Dynamics and Synchronization of Broad Area Semiconductor Laser Arrays

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Semiconductor lasers are most compact and have inherently the largest electrical-optical conversion efficiency over all types of coherent light sources. A stacked array of broad-area semiconductor lasers with an overall emission aperture size of a few square centimeters can readily provide kilowatts of output power. The limitation in the application of high-power broad-area semiconductor lasers is their poor beam quality and broad spectrum.

To overcome this drawback, a variety of laser synchronization techniques have been applied to lock the modes of broad-area lasers and to synchronize multiple lasers. We will describe our recent experimental designs aimed to synchronize high power broad-area laser arrays. The experiments are conducted on a commercial available integrated bar laser array that contains InGaAsP broad-area emitters with the total output power over 20 W. Each broad-area laser emitter in the array has a cavity length of 1 mm and an emission aperture of 125 μm×1 μm, which is wider than that of the overall aperture (100 μm) of many laser arrays reported in previous work. The entire laser array is driven by a common current source. Our experimental results show that all 19 broad-area lasers are frequency-locked over the entire pumping current range. The far-field pattern of the laser array shows single mode. The wavelength of the array output can be tuned over 10 nm with the side mode suppression ratio larger than 25 dB.

Theoretical and numerical work revealed that coherent coupling of a phase-locked laser array results in a very high light intensity which is proportional to N^2 where N is the number of the lasers in the array. However, laser array is a highly nonlinear system and possesses a variety of complex behavior. We will address a number of nonlinear dynamics issues that affect the synchronization of broad-area lasers including the effects of laser coupling on the frequency locking, the dynamical filamentation, as well as Giga-hertz complementary intensity oscillations occurring at different transverse modes of broad-area lasers subject to optical injection.

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* The talk will be presented by Y. Braiman