**Stage Master 2 on Multilevel Robust Preconditioners**
**Part of ERC Synergy project EMC²**

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*Funded internship*, to start in March/April, for 5/6 months. Can be pursued with a PhD.

*Context:*
The most time consuming step in a numerical simulation requires solving a linear system of equations of very large size. There are two main challenges that we need to address when designing linear solvers for large scale computers. The first one aims at achieving scalability on large scale computers, while the second one aims at preserving numerical robustness to be able to solve systems arising from complex simulations involving large domains and many time steps. We will consider preconditioned Krylov subspace solvers. Getting scalability relies on reducing global synchronizations between processors, while also increasing the arithmetic intensity on one processor. Achieving robustness relies on ensuring that the condition number of the preconditioned matrix is bounded.

*Description of the project:*
Standard domain decomposition preconditioners such as block Jacobi, additive Schwarz, and restricted additive Schwarz methods are widely used and they are highly parallel. However, they are not robust, in the sense that the number of iterations required for convergence increases drastically when the number of processors increases. In the recent years we have developed a novel robust multilevel additive Schwarz preconditioner [1], where at each level the condition number is bounded, ensuring a fast convergence for each nested solver. It is based on a hierarchy of robust coarse spaces that are able to transfer spectral information from one level to the next. In this internship we will focus on other types of matrices and we will aim at designing similar techniques that allow to develop robust coarse spaces for such kind of matrices. We will in particular study the usage of randomized methods in this context. We will investigate the methods developed on several numerical simulations in collaboration with scientists from these application domains.

[1] H. Al Daas, L. Grigori, P. Jolivet, P. H. Tournier, *A multilevel Schwarz preconditioner based on a hierarchy of robust coarse spaces*, SIAM Journal on Scientific Computing, Vol 43(3), pages 1907 - 1923, 2021.