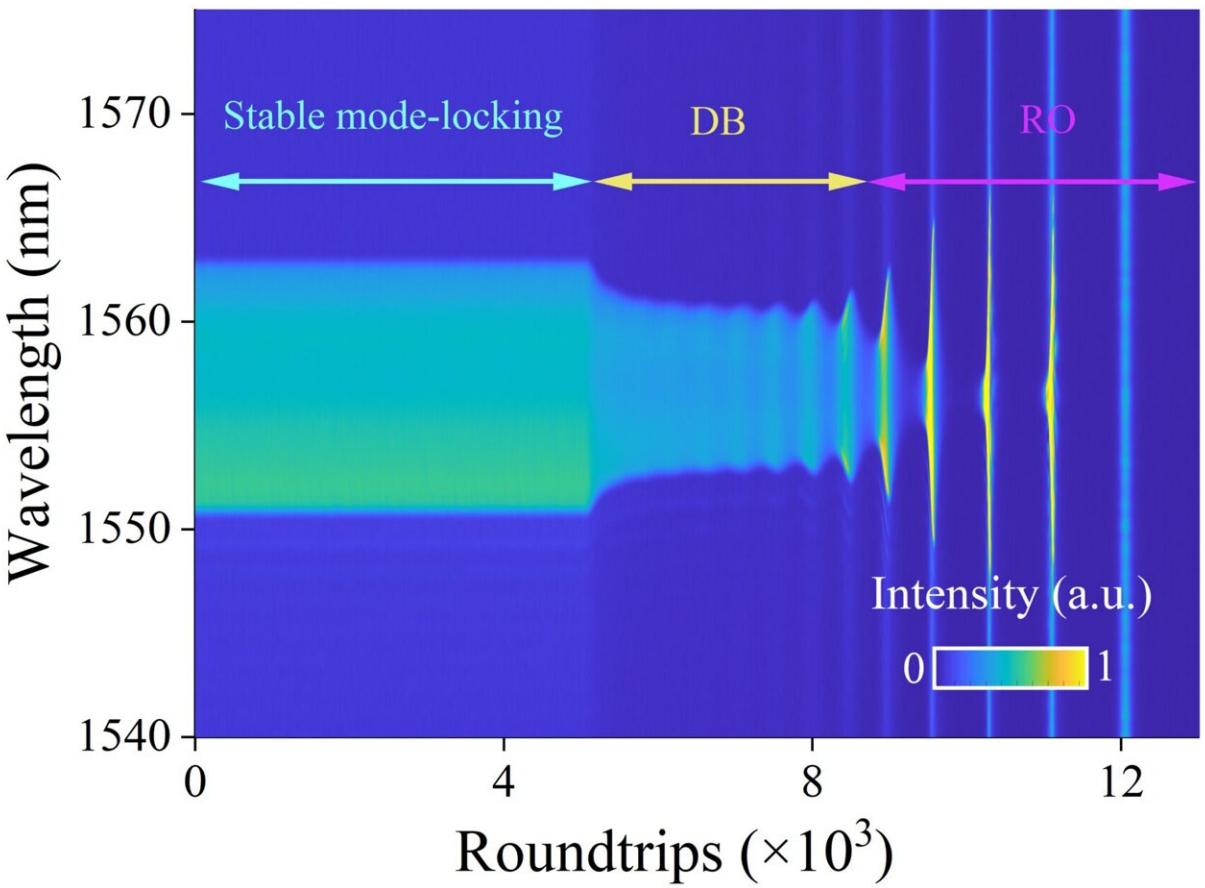
When dissipative solitons vanish, breathing dynamics occur: Study

January 31 2024



Transient breathing dynamics of dissipative solitons captured by DFT technique. Credit: Zichuan Yuan, Si Luo, Ke Dai, Xiankun Yao, Chenning Tao, Qiang Ling, Yusheng Zhang, Zuguang Guan, Daru Chen, Yudong Cui

Solitons are quasiparticles that propagate along a non-dissipative wave. Put another way, they are waveforms that hold their shape as they move—like a single wave moving across the surface of a pond. They can also show particle-like behavior, such as collision, attraction, and repulsion.

Ultrafast fiber laser is an ideal platform to explore nonlinear dissipation dynamics and deepen the understanding of optical soliton properties. In a dissipative system, dissipative solitons can be obtained due to the balance between nonlinearity and dispersion, gain and loss.

In recent years, with the development of emerging time-stretch dispersive Fourier transform (TS-DFT) technique, the real-time buildup dynamics of breathing dissipative soliton have been widely observed. Since the pump power changes greatly during the extinction process, scientists speculate whether breathing dynamics can occur during the annihilation of solitons.

At present, there is a lack of comprehensive research on the transient breathing dynamics and the impact of breathing characteristics during the extinction process.

Researchers led by Associate Prof. Yusheng Zhang at Zhejiang Normal University, China, are interested in ultrafast measurement, where the rich nonlinear dynamics of solitons can be revealed. This technique can convert the optical signals in spectral domain into the time domain, enabling ultrafast spectral characterization.

The work titled "Transient breathing dynamics during extinction of dissipative solitons in mode-locked fiber lasers" was published in *Frontiers of Optoelectronics*.

Their idea is to start with buildup of dissipative soliton. This way, by

controlling the pump power, the dissipative soliton receives transient change that Q-switched instabilities occur. This discovery has the potential to significantly advance our understanding of laser dynamics, and offers novel opportunities for the development of diverse operational frameworks within the field of ultrafast laser systems.

More information: Zichuan Yuan et al, Transient breathing dynamics during extinction of dissipative solitons in mode-locked fiber lasers, *Frontiers of Optoelectronics* (2024). DOI: 10.1007/s12200-024-00106-6

Provided by Higher Education Press