Abstract Submitted
for the DFD20 Meeting of
The American Physical Society

Direct statistical simulation: an alternative approach to turbulence KUAN LI, Mathematics, Uni. of Leeds, UK, BRAD MARSTON, Physics, Brown University, STEVEN TOBIAS, Mathematics, Uni. of Leeds, UK —
Direct statistical simulation (DSS) is a revolutionary mathematical framework in the field of computational fluid dynamics. DSS is especially suited for simulating the large scale motions of the inhomogeneous and anisotropic turbulent flows, e.g., Tobias etal, (2011). In the DSS framework, the statistics, namely cumulant, are employed to describe the fluid motions of different scales. The large scale behaviour of the fluid that correspond to the low order cumulant terms are therefore smooth in phase space and need much fewer degrees of freedom in both space and time for the numerical computation as that required for the direct numerical simulation (DNS). DSS is expected to compute the turbulent flow in the extreme turbulent regimes beyond the reach of DNS.
We present a matrix-free method for computing the governing cumulant equations up to the third order and demonstrate its numerical supremacy via the Barotropic jets problem. For this illustrative 2-dimensional problem, we observe that our matrix-free method is at least 10^3 to 10^4 times faster than the DNS computation or the conventional matrix-based algorithm of DSS with the same numerical accuracy.

Kuan Li
Mathematics, Uni. of Leeds, UK

Date submitted: 03 Aug 2020 Electronic form version 1.4