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Quantum Breakup of Higher Order Bright Solitons[1] LINCOLN CARR, Department of Physics, Colorado School of Mines, Golden, Colorado, USA, CHRISTOPH WEISS, Joint Quantum Centre (JQC) Durham-Newcastle, Department of Physics, Durham University, Durham, UK — Semiclassical mean field theory in the form of the nonlinear Schrodinger equation (NLS) has had incredible success in modeling the dynamics of repulsive Bose-Einstein condensates (BECs): experimentally observed predictions range from dark solitons to skyrmions. A key prediction for attractive BECs is the bright soliton. An order-two soliton can be produced in a BEC simply by increasing the interaction strength by a factor of four, via a Feshbach resonance. The NLS is exactly solvable in this case and predicts a beautiful time-periodic dynamical pattern. Using matrix-product state methods, we show that such far-from-equilibrium higher order bright solitons exhibit quantum depletion and in fact break up rapidly in the more complete underlying quantum theory. Such break-up presents a smoking gun signal for emergent phenomena in quantum systems that do not have a semiclassical limit, and are therefore truly quantum in nature at macroscopic scales. They also indicate a breakdown of semiclassical integrability at a more fundamental quantum level.

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