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Kolmogorov to Kelvin Wave Cascades in Turbulence: from large scales to quantum vortex core scales GEORGE VAHALA, William & Mary, JEFFREY YEPEZ, Air Force Research Lab., Hanscom, MIN SOE, Rogers State University, LINDA VAHALA, Old Dominion University — A novel unitary mesoscopic lattice algorithm with low memory requirements, permits simulations of the nonlinear Schrodinger equation (NLS) on spatial grids up to 5760^3. The algorithm is built from the collisional unitary entanglement of 2 qubits at each spatial node and then unitary streaming of this entangled state to neighboring sites. The algorithm scales perfectly – even to the full 163840 processors on Blue Gene P/Intrepid. Our simulations have determined 3 distinct power laws in the incompressible kinetic energy spectrum: a classical Kolmogorov $k^{-5/3}$ spectrum at large scales, and a quantum Kelvin wave cascade spectrum of at scales of the order of the quantum cores. In the adjoining semiclassical regime there is a non-universal steeper spectral decay adjoining the classical and quantum regimes. Our unitary (reversible) algorithm fully respects the Hamiltonian nature of the GP equation and approaches pseudo-spectral accuracy. Somewhat unexpectedly, we find a set of initial conditions that exhibit very short Poincare recurrence times.

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