Scientists greatly expand the frequencies generated by a miniature optical ruler

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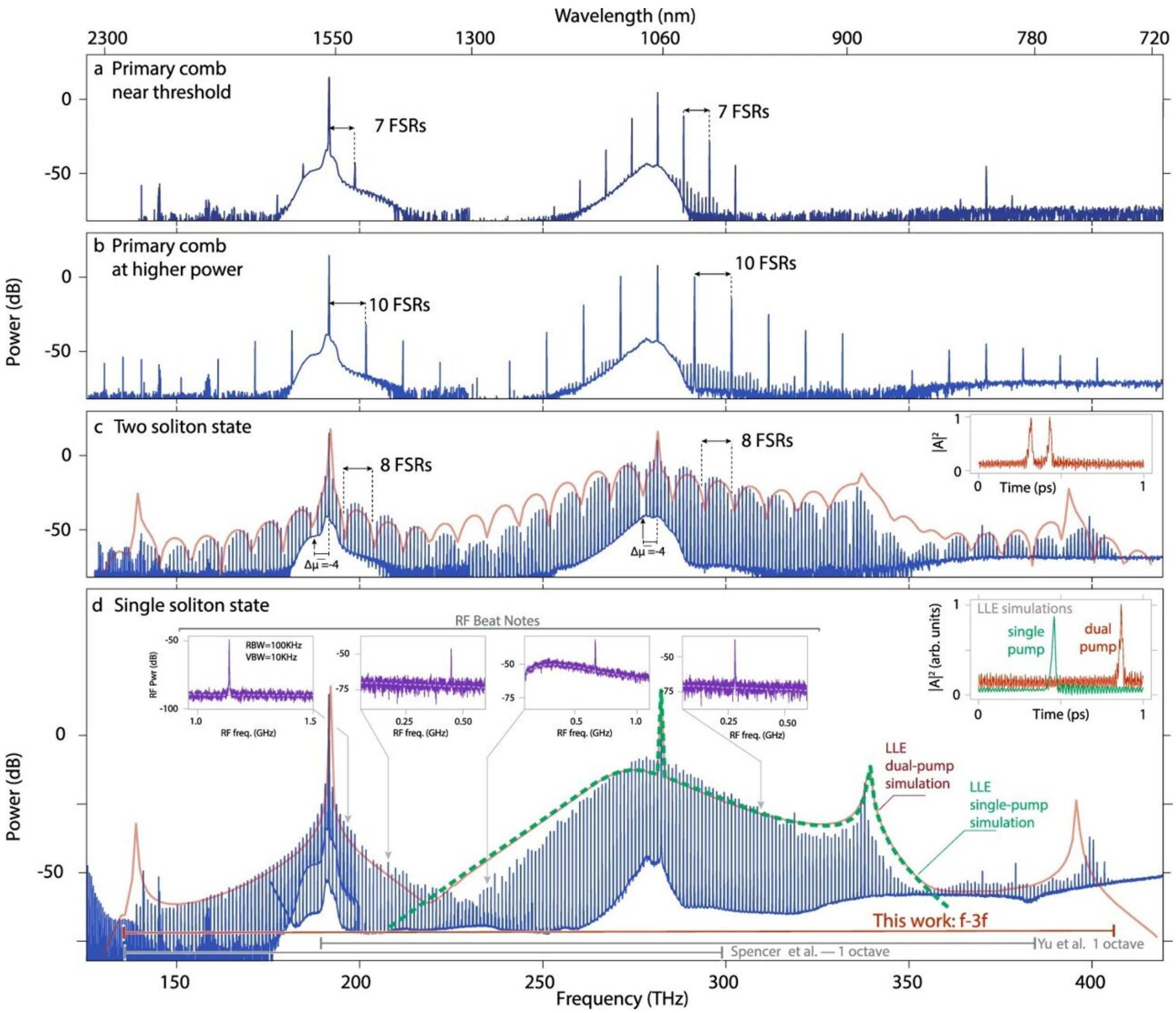

Spectral translation to create ultra-broadband microcombs. A microring resonator with RW = 1117 nm is pumped by a primary pump at 282 THz and synthesis pump at 192 THz. a Primary comb generation with low primary pump power near threshold. The comb spacing is equal to seven free spectral ranges (FSRs) and reproduced around the synthesis pump and idlers, highlighting the mixing process between the two pumps and the primary portion comb teeth. b Primary comb generation at a higher primary pump power where, as previously, the spectral spacing in the primary portion is matched by that in the synthesis portion, as expected by the FWM-BS theory. c Two-soliton state, where the characteristic 8 FSR modulation in the comb envelope is replicated near the synthesis pump. The inset shows the LLE-calculated two-soliton pulse arrangement that results in the simulated comb envelope shown in red. We highlight the missing comb tooth in the primary portion ($\Delta\mu = -4$), whose absence is translated onto the synthesized portion of the comb, respecting the FWM-BS phase-matching condition. d Single soliton state, where the impact of the synthesis pump is to expand the comb bandwidth to 1.6 octaves and create new DWs on both ends of the spectrum. The spectrum agrees with the generalized LLE solution using the dual-pump model (red line), and greatly exceeds the expected spectrum if just the primary pump is applied (dashed green line). The phase-coherent nature of the comb is verified through beat note measurements with narrow linewidth lasers throughout the comb spectrum (four left insets). The noise floor for each measurement is shown in dashed lines, and is higher in the O-band due to use of an additional RF amplifier. The rightmost inset shows the LLE simulation of the expected time-domain behavior under dual pumping (red) and if only the primary pump is applied (green). The horizontal bars at the bottom of the graph compare the span achieved here with octave-spanning DKSs from refs. 3, 32. We note that the low frequency portion of the spectrum exhibits OSA artefacts, at 146, 159, and