

Field theoretical study of disorder in non-Hermitian topological models

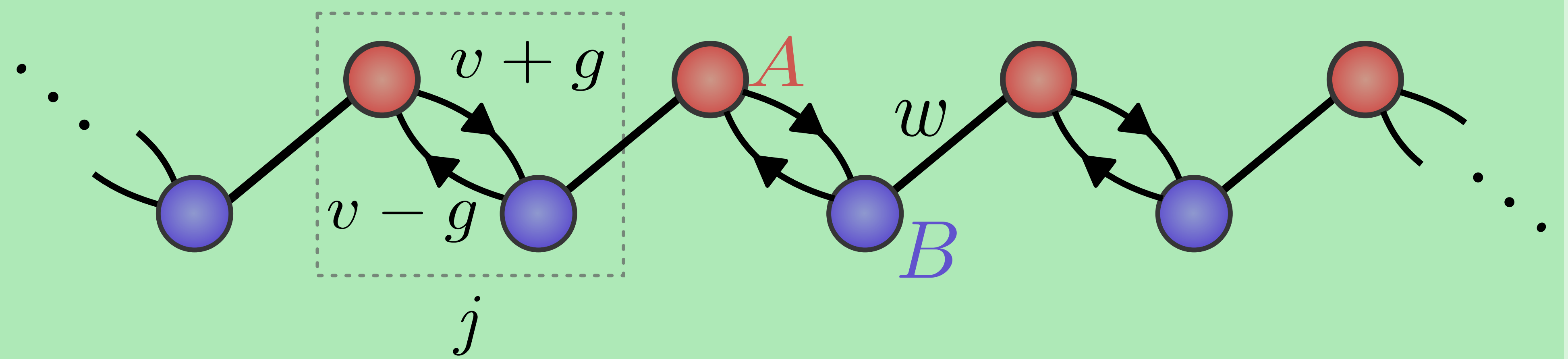
A. Moustaj^{*1}, L. Eek¹, and C. M. Smith¹

1. Institute for Theoretical Physics, Utrecht University

1. Introduction

We provide a **new method** to **analytically** study the effect of **disorder**, using tools from **quantum field theory** applied to discrete models around phase-transition points. We investigate two different one-dimensional models, the paradigmatic **non-Hermitian SSH model** and a s-wave superconductor with imbalanced pairing. These analytic results are compared to numerical calculations in the lattice models. It is found that the systems are driven from a topological to a trivial phase in the same way

2. Model



$$\hat{H} = (v - g) \sum_{j=1}^N c_{A,j}^\dagger c_{B,j} + (v + g) \sum_{j=1}^N c_{B,j}^\dagger c_{A,j} + w \sum_{j=1}^N (c_{B,j}^\dagger c_{A,j+1} + c_{A,j+1}^\dagger c_{B,j})$$

3. Methods and results

- Topological linear response to a $U(1)$ gauge field $A(x)$
- \mathcal{W}_\pm refers to gap closings at $k = 0, \pi$
- Disorder average using the Born approximation
- Introduce self-energy Σ_E at the Born approximation
- Calculate the self-consistent Born approximation

Green's function, Parameters, Pauli matrices

$$S_{\text{eff}}[A; E] = -i \text{Tr} [G_{0,E} (\boldsymbol{\alpha} \cdot \boldsymbol{\sigma}) A] = \mathcal{W}(E) \int dx A(x)$$

Disorder averaging, Spectral winding

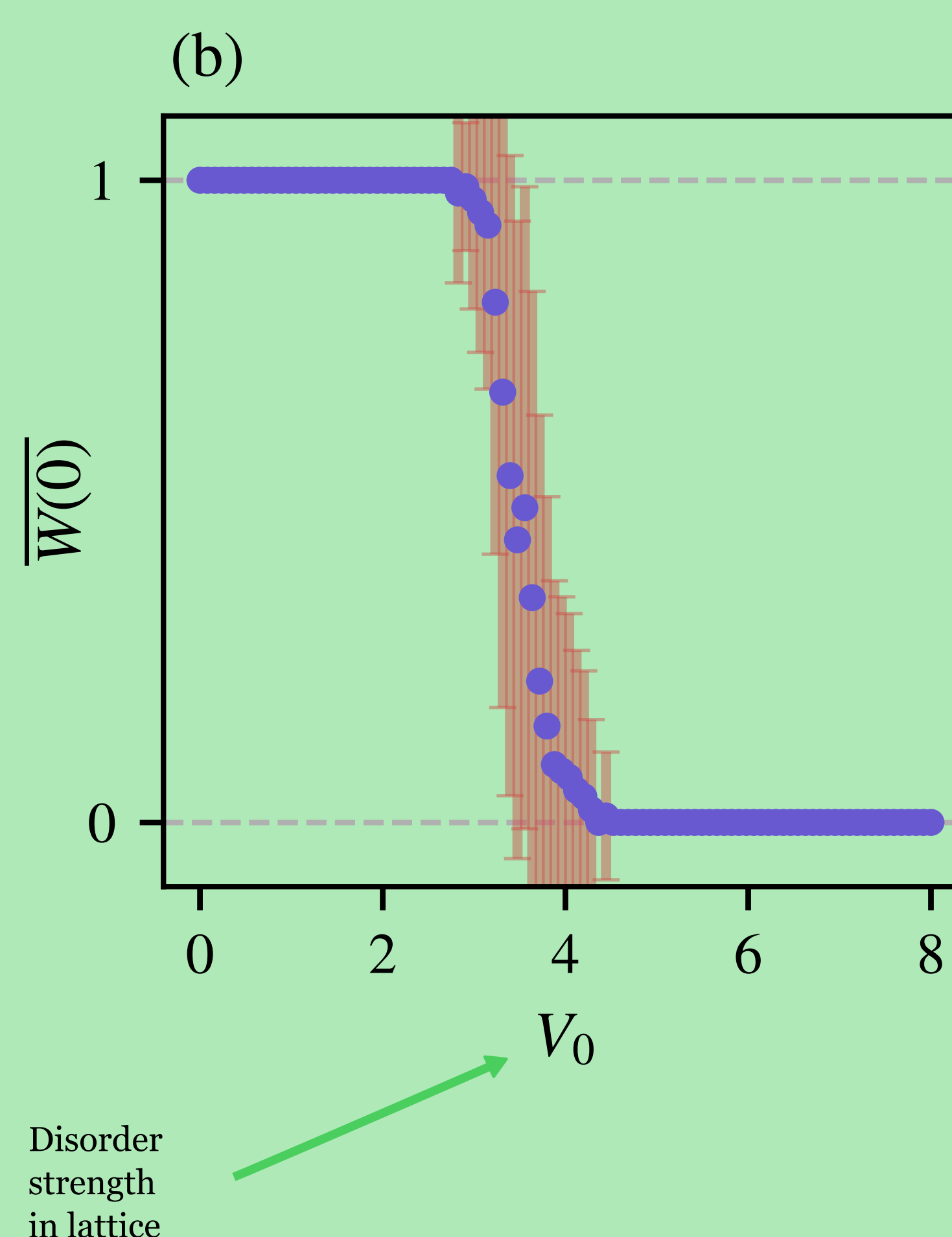
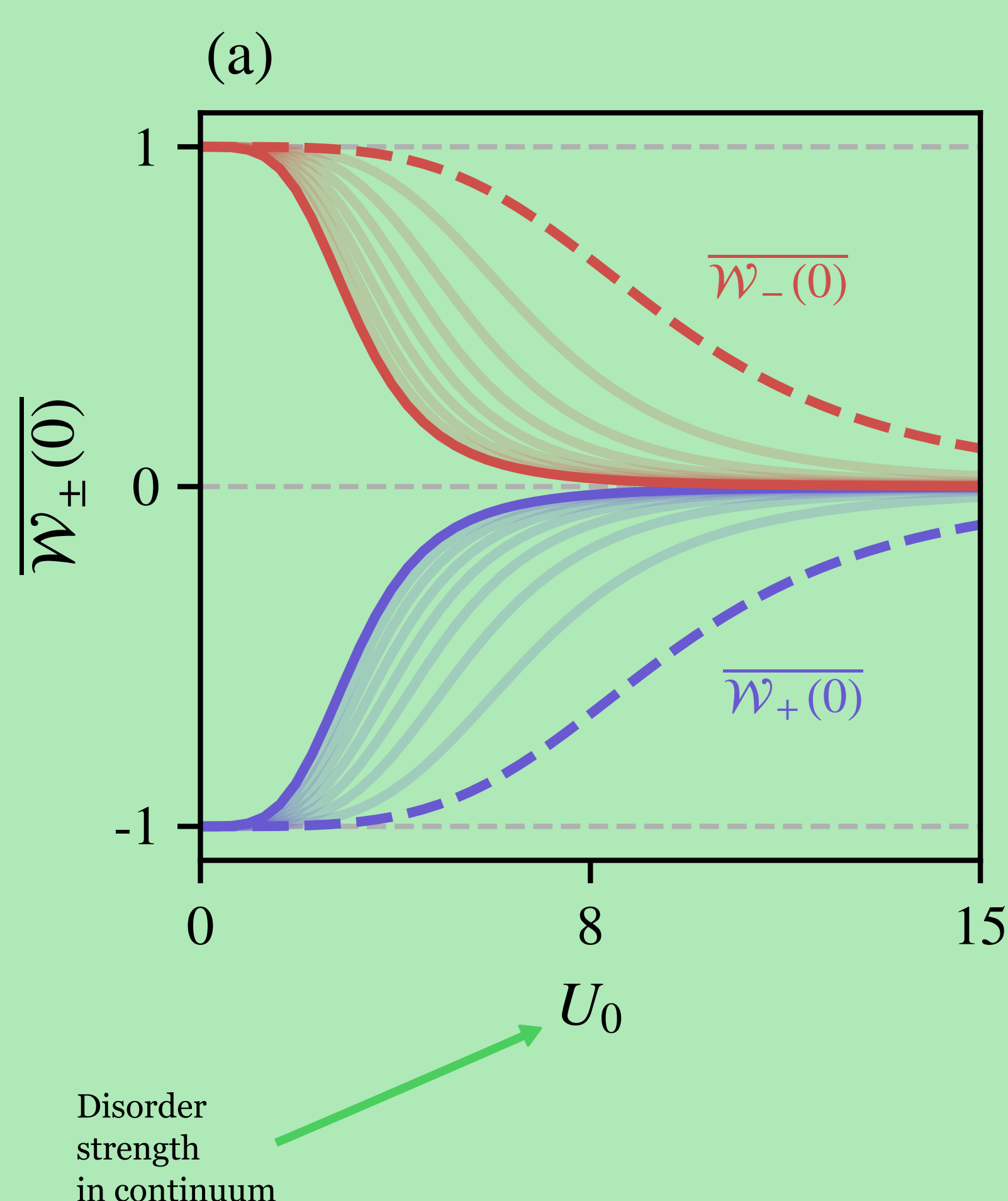
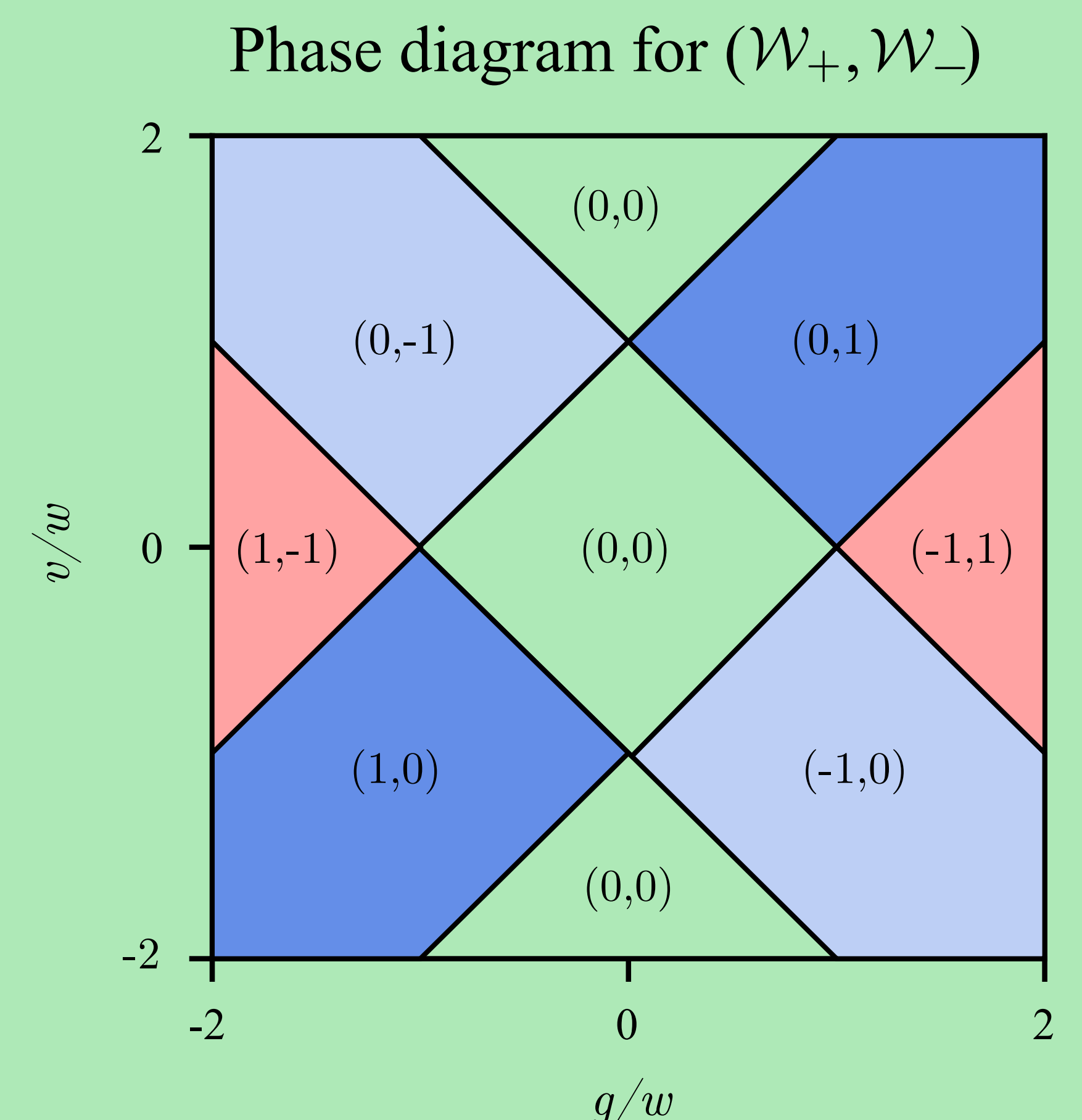
$$\overline{\mathcal{W}_\pm(E)} = \int \frac{dk}{2\pi i} \text{tr} [\overline{G_E^{(\pm)}} (\boldsymbol{\alpha} \cdot \boldsymbol{\sigma})]$$

Generalized tensor product

$$\overline{G_E} = G_{0,E} + G_{0,E} * \Sigma_E * \overline{G_E}$$

Disorder fluctuations

$$\Sigma_E(x, y) = -G_{0,E}(x, y) \delta V(x) \delta V(y)$$



4. Conclusion

- We derive the topological field theory of non-Hermitian two-band models and study the modification of the spectral winding number under disorder averaging
- We apply to two specific models: the NH SSH model and an s-wave NH superconductor
- We can analytically derive the phase transition to a trivial state under strong enough disorder
- **Outlook:** Apply the same formalism to models with interactions and study disorder using the replica method

