The role of optical thermodynamics and vacuum noise for the design of ultrafast optical systems

We typically discuss ultrafast laser and nonlinear optical systems in the Newtonian framework of the Lorentz oscillator. While this strategy has proven highly successful over the years, there are certain situations in which this rather deterministic engineering approach is prone to fail. One of these scenarios is parametric amplification, which is often seeded by vacuum fluctuations and can lead to unfavorable outcomes, such as optical rogue waves. Deterministic modeling by coupled partial differential equations also fails in the case of multimode optics, where statistical mechanical methods appear more promising for understanding the underlying physics. This talk will explore the current borders of understanding limitations of ultrafast optics.