Modal characterization of the temporal dynamics in particle-laden turbulence

M. Schiødt[*], A. Hodžić[*], F. Evrard[†‡], M. Hausmann[†],
B. Van Wachem[†] and C.M. Velte[*]

The study of particle-laden turbulence has seen renewed attention and advancements in the past decade[1]. In statistically stationary flows, analytically derived response functions relate the energy of inertial particles to that of the surrounding fluid on a modal level[2]. However, in non-stationary flows, the models fall short. In this contribution, we use the particle proper orthogonal decomposition (PPOD)[3], and compute the Lagrangian spectrum of the carrier- and dispersed phase in a POD frame of reference. In particle-laden decaying homogeneous isotropic turbulence, the PPOD-based Lagrangian spectra of the two phases are related through simple analytic response functions (Figure 1) dependent on the Stokes number. The response functions are found to resemble those derived for stationary flows using the Fourier decomposition. The results suggest that PPOD-based response functions are a generalization of Fourier-based response functions. Significantly, the PPOD approach to response functions may appropriately be applied for the analysis of both stationary and non-stationary flows, whereas the Fourier approach is limited to statistically stationary systems[4]. The PPOD approach therefore offers potential insights of energy relations in a wide range of complex flows.

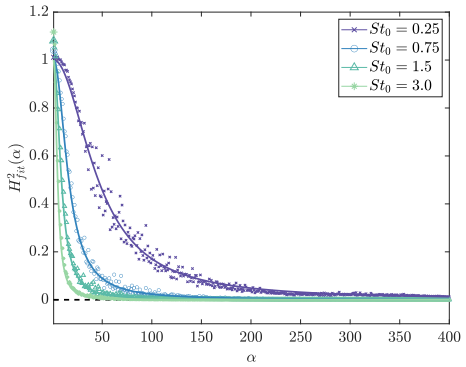

Figure 1: Response function relating the PPOD-based Lagrangian spectrum of inertial particles to the corresponding spectrum of the fluid at particle position. The solid line represents the analytic fit to the empirically evaluated response function (markers).

[*]DTU Construct, Technical University of Denmark, Kongens Lyngby, Denmark
[†]Faculty of Process & Systems Engineering, Otto von Guericke University, Magdeburg, Germany
[‡]Sibley School of Mechanical and Aerospace Engineering, Cornell University, Ithica, United States

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