Università degli Studi di Udine

Dottorato di Ricerca in Ingegneria Energetica e Ambientale

Seminari del Corso di Dottorato

Large-eddy simulation of particle-laden flow - recovering small scales

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Abstract: The motion of small particles in turbulent conditions is influenced by the entire range of length- and time-scales of the flow. At high Reynolds numbers this range of scales is too broad for direct numerical simulation (DNS). Such flows can only be approached using large-eddy simulation (LES), which requires the introduction of a sub-filter model for the momentum dynamics. Likewise, for the particle motion the effect of sub-filter scales needs to be reconstructed approximately, as there is no explicit access to turbulent sub-filter scales. To recover the dynamic consequences of the unresolved scales, partial reconstruction through approximate deconvolution of the LES-filter is combined with explicit stochastic forcing in the equations of motion of the particles. We first analyze DNS of high-Reynolds turbulent channel flow to a priori extract the ideal forcing that should be added to retain correct statistical properties of the dispersed particle phase in LES. The probability density function of the velocity differences that need to be included in the particle equations and their temporal correlation display a striking and simple structure with little dependence on Reynolds number and particle inertia, provided the differences are normalized by their RMS, and the correlations expressed in wall units. Based on this a priori analysis a "stand-alone" stochastic forcing model for inertial particles in LES is put forward, combining the a priori DNS findings with approximately preserving the well-mixed property relevant to near-wall turbulence.

CV: Bernard Geurts holds the Chair for Multiscale Modeling and Simulation at the University of Twente and the Chair for Anisotropic Turbulence at Eindhoven University of Technology. He is scientific director of the Applied Mathematics Institute of the Universities of Technology in the Netherlands (3TU.AMI). He chairs the Scientific Program Committee of ERCOFTAC (European Research Community On Flow, Turbulence and Combustion), and leads the European COST-Action LESAID, which involves over 50 academic and industrial research groups. His PhD was devoted to the theory of dense macromolecular systems, which was defended at the University of Twente in 1989. A leading theme in his work is the modeling and analysis of interacting dynamical phenomena that are characterized by a wide range of simultaneously occurring length- and time-scales. Specific application areas include process engineering, with emphasis on energy and resources, environmental dynamics, with emphasis on transport processes and aerosol dynamics, and biophysical systems, with emphasis on bio-fluid mechanics and tissue engineering. These require an integrated multiscale approach based on `first principles' from a range of disciplines such as physics, chemistry and biology. His work combines elements of mathematical physics, high-performance computing and numerical analysis.