Abstract Submitted
for the DFD09 Meeting of
The American Physical Society

Energy flux in non-equilibrium energy spectra in steady turbulence KIYOSI HORIUTI, KENSAKU SAITOU, Tokyo Institute of Technology — The energy spectrum $E(k)$ and energy flux function $\Pi(k)$ in non-equilibrium state are obtained using the spectral energy equation based on the Kovasznay, Leith diffusion and Heisenberg hypothesis. The derived models are assessed using the DNS data for forced homogeneous isotropic turbulence. Three different forcing schemes are used and compared. In all these forcing schemes, the base spectrum obeys the Kolmogorov law $E(k) \propto k^{-5/3}$, and $\Pi(k) = \text{const}$, but the temporal development of the the deviatoric spectrum and flux is divided into the three phases. In the period in which $d\varepsilon/dt \equiv \dot{\varepsilon} > 0$, $E(k) \propto k^{-7/3}$ and $\Pi(k) \propto k^{-2/3}$ in the inertial subrange (Phase 1), while $E(k) \propto -k^{-7/3}$ and $\Pi(k) \propto -k^{-2/3}$ when $\dot{\varepsilon} < 0$ (Phase 2), where ε is the dissipation rate. In the transient period between Phase 1 and Phase 2, $\dot{\varepsilon} \approx 0$ and $\ddot{\varepsilon}$ is large, and $E(k) \propto k^{-9/3}$ and $\Pi(k) \propto k^{-4/3}$ (Phase T). On average, the deviatric spectrum induces the forward scatter of the energy into the small scale in Phase 1, and the backward scatter of the small scale energy into the large scale in Phase 2. These results are overall consistent with the prediction obtained using the closure models, but the eddy-viscosity Heisenberg model does not yields $E(k) \propto k^{-9/3}$ in Phase T. Due to the effect of the intermittency, the energy spectrum and flux exhibit a slight deviation in the exponents.

Kiyosi Horiuti
Tokyo Institute of Technology

Date submitted: 11 Aug 2009 Electronic form version 1.4