

Abstract. Linear processing of broadband traveling quantum fields are of interest in a variety of applications such as continuous variable quantum information processing with Gaussian states and linear precision sensing in devices such as gravitational-wave interferometers. The processing is carried out by linear quantum systems that are realized by open oscillator systems with a quadratic internal Hamiltonian and linear coupling to external traveling fields. They are distinguished by the linear dynamics of the amplitude and phase quadratures of the oscillators and traveling fields. The last decade has seen a network synthesis theory for this class of quantum systems being developed, extending well-established techniques for classical linear state-space systems that have been central in the development of modern control theory.

In this talk I will present recent research on the application of network synthesis theory for realizing an active unstable filter with anomalous dispersion, proposed for improving the quantum-limited sensitivity of gravitational-wave detectors. This is based on a procedure that starts from a specification of the desired transfer function or frequency-domain response for the coherent filter and ends with the filter's quantum optical realization. This approach not only facilitates the construction of coherent filters that defy conventional intuition, but also opens a path towards the systematic design of optimal quantum measurement devices.

This talk is based on joint work with Joe Bentley (Hamburg), Yanbei Chen (Caltech) and Haixing Miao (Tsinghua)