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Comparison of continuous and discontinuous discretizations for the Stokes flow

Ragnar Lehmann (1,2), Boris J.P. Kaus (1,2), Maria Lukáčová-Medvid'ová (2,3)

(1) Institute of Geosciences, University of Mainz, Germany, (2) Center of Computational Sciences, University of Mainz, Germany, (3) Institute of Mathematics, University of Mainz, Germany

Finite element methods (FEM) of various types are widely used to solve incompressible flow problems in general and Stokes flow in particular. We present first results of a study comparing two numerical methods: the continuous Galerkin and the discontinuous Galerkin (DG) method. For this purpose a Matlab code was developed employing 2D Stokes flow in a model setup with known analytical solution. [2]
Nonlinearities of, e.g., the viscosity can lead to discontinuities in the velocity-pressure solution. Hence, using continuous approximations may result in avoidable inaccuracies. In contrast to the FEM, the DG method allows for discontinuities of velocity and pressure across interior mesh edges. This increases the number of degrees of freedom by a constant factor depending on the chosen element. A parameter is introduced to penalize the jumps in the velocity. The DG method provides the capability to locally adapt the polynomial degree of the shape functions. Moreover, it only needs communication between directly adjacent mesh cells, which makes it highly flexible and easy to parallelize.
The velocity and pressure errors of the methods are measured in the L1-norm [1]. Orders of convergence are determined and compared.

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[2] Zhong, S., 1996. Analytic solution for Stokes' flow with lateral variations in viscosity, Geophys. J. Int., 124, 18–128, doi:10.1111/j.1365-246X.1996.tb06349.x.