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GENERALIZED NAVIER-STOKES MODEL WITH VISCOUS STRENGTH

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In the laminar mode interactions among molecules generate friction between layers of water that slide with respect to each other. This friction triggers the shear stress, which is traditionally presumed to be linearly proportional to the velocity gradient. The proportionality coefficient characterizes the viscosity of water. Remarkably, the standard Navier-Stokes model surmises that materials never fail – the transition to turbulence can only be triggered by some kinematic instability of the flow. This premise is probably the reason why the Navier-Stokes theory fails to explain the so-called subcritical transition to turbulence with the help of the linear instability analysis. When linear instability analysis fails, nonlinear instability analysis can be resorted to, but, despite the occasional uses of this approach, it is intrinsically biased to require finite flow perturbations which do not necessarily exist.

In the present work [1] we relax the traditional restriction on the perfectly intact material and introduce the parameter of *fluid viscous strength*, which enforces the breakdown of internal friction. We develop a generalized Navier-Stokes constitutive model which unites two modes of the Newtonian flow: inviscid ideal and linearly viscous. We use the new model to analyze the Couette flow between two parallel plates to find that the lateral infinitesimal perturbations can destabilize the laminar flow. Furthermore, we use the results of the recent experiments on the onset of turbulence in pipe flow to calibrate the viscous strength of water. Specifically, we find that the maximal shear stress that water can sustain in the laminar flow is about one Pascal. We note also that the introduction of the fluid strength suppresses pathological stress singularities typical of the traditional Navier-Stokes theory and uncovers new prospects in the explanation of the remarkable phenomenon of the delay of the transition to turbulence due to an addition of a small amount of long polymer molecules to water.

REFERENCES

[1] K. Volokh, Navier-Stokes model with viscous strength. *Computer Modeling in Engineering & Sciences* 92:87-101., Vol. **92**, pp. 87–101, 2013.