Consistent wall boundary treatment for laminar and turbulent flows in SPH

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Abstract: A consistent wall boundary treatment for SPH has been developed by Ferrand *et al.* (2010) based on a renormalizing factor for writing boundary pressure forces. This factor depends on the local shape of a wall and on the position of a particle relative to the wall, which is described by segments (in 2-D), instead of the cumbersome fictitious or ghost particles used previously. By solving a dynamic equation for the renormalizing factor, the authors have significantly improved traditional wall pressure treatment in SPH.

The present paper aims to extend this method to wall friction and turbulent variables' boundary conditions, on the basis of the standard k–ε model. By using Gauss' theorem in a continuous SPH form of the fluid equations, all diffusive terms are re-written with boundary contributions. The latter are then discretized using particles (for the fluid) and segments (for the wall), leading to corrections for the strain rate and flux conditions of the kinetic energy. This method yields consistent Von Neumann wall conditions for momentum, turbulent kinetic energy and energy dissipation.

Two validations are presented: (i) a steady laminar or turbulent flow in a closed channel, where for a Reynolds number of Re = 2×10^6 the logarithmic region close to the wall is well reproduced in comparison with reference solutions, and (ii) a turbulent steady flow in a periodic fish-pass, with comparison to a validated commercial Finite-Volume code (Figure below), which gives very satisfactory results.

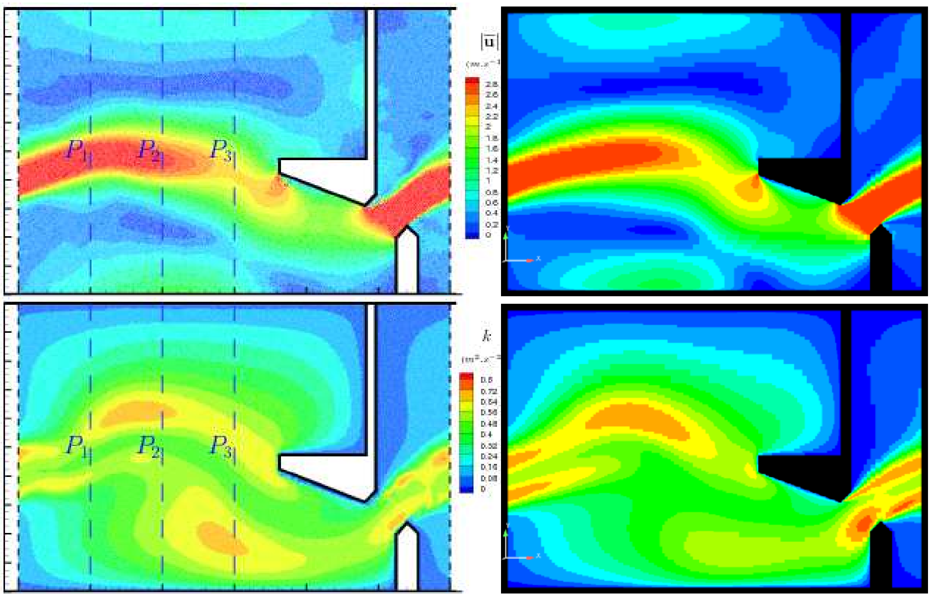

Figure 1 – Validation of consistent wall boundary condition in SPH: periodic turbulent flow in a fish pass. Comparison of SPH (left) to Finite Volumes (right). Distribution of the modulus of Reynolds-averaged velocity (top) and turbulent kinetic energy (right).

Reference:

M. Ferrand, D. Laurence, B. Rogers, D. Violeau (2010), *Improved time scheme integration approach for dealing with semi-analytical wall boundary conditions in Spartacus-2D*, Proc. 5th SPHERIC International workshop, Manchester (UK), 22-25 June 2010.