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I-CReST 2025:163-119 – Analysis of Soliton Microcomb Dynamics for Energy-Efficient WDM Data Centre Interconnects

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ABSTRACT

Conventional wavelength-division multiplexing (WDM) links in data centres rely on multiple discrete lasers, which are power-hungry and scale poorly in energy efficiency. Optical frequency combs produced in integrated microresonators, known as soliton microcombs offer a compelling alternative by providing many wavelength channels from a single laser pump, drastically reducing the energy per bit for WDM transmission. In this work, we present an analysis of soliton microcomb dynamics tailored for energy-efficient WDM data centre interconnects. We model the generation of dissipative Kerr solitons under realistic low-power conditions and evaluate key metrics such as pump power, conversion efficiency and per-line power. Our results show that a microcomb source can produce a broad set of WDM carriers with high spectral purity while operating at a fraction of the power consumption of multi-laser arrays. With pump powers on the order of tens of milliwatts, conversion efficiencies of about 50% to 70% can be achieved, yielding per-channel optical power on the order of 1 mW. This is significantly lower than per-channel outputs of individual distributed feedback (DFB) lasers. We further demonstrate that the microcomb-based WDM transmitter can improve the energy-per-bit by an order of magnitude compared to legacy architectures. This analysis underscores that soliton microcombs enable energy-efficient scaling of data centre interconnect bandwidth. By consolidating multiple channels into one miniature comb source, overall transmitter power is minimised, paving the way for high-capacity and low-energy optical links in future green data centres.

Keywords: Soliton microcomb; Lugiato-Lefever equation; Wavelength-division multiplexing; Data center interconnects; Kerr frequency comb