MESOSCOPIC LATTICE BOLTZMAN ALGORITHMS FOR QUANTUM TO CLASSICAL TURBULENCE

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The nonlinear Schrodinger (NLS) equation plays a important role in physics: from plasma wave and soliton propagation to turbulence in Bose-Einstein condensates where the NLS equation is known as the Gross-Pitaevskii equation. Here we will consider a lattice Boltzmann (LB) mesoscopic representation of the 3D NLS equation to examine the multi-scale physics of turbulence spanning from the quantum vortex core scales to the classical large eddies where the quantization of vortices is unimportant.

In the LB approach, the linearized BGK collision operator is discretized on a spatial lattice, with the cubic nonlinearity of the NLS equation being determined from a phase rotation with the distribution function now being complex [1]. The standard explicit LB algorithm for MHD has to be abandoned because of the accuracy needed to determine the cubic nonlinearity in NLS. Instead, we resort to an implicit-explicit scheme with phase rotation. The BGK collision operator can be treated explicitly, but the phase rotation is handled implicitly. Rapid convergence is obtained from a continued fraction representation. Zhong et. al . [1] only considered the simple case of 1D soliton propagation. We extend this to now cover 1D soliton-soliton collisions and the 2D transverse instability. Preliminary results will also be presented for 3D NLS. It is interesting to note that the usually dissipative LB algorithm can now in complex space successfully model the time-reversible Hamiltonian structure underlying the NLS/GP equation.

[1] L. Zhong, S. Feng, P. Dong ad S. Gao, Phys Rev. **E74**, 036704 (2006)

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