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A mixed RKPM/RBF immersed method for FSI simulations

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Simulating fluid-structure interaction still represents a challenging multiphysics application in the framework of Civil and Environmental Engineering. Techniques to couple in an efficient way the two continua have become more and more sophisticated and they all aim to find an efficient way to deal with the two different frames of reference and to avoid the need to re-mesh when the element aspect ratio has become unacceptable (e.g. large deformations).

To overcome such problems we propose a mixed RKPM / RBF immersed method in which a Lagrangian meshless solid domain moves on top of a background Eulerian fluid mesh that spans over the entire computational domain. This method is similar to the original Immersed Boundary Method introduced by C.Peskin, except that the structure has the same spatial dimension of the fluid domain and therefore the effects of the fluid-embedded bodies are summarized into a volumetric source term. The governing equations for the viscous fluid are discretized and solved on a regular, Cartesian mesh using a pseudo-spectral approach, while the solid equations are solved by means of RKPM basis functions. The use of a Reproducing Kernel Particle Method for the solid domain enables us to easily handle large deformations without the typical mesh distortion of Finite-Element-Methods while still providing sufficient accuracy in the solution.

At the moment we're validating the code by running simple-geometry, low-Reynolds DNS simulations; a further step will be including a subgrid-scale model in the fluid formulation and run simulations with turbulent flows at high-Reynolds numbers, to study the effects of flexible structures (e.g. trees, bridges, towers) on the Atmospheric Boundary Layer.