IWH Symposium

Simulation and Optimization of Extreme Fluids

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I. Lasiecka: Global existence of solutions to 3-D fluid structure interactions with moving interfaces

- The model is a quasilinear system with parabolic-hyperbolic coupling acting on a moving boundary. One of the main features and difficulty in handling the problem is a mismatch of regularity between parabolic and hyperbolic dynamics.
- The existence and uniqueness of smooth local solutions has been established by [D. Coutand, S. Shkoller: "The Interaction Between Quasilinear Elastodynamics and the Navier-Stokes Equations.", 2005.]
- Other local wellposedness results with a decreased amount of necessary smoothness have been proved in a series of papers by I. Kukavica, A. Tuffaha and M. Ziane.
- The main contribution of the present paper is global existence of smooth solutions. This is accomplished by exploiting natural viscous damping occurring in the model.
- The mismatch of regularity between hyperbolocity and parabolicity is handled be exploiting recently established sharp regularity of the "Dirichlet-Neuman" map for hyperbolic solvers along with maximal parabolic regularity available for Stokes operators.

Ignatowa, Kukavica, Lasiecka, Tuffaha: On well-posedness and small data global existence for an interface damped free boundary fluid-structure model. Nonlinearity, 2014.

Lasiecka, Ignatowa, Kukavica, Tuffaha: On well-posedness for a free boundary fluid-structure model, Journal of Mathematical Physics, 2013.

Lasiecka, Lu: Stabilization of a fluid structure interaction with nonlinear damping, Control and Cybernetics, 2013.

M. Braack: Outflow conditions for the Navier-Stokes equations with convective and skew-symmetric formulations of the convective term

- Classical do-nothing condition for the Navier-Stokes equations - not even existence of weak solutions can be shown. The reason is that this boundary condition does not exhibit any control about inflow across such boundaries.
- We address such modifications in the context of the convective formulation and of the skew-symmetric formulation of the convection. The resulting formulations ensure existence of weak solutions and, in the case of small data, uniqueness as well.

☞ The DDN (directional do-nothing) boundary condition

$$\nu[\nabla \mathbf{v}]\mathbf{n} - p\mathbf{n} - \frac{1+\beta}{2}(\mathbf{v}\cdot\mathbf{n})_{-}\mathbf{v} = 0 \tag{1}$$

Braack, Mucha: Directional Do-Nothing Condition for the Navier-Stokes Equations. Journal of Computational Mathematics, 2014.

Fabrie, Boyer, F.: Outflow boundary conditions for the incompressible non-homogeneous Navier-Stokes equations. Discrete and Continuous Dynamical Systems - Series B, 2007.

Bruneau, Fabrie: New efficient boundary conditions for incompressible Navier-Stokes equations: a well-posedness result. RAIRO Modélisation Mathématique et Analyse Numérique, 1996.

M. Olshanskii Numerical visco-plastic free-surface flows with application to natural hazards impact prediction

- An approach for numerical simulation of free surface flows of visco-plastic incompressible fluids in a non-simplified full 3D setting: dynamically adapted Cartesian grids, a splitting technique for numerical time integration.
- Several open problems in mathematical and numerical analysis of equations governing free surface flows of visco-plastic fluids.

`http://www.math.uh.edu/~molshan/viscoplastic.html`

Danilov, Nikitin, Olshanskii, Terekhov, Vassilevski, A unified approach for computing tsunami, waves, floods, and landslides, in Numerical Mathematics and Advanced Applications, 2014.

Nikitin, Olshanskii, Terekhov, Vassilevski, A numerical method for the simulation of free surface flows of visco-plastic fluid in 3D, J. Computational Mathematics, 2011.

Nikitin, Olshanskii, Terekhov, Vassilevski, A CFD approach to the 3D modelling of large-scale hydrodynamic events and disasters, Rus. J. Num. Anal. Math. Model., 2012.

J. Jansson: Automated adaptive computational modeling of high Reynolds number turbulent flow and fluid-structure interaction with contact in the FEniCS-HPC framework

- High Reynolds number turbulent flow
- Turbulent fluid-structure interaction (FSI) with contact
- General duality-based adaptive error control for multiphysics problems

Jansson, Hoffman, Spuhler, Degirmenci. Automated error control in finite element methods with applications in fluid flow. Technical Report KTH-CTL, Computational Technology Laboratory, 2013.

EUNISON EU FP7 project. http://eunison.eu, 2013.

A. Linke: On the Role of the Helmholtz Decomposition in Incompressible Flows and a New Variational Crime

- the irrotational parts of the momentum balance equations of the incompressible Navier-Stokes equations are balanced by the pressure gradient
- nearly all mixed methods for incompressible flows violate this fundamental property $\rightarrow$ nearly all mixed methods for incompressible flows violate this fundamental property
- problem is the lack of L2-orthogonality between discretely divergence-free velocities and irrotational vector fields in FE mixed methods
- perform H(div)-conforming velocity reconstructions

Linke, A., 2014. On the role of the Helmholtz decomposition in mixed methods for incompressible flows and a new variational crime. Comput. Methods Appl. Mech. Engrg., 268, pp.782–800.

Galvin, K.J. et al., 2012. Stabilizing poor mass conservation in incompressible flow problems with large irrotational forcing and application to thermal convection. Computer Methods in Applied Mechanics and Engineering, 237–240(0), pp.166–176.

Linke, A., Matthies, H.G. , Tobiska, L., 2014. Robust arbitrary order mixed finite element methods for the incompressible Stokes equations. pp.1–22.

V. John On the simulation of mantle convection

A. Caiazzo, T. Iliescu, V. John, S. Schyschlowa A Numerical Investigation of Velocity-Pressure Reduced Order Models for Incompressible Flows, J. Comput. Phys. 259, 598 - 616 , 2014

M. Picasso Numerical simulation of viscoelastic flows with free surfaces

Bonito, A., Picasso, M. , Laso, M., 2006. Numerical simulation of 3D viscoelastic flows with free surfaces. Journal of Computational Physics, 215(2), pp.691–716.

L. Tobiska ALE-FEM for incompressible flows with surfactants

S. Ganesan, L. Tobiska, Arbitrary Lagrangian-Eulerian finite element method for computation of two-phase flows with soluble surfactants. J. Comp. Physics 231(2012), 3685-3702