Augmented Lagrangian preconditioning for fluids: theory and practice

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Augmented Lagrangian preconditioning for fluids problems was introduced by Benzi and Olshanskii in 2006. The approach offers excellent, parameter-robust, control of the Schur complement approximation. The drawback is that the preconditioning scheme for the top-left block is significantly more complicated, and at the time, an extension to three dimensions was not known.

In recent years, there has been significant progress in this area, guided by a deeper understanding of how to construct appropriate preconditioners, and software advances that ease implementation.

The core idea in the design of effective preconditioners for the top left block is characterising a basis for the kernel of the augmented Lagrangian term. Structure preserving discretisations offer a systematic way to attack this problem when the augmentation is a differential operator. The resulting robust multigrid methods require small block overlapping additive Schwarz smoothers.

In this talk I will discuss the general augmented Lagrangian approach, discuss a flexible preconditioning package that provides fast implementation of optimal methods, and illustrate with some examples covering stationary Navier–Stokes and MHD, along with time-dependent problems.