Mode-Coupling Effects in Microlasers: From Full Photon Statistics to Exceptional Points

J Wiersig[1]

[1] *Otto von Guericke University Magdeburg, Magdeburg, Germany*
Contact Email: jan.wiersig@ovgu.de

In this talk, I will review three different studies from my group related to mode-coupling effects in microlasers. First, I will present an extended Monte Carlo method to verify experimental results on the full photon statistics of a bimodal quantum-dot-microlaser based on a two-channel photon-number-resolving transition-edge sensor system [1]. The Monte Carlo approach explicitly includes the external degrees of freedom, enabling a natural treatment of finite measurement times.

Our second study is concerned with non-Hermitian degeneracies, so-called exceptional points (EPs), which have attracted immense attention in photonics and optics. Despite the rapid growth of research on EPs, creating high-order EPs – where more than two eigenfrequencies and their corresponding modes merge – remains challenging. We tackle this challenge by coupling microring cavities via a common waveguide, which is terminated at one side by a partial mirror [2]. Our simple scheme allows for the robust and scalable construction of high-order EPs in integrated semiconductor platforms.

In a very recent study, we demonstrate that EPs can influence the transition to lasing in an interesting way. In laser physics, it is common wisdom that the mode with the highest quality factor and the largest modal gain will reach lasing threshold first when gain is applied to the cavity. However, under certain conditions, an EP can induce a surprising mode switching, allowing a mode that is initially less confined and possesses a smaller modal gain to reach the lasing threshold first, even with spatially uniform pumping.

References

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[2] Kullig, D Grom, S Klembt and J Wiersig, Photonics Res. **11**, A54 (2023)