## High-order virtual gain for optical loss compensation in plasmonics and metamaterials

## Abstract:

Plasmonic materials and metamaterials display fascinating properties but suffer from high wave dissipation, particularly at optical frequencies. Recently, it has been demonstrated that synthetic optical wave of complex frequencies can provide a practical solution for compensating intrinsic loss. However, further improvement of the performance of this approach has been limited by the temporal truncation of the complex frequency signal and the finite frequency range available for synthesizing the signal. Here, to address these challenges, we introduce synthetic waves of high-order virtual gains, based on a high-power Lorentzian function, for loss compensation. We numerically and experimentally verify that the synthetic wave with high-order virtual gains allows for higher resolution imaging and improved recovery of sharp plasmonic resonances than that of complex frequency excitation. Our approach can be applied to various applications including imaging, sensing and on-chip information processing.