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Preconditioned Solenoidal Basis Method for Saddle-Point Problems

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Saddle-point systems arise in a number of applications where conservation laws are enforced through discrete linear constraints. For incompressible fluids, a divergence-free constraint forces the fluid velocity to lie in the null space of a constraint matrix. This talk describes the solenoidal basis method for solving saddle-point problems. The solenoidal basis method is a projection technique that uses a discrete divergence-free basis to satisfy the linear constraints. A reduced system in the projected space is solved by an iterative method. The main challenges in this approach include construction of the discrete solenoidal basis and preconditioning the reduced system. In this talk, we present algebraic schemes to construct sparse and dense bases for the null space of the constraint matrix. These bases can be used to represent the discrete divergence-free subspace. We also outline preconditioning techniques for the reduced system and discuss the performance of the preconditioned solenoidal method.