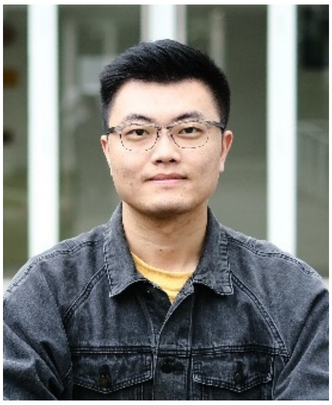
PhD Oral Defense

Date: **22 October 2021 (Friday)** **Time:** **3:30 pm**

Thesis Title

Diverse Dynamical Switching in Semiconductor Lasers with Long External Cavity Feedback



Mr. DONG Jiaxin (Supervisor: Prof. CHAN S C Nelson)

Abstract

Semiconductor lasers under external cavity feedback exhibit various nonlinear dynamics such as self-locking, periodicity, quasi-periodicity, and chaos. For a single-mode laser with optical feedback, the dynamical behaviors are closely related to the interactions between the relaxation resonance and the external cavity modes (ECMs), which are separated by roughly the inverse of the feedback delay time. Diverse dynamical variations are supported when the frequency separations of the ECMs are much smaller than the relaxation resonance frequency in the long-cavity regime. In this thesis, dynamical switching is unveiled for a semiconductor laser under optical feedback in the long-cavity regime. Such a new dynamics of switching is found to spontaneously occur between a stable stage of constant intensity and an unstable stage of fast oscillatory intensity. Firstly, the regular stable-unstable switching is investigated numerically in detail, revealing the switching regions in the feedback parameter space, which is found to be bounded by the analytical Hopf boundary of the minimum linewidth mode. Secondly, in the plane of instantaneous optical frequency and gain, the laser is found to follow an ellipse in slowly visiting different ECMs during the stable stage, allowing for an analytical derivation of the stable-unstable switching period. Drawing relation to recent works on cavity solitons and spatiotemporal chimeras, the analytical results explain the commonly observed dynamical period expansion from the feedback delay time, where the expansion time is derived to be inversely proportional to the feedback field strength. Thirdly, an experiment on the regular stable-unstable switching is demonstrated. Without employing any high-speed electronics, the laser generates an intensity time series comprising of a square-wave envelope repeating in a feedback delay time of 63 ns, which is modulated on a microwave carrier at 8.36 GHz near the relaxation resonance frequency. Additionally, experiments are extended for yielding irregular switching for wireless random bit distribution applications. Wirelessly distributed using a microwave carrier at 3.7 GHz, random bits are generated at an output rate reaching 2.2 Gbps. Overall, the thesis investigates the dynamical switching in lasers with feedback, where the regular or irregular switching generates diversely modulated microwave signals for applications.