Radiation build-up and dissipation in Raman random fiber laser

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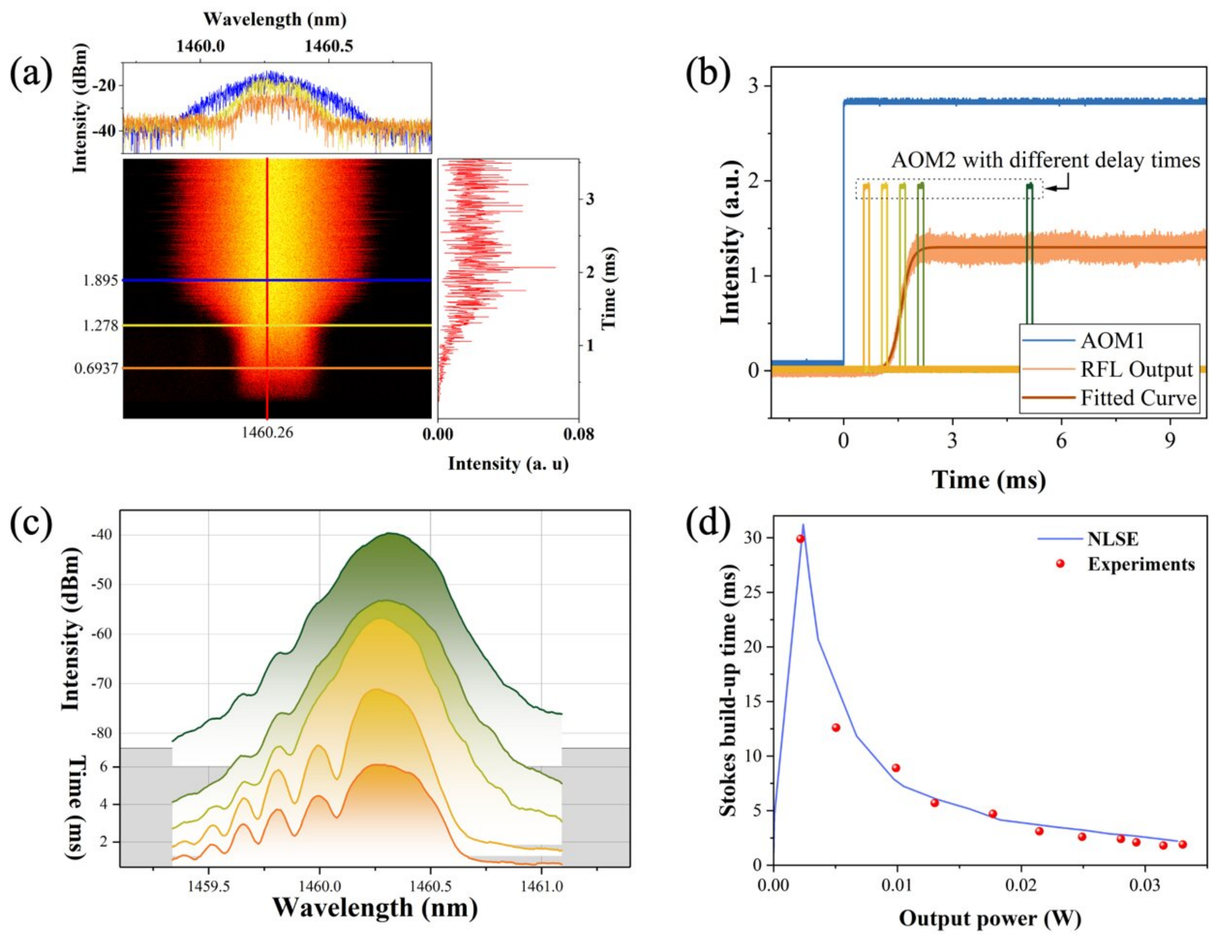

(a) Simulation results of RRFL temporal and spectral evolution at transient state; Corresponding experimental results of RRFL (b) temporal evolution and (c) spectral evolution; (d) Build-up time of the RRFL at different power levels. Credit: Science China Press

Raman random fiber lasers (RRFL) have attractive features, such as their simple structure, excellent wavelength-tunability and high optical-optical conversion efficiency. They show great potential for long-distance fiber sensing, speckle-free imaging, high-energy physics, and other applications. The unique feedback in the RRFL comes from distributed fiber Rayleigh scattering with intrinsic randomness.

Investigating its dynamic properties in its steady state has become a bridge to probing complex physical systems with the optical platform, including turbulence, spin glasses behaviors, etc. Meanwhile, the transient state, such as the laser build-up and dissipation processes, could reveal light-wave interactions and aid in the exploration of the formation process of some complex physical systems.

The transient state of RRFL has been investigated for the first time by Zinan Wang and co-authors from UESTC and SCU. They have published their results in *Science China Information Sciences*.

Based on the generalized nonlinear Schrödinger equations, the temporal and spectral evolution of RRFL at the transient state is analyzed theoretically, and corresponding experimental verification is carried out, then a series of interesting conclusions are drawn. The specific significance and novelty are summarized as follows:

(1) For the RRFL build-up transient state, the output power of the RRFL shows a continuous growth curve, which is fundamentally different from the step-like growth curve of conventional Raman fiber lasers, providing intuitional evidence to differentiate the lasing mechanisms of the two cavities. Particularly, the RRFL growth curve satisfies the Verhulst logistic model, which is widely observed in biological growth dynamics. Based on the cross-disciplinary approach, this work could open up new important avenues for understanding complex biological phenomena through the RRFL system.

(2) Above the threshold, the RRFL build-up time is inversely related to the pump power, and only several optical round-trip times are required at a relatively high pump power. This finding is crucial for any applications that require a precise understanding of the RRFL build-up time. For example, in long-distance RRFL point-sensing, the build-up time decides the upper bound of the sensing bandwidth, and the results in this work provide a lucid guideline for achieving wideband dynamic sensing.

This work provides valuable insights into the underlying complex physics of the RRFL dynamics, and the results could be beneficial to research on other complex systems, such as biological dynamics and rogue wave build-up.

More information: Shengtao Lin et al, Radiation build-up and dissipation in Raman random fiber laser, *Science China Information Sciences* (2023). www.sciengine.com/SCIS/doi/10. … 97-abe8-339d93601952

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