA solutions at different powers perturbated by a phase kick.
- We found several regions of parameters with good transverse mobility of energy.



Mobility

- Even at high kicks we have low radiation, this allows to control the output location of the solution without modification of the sample.





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References:

- [1] Kittel, C. (1976). Introduction to solid state physics (Vol. 8). New York: Wiley.
- [2] Kawano, K., & Kitoh, T. (2004). Introduction to optical waveguide analysis. Wiley-Interscience.
- [3] Vicencio, R. A. et al. (2015). Observation of localized states in Lieb photonic lattices. Physical review letters, 114(24), 245503.
- [4] Perez-Leija, A. et al. (2013). Coherent quantum transport in photonic lattices. Physical Review A, 87(1), 012309.
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$$P \equiv \sum_{\vec{n}} |\psi_{\vec{n}}|^2$$

$$H \equiv -\sum_{\vec{n}} \left[\left(\sum_{\vec{m} \neq \vec{n}} V_{\vec{n},\vec{m}} \psi_{\vec{m}} \psi_{\vec{n}}^* + \text{c.c.} \right) + \frac{\gamma |\psi_{\vec{n}}|^4}{2} \right]$$

$$R = \frac{P^2}{\sum_{\vec{n}} |\psi_{\vec{n}}|^4}$$

G:

We linearly perturb the nonlinear solutions and obtain a set of equations for the perturbation, which yields to a linear eigenvalue spectrum. We look for the largest eigenvalue G, which indicates the most unstable perturbation mode and, hence, the degree of linear instability of a given solution (perturbation modes start to grow on a distance $z \sim 1/G$).