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Editorial

Dedication

Over more than 30 years, Tony Leonard's contributions to fluid mechanics, continuum mechanics and numerical methods have been dense and seminal. He has worked in diverse areas including vortex dynamics, vortex-based numerical methods, wall-bounded turbulence, quantized turbulence, Large–Eddy Simulation (LES), Lagrangian mixing, spectral numerical methods, bluff body flows and flow-induced vibrations. Tony's first paper on LES, "Energy Cascade in Large–Eddy Simulation of Turbulent Fluid Flows" appeared as an article in a review series, "Advances in Geophysics", in 1974. It proposed the concept of spatial filtering that has since been a cornerstone of LES. The idea of numerically simulating the evolution of large scales of turbulence while modeling the small scales was not new in the 1970s but it lacked a firm theoretical framework for the conceptual separation of the resolved or computed scales, and the subgrid or unresolved scales. Tony Leonard's 1974 introduction of the convolution operation of a field with a filter to produce the resolvable-scale function, and its application to the Navier Stokes equations of motion provided the means of identifying "resolved scales" while isolating and grouping those filtered products of subgrid fields with themselves and with resolved-scale fields, that required modeling. Tony's filter formalism has had a profound impact on the development of LES methodology and indeed is the starting point for most modern expositions on this topic. There is little doubt that his 1974 paper, which has not been published elsewhere, has become an unquantified citation classic.

Perhaps Tony Leonard's next major contribution to fluid mechanics was to develop numerical methods based on the self and mutual interaction of Lagrangian vortex filaments. Numerical vortex methods have a long history in fluid mechanics going back to Rosenhead's classic 1930s Proc. R. Soc. articles. Their appeal is, of course, that for many external fluid flows, the velocity field is extended while the vorticity remains compact. Prior to the mid 1970s, most work had been in two-spatial dimensions (2D) where there is no vortex stretching or folding. It had long been known that the Lagrangian dynamics of zero-thickness vortex filaments in three dimensions (3D) was singular. Theoretical studies by Kelvin, Moore, Saffman and others had shown how the filament–core dynamics regularizes the filament self-induced velocity, indicating that a self-consistent computational scheme for vortex filaments was likely to contain subtleties. Tony Leonard was the first to perform realistic simulations based on three-dimensional vortex filaments. Generalizing the idea of finite-area "vortex blobs" from 2D simulation work to 3D filaments with smoothed, finite vorticity, he was developed tractable algorithmic solutions of great ingenuity to the delicate limits involved in Lagrangian filament dynamics. His 3D simulations performed on the ILLIAC IV at NASA Ames included realistic simulations of aircraft trailing vortices and the development of a turbulent spot. These were a true first. His review articles; "Vortex methods for flow simulation", (J. Comp. Phys., 1980) and "Computing three-dimensional Incompressible Flows with vortex elements", (Ann. Rev. Fluid Mech., 1985) are now standard references and have stimulated much new work aimed at improving, extending and applying vortex-based numerical methods. Today, vortex methods are widely used and continue to find new applications. They have proved the ideal tool for the simulation of vortex filaments with quantized circulation in Euler superfluid dynamics and are finding novel application to the fluid dynamics of deformable bodies in the area of bio-propulsion.

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More recently Tony has been at the forefront of the application of vortex methods to bluff-body flows and in particular to flow-induced vibration (FIV), where the body, while dynamically connected to supports, is free to oscillate in a cross flow. While the traditional method has used the natural frequency of vibration to non-dimensionalize the mass, stiffness and damping of the structure, Tony has instead used flow velocity, fluid density and the cylinder diameter. This has allowed the examination of interesting limits and has led to an enhanced appreciation of the role of added mass in separated, vortical flows.

Tony's approach to fluid dynamics and the development of numerical methods has shown creativity, depth, technical mastery and above all, sound physical judgment. He stands as a true pioneer in the computational fluid sciences whose work and ideas, passed on through his students and others, has enabled a new generation of computational scientists. It is therefore fitting that on the occasion of his 70-th birthday celebration, this issue of the JCP, containing contributions that have been influenced and guided by his work, be dedicated to him.

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