Abstract Submitted
for the DFD19 Meeting of
The American Physical Society

A symmetry of the pressure Hessian in the incompressible Euler and Navier-Stokes equations MAURIZIO CARBONE, Politecnico di Torino, ANDREW BRAGG, Duke University, MICHELE IOVIENO, Politecnico di Torino — The Lagrangian dynamics of the velocity gradient is examined in the strain-rate eigenframe, in three-dimensional (3D) and incompressible flows. The equations highlight a symmetry of the pressure Hessian. Indeed, the component of the eigenframe angular velocity along the vorticity direction does not play any role in the Lagrangian dynamics of the velocity gradient invariants. Such symmetry involving the eigenframe angular velocity turns into a gauge symmetry for the pressure Hessian, which is determined up to a term proportional to the commutator between the symmetric and anti-symmetric part of the velocity gradient tensor. Therefore, only four numbers are necessary to specify the effective pressure Hessian in 3D flows. The gauge term is exploited to simplify the geometry of the non-local pressure Hessian, reducing it to a tensor of rank two. This simplifies the geometric interpretation of the pressure Hessian effect on the dynamics of the velocity gradient invariants and allows to compare two- and three-dimensional flows. We characterize the geometry of the effective pressure Hessian by means of DNS results, focusing on the statistics of its independent eigenvalue and the alignment between the plane on which the effective pressure Hessian acts and the strain-rate eigenframe.

Maurizio Carbone
Politecnico di Torino

Date submitted: 01 Aug 2019 Electronic form version 1.4