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A modified Navier-Stokes model: Validation cases and a convergent numerical scheme

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I will briefly review the physical reasons why the standard compressible Navier-Stokes system needs a revision. In short, it is the analogy with solids used in the derivation of the Navier-Stokes equations that leads to some shortcomings. If viewed as a gas, whose molecules have a random velocity component, another parabolic regularization is obtained, [1]. For this new system, I will present a suite of validation cases ([2]) that demonstrate that it is at least as accurate as the standard system.

To obtain truly predictive numerical tools that do not randomly fail or produce erroneous solutions, provably convergent schemes are absolutely essential and such schemes can not be designed unless sufficiently strong well-posedness results are available. To date, there are none for the standard Navier-Stokes system and this severely hampers the design of numerical schemes. (See e.g. [3] for a description of problems with state-of-the-art entropy consistent schemes.)

The situation for the modified system is significantly better: There exist weak solutions for large data and no a priori assumptions on the solution are required ([4]). I will discuss what a priori bounds that approximate solutions must satisfy and I will present the particular finite volume scheme for which convergence to weak solutions can be proven. This, practically useful and convergent, finite volume scheme constitutes a quantum leap towards reliable predictions for compressible flows.

REFERENCES

[1] M. Svärd. A new Eulerian model for viscous and heat conducting compressible flows. *Physica A*, 506:350–375, 2018.

[2] Vít Dolejší and Magnus Svärd. Numerical study of two models for viscous compressible fluid flows. *J. Comp. Phys*, 427:110068, 2021.

[3] G.J. Gassner, M. Svärd, and F.J. Hindenlang. Stability issues of entropy-stable and/or split-form high-order schemes. *to appear in Journal of Scientific computing*, 2021.

[4] M. Svärd. Analysis of an alternative Navier-Stokes system: Weak entropy solutions and a convergent numerical scheme. Technical report, ResearchGate, 2021. Preprint: DOI: 10.13140/RG.2.2.16184.47366.