



University of Crete
Department of Physics

Physics Colloquium

Thursday, 15 October 2026 | 17:00 – 18:00, Seminar Room 3rd Floor

Optical Thermodynamics: From Light Thermalization to Entropy-Driven Photonic Control

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ABSTRACT

Modern photonics has achieved extraordinary control over light in single-mode and few-mode systems, enabling technologies ranging from optical communication and integrated photonics to lasers, sensing, and imaging. Yet many of the most important frontiers in photonics — including power scaling, high-brightness sources, complex wave control, and information transport in high-dimensional systems — inevitably push light into multimode and nonlinear regimes. In these settings, light can no longer be viewed as a collection of independently controlled waves. Instead, it behaves as a many-degree-of-freedom system, where nonlinear interactions drive collective dynamics, thermalization, and self-organization.

In this talk, I will discuss the emerging field of optical thermodynamics, where concepts from statistical physics including temperature, entropy, equilibrium, irreversibility, condensation, and localization provide a new language for understanding and controlling nonlinear multimode photonic systems. I will describe how optical modes can exchange energy and relax toward thermodynamic distributions, and how this process can be harnessed to generate ordered optical states from seemingly disordered initial conditions. Recent examples include negative-temperature states of light, optical analogues of Joule expansion and Joule–Thomson cooling, entropy-driven universal routing, and passive brightness enhancement through nonlinear multimode interactions.