Optomechanical control of non-Hermitian dynamics and topology

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Non-Hermitian bosonic systems with carefully tailored distributions of gain and loss have attracted intensive interest due to the unique spectral and dynamical properties associated with parity-time symmetry and exceptional point degeneracies, and their functions in signal generation, routing, and sensing. We investigate small synthetic networks of nanomechanical resonators that are created through time-modulated laser control fields. This allows generating arbitrary quadratic bosonic Hamiltonians for nanomechanical motion. We show that by combining particle-conserving interactions with optomechanically-induced squeezing, non-Hermitian dynamics can be induced in the networks without relying on coupling to dissipative baths. The networks' dynamical stability is controlled by geometric phases, which allows tuning of exceptional points and chiral amplification that is not present in conventional parity-time symmetric systems. We recognize a class of networks that is characterized by *quadrature nonreciprocity*: a type of phase-dependent unidirectional transmission that can occur in parametrically driven systems even in the presence of time-reversal symmetry. Finally, we experimentally demonstrate the emergence of novel non-Hermitian topological phases with extreme sensitivity to the network boundary conditions.

The most relevant papers I will cover are:

J.P. Mathew, J. del Pino, and E. Verhagen, *Synthetic gauge fields for phonon transport in a nano-optomechanical system*, Nat. Nanotechnol. 15, 198 (2020)
J. del Pino, J.J. Slim, and E. Verhagen, *Non-Hermitian chiral phononics through optomechanically induced squeezing*, Nature 606, 82 (2022)
C.C. Wanjura, J.J. Slim, J. del Pino, M. Brunelli, E. Verhagen, and A. Nunnenkamp, *Quadrature nonreciprocity: unidirectional bosonic transmission without breaking time-reversal symmetry*, arXiv:2207.08523