Light Science & Applications

Hotter than hot multimode beams reach negative absolute temperatures

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Statistical mechanics permits to connect the macroscopic properties of matter with the laws governing the evolution of its microscopic constituents. Such an approach has been very successful for systems of particles governed by either classical or quantum mechanics. In a classical gas, different thermodynamic laws apply to the weakly or strongly interacting particles of an ideal or real gas, respectively. In this talk, we show that a similar situation occurs for a gas of photons, which is contained in a finite-dimensional box such as a multimode waveguide. We use a few-mode system provided by a standard step-index fiber operated below cutoff, which permits to prepare a high-density gas of photons. Because of the attractive potential energy contribution to the photon energy induced by the nonlinear Kerr effect, the mode population exhibits a spontaneous inversion from the fundamental to the highest-order mode, as the input laser beam power grows larger. This inversion of the mode power distribution leads to a stable attractor for the output beam and is associated with a progressive increase of the optical temperature until a flip of its sign leads to a new regime of negative absolute temperatures. Our work demonstrates the ability to all-optically control the shape of laser beams, which is a prerequisite for applications in high-power laser sources, nonlinear imaging, and optical

communication systems.

Short Bio:

Stefan Wabnitz obtained the Laurea Degree in Electronics Engineering from Sapienza University of Rome in 1982, the MS in Electrical Engineering from Caltech in 1983, and the PhD in Applied Electromagnetism from the Italian Ministry of Education in 1988. He was with the Ugo Bordoni Foundation between 1985 and 1996. From 1996 until 2007 he was full professor in Physics at the University of Bourgogne in Dijon, France. Between 1999 and 2003 he was with Alcatel Research and Innovation Labs in France, and with Xtera Communications in Allen, Texas. Since 2007 until 2018 he was full professor in Applied Electromagnetics at the University of Brescia, Italy. Since November 2018 he is full professor in Telecommunications at Sapienza University of Rome. His research activities involve nonlinear propagation effects in optical communications and information processing devices. He is the author and co-author of over 1000 international refereed papers, conference presentations, and book chapters. He is the Editor-in-Chief of Elsevier's Optical Fiber Technology, a Fellow member of the Optical Society of America, and senior member of IEEE-Photonics Society