

SAMG-Coupled

The solver for systems of PDEs

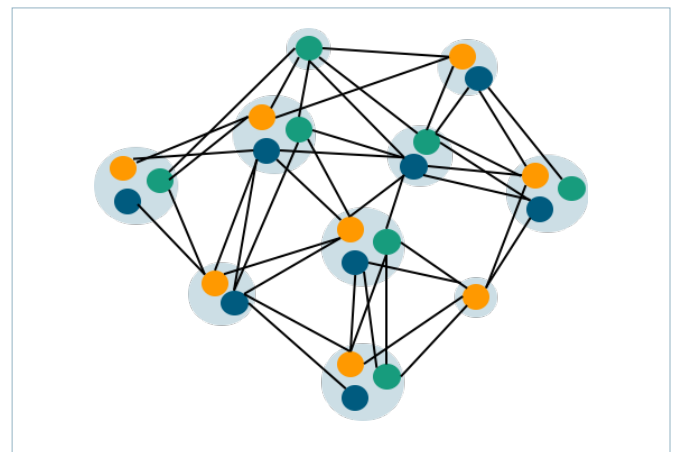
Different, coupled physical unknowns

The modelling and simulation of physical processes may involve different types of unknowns that depend on each other. For example, pressure, velocity, temperature or displacements. Such systems of partial differential equations (PDEs) lead to challenging linear systems where the application of established linear solver methods is not straightforward.

SAMG-Coupled is aware of the physical background of such coupled systems. It constructs solver setups and AMG hierarchies tailored to the underlying problems: They reflect the coupled nature of the problems throughout the solution process. Couplings within an unknown as well as cross-couplings between different physical unknowns are clearly distinguished in all stages of the linear solver. This is the key to provide an efficient and robust linear solver approach.

$$\begin{pmatrix} A_{11} & A_{12} & A_{13} \\ A_{21} & A_{22} & A_{23} \\ A_{31} & A_{32} & A_{33} \end{pmatrix} \cdot \begin{pmatrix} u_1 \\ u_2 \\ u_3 \end{pmatrix} = \begin{pmatrix} f_1 \\ f_2 \\ f_3 \end{pmatrix}$$

Linear system resulting from a system of PDEs



Visualization of a matrix coupling structure regarding different types of physical unknowns

Only minimal additional information needed

SAMG-Coupled still works purely algebraically: only the linear system of equations needs to be provided, no geometric information are necessary.

Therefore, SAMG-Coupled is well-suited as a linear solver for complicated domains and unstructured meshes.

However, to properly reflect the coupled nature of the problem, SAMG-Coupled requires some basic affiliation information between physical unknowns and matrix rows. This trivial information is typically available anyway in a simulator.

Further information, such as grid coordinates, may be provided to further enhance the solver's applicability. This is not mandatory for typical applications, though.

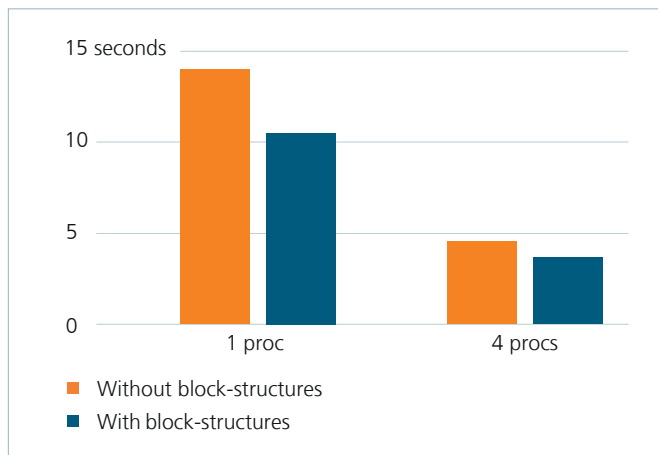


SAMG-Coupled transfers the mathematical power of AMG to challenging coupled systems of PDEs."

Exploiting block-structures

SAMG-Coupled is based on well-established and standardized scalar data formats. Yet, the coupled system information allow to identify block information and group together closely related parts of the linear system.

This can be exploited to optimize the internal operations of SAMG-Coupled. The result is a performance improvement with no compromises regarding the numerical robustness.



Performance of SAMG-Coupled with a three-dimensional linear elasticity problem w/ 200k DOFs

In addition, the block- and unknown information allow SAMG-Coupled to apply preparational and scaling steps to the linear system. There are constellations where an appropriate application of such steps can drastically improve the applicability of multigrid solver approaches: Again, the underlying physics are exploited, and the linear solver is tailored to the particular application.



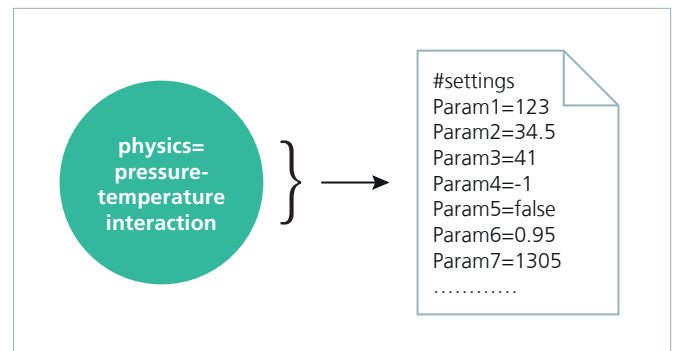
Exemplary structure of unknown couplings



Pre-defined solver profiles based on physics

Challenging linear systems require sophisticated linear solver approaches and the appropriate setting of different fine-grained control parameters. However, the reason for almost all these settings originates in the underlying physics and what these induce for the structure of the linear system.

Thus, SAMG-Coupled allows for rather setting general physical information. This mechanism is provided for more and more combinations of types of unknowns. This background information is naturally available in simulators, allowing SAMG-Coupled to adjust its default solver settings to the applications.



SAMG-Coupled translates the physical properties into SAMG parameters.

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