Abstract Submitted
for the DPP11 Meeting of
The American Physical Society

Unitary Qubit Representation of Quantum and Classical Turbulence GEORGE VAHALA, BO ZHANG, William and Mary, LINDA VAHALA, Old Dominion University, MIN SOE, Rogers State University — A unitary qubit lattice algorithm, which scales almost perfectly to the full number of cores available (216000 cores on a CRAY XT5), is used to examine quantum turbulence and its interrelationship to classical turbulence with production runs on grids up to 5760^3. The maximal grids achievable by conventional CFD for quantum turbulence is just 2048^3, and artificial dissipation had to be introduced. Our unitary algorithms preserve the Hamiltonian structure of the Gross-Pitaevskii equation which describes quantum turbulence in a zero-temperature (BEC). As a result, parameter regimes have been uncovered which exhibit very short Poincare recurrence time, as well as a strong triple cascade structure in the kinetic energy spectrum, with small k-region obeying a Kolmogorov $k^{-5/3}$ spectrum The incompressible energy spectrum shows a k^{-3} spectrum for large-k, but a Saffman-like k^{-4} for smaller-k which is attributed to vorticity discontinuities. 2D and 3D turbulence is considered. These unitary qubit lattice algorithms are directly applicable to quantum computers.

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Date submitted: 14 Jul 2011 Electronic form version 1.4