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Interaction of Shells and Membranes with Incompressible Flows

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ABSTRACT

For the dynamic behavior of lightweight structures like thin shells and membranes exposed to fluid flow the interaction between the two fields is often essential. Computational fluid-structure interaction provides a tool to predict this interaction and complement or eventually replace expensive wind tunnel experiments.

Partitioned analyses techniques enjoy great popularity for the numerical simulation of these interactions. This is due to their computational superiority over simultaneous, i.e. fully coupled monolithic approaches, as they allow the independent use of suitable discretization methods and modular analysis software. We use, for the fluid, GLS stabilized finite elements on a moving domain based on the incompressible instationary Navier-Stokes equations, where the formulation guarantees geometric conservation on the deforming domain. The structure is discretized by nonlinear, three-dimensional shell elements.

Commonly used sequential staggered coupling schemes may exhibit instabilities due to the so-called artificial added mass effect. As best remedy to this problem subiterations should be invoked to guarantee kinematic and dynamic continuity across the fluid-structure interface. Since iterative coupling algorithms are computationally very costly, their convergence rate is very decisive for their usability.

To ensure and accelerate the convergence of this iteration the updates of the interface position are relaxed. The time dependent, 'optimal' relaxation parameter is determined automatically without any user-input via exploiting a gradient method or applying an Aitken iteration scheme.

A variety of numerical examples will show the capabilities of the presented methods.

References

[1] Ramm, E., Wall, W. A.: Shell Structures - A Sensitive Interrelation between Physics and Numerics. *International Journal for Numerical Methods in Engineering* **60**, 381-427, 2004.

[2] Neumann, M., Tiyyagura, S.R., Wall, W.A., Ramm, E.: Robustness and Efficiency Aspects for Computational Fluid Structure Interaction. Proc. of the Second Russian-German Advanced Research Workshop on Computational Science and High Performance Computing, Stuttgart, Germany, March 14-16, 2005. In: *Notes on Numerical Fluid Mechanics and Multidisciplinary Design (NNFM),* Springer, 2005.

[3] Förster, Ch., Wall, W.A., Ramm, E.: On the Geometric Conservation Law in Transient Flow Calculations on Deforming Domains. *Int. J. Num. Meth. Fluids*, 2005 (accepted).