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Mathematical Foundations of Non-Hermitian Quantum Field Theory

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A foundational principle of "standard" quantum mechanics (QM) is that physical observables, particularly the Hamiltonian, must be Hermitian. This ensures unitary time evolution and yields real expectation values. However, these properties are not unique to Hermitian operators, but are shared across all operators possessing an anti-linear symmetry. This includes PT-symmetric Hamiltonians, which have found a range of applications in optics, photonics and condensed matter physics. Despite the success of non-Hermitian QM, the subject of non-Hermitian quantum field theory (QFT) has only recently began to gain traction.

To date, most non-Hermitian QFTs have been constructed in a similar fashion to non-Hermitian QM: by appending non-Hermitian terms to an otherwise Hermitian Hamiltonian or analytical continuation. However, these approaches have been leading to various physical inconsistencies. The primary reason for this lies in the fundamental difference between non-Hermitian quantum mechanics and non-Hermitian quantum field theory. Quantum field theory heavily relies on the behaviour of fields under spacetime symmetries, i.e., the Poincaré group. The non-Hermitian nature of the Hamiltonian significantly impacts the underlying symmetry group structure. Thus, to build a non-Hermitian QFT, we must revisit its mathematical foundations, starting with the symmetries of spacetime and constructing the theory from the ground up.

Reference:
arXiv:2307.16805

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