ONERA

Office National d'Études et de Recherches Aérospatiales - BP 72 - 92322 Châtillon CEDEX

## PROPOSITION DE STAGE

## TITRE : Time space parallel solvers

Laboratoire d'accueil à l'ONERA :
Branche : TIS
Département : DTIM
Unité : CHP
Location (centre ONERA) : Châtillon
Duration = 6 mois
Renumeration = 560 E/month

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## SUMMARY :

Subdomain methods are very effective to solve static problems in structure mechanics on parallel calculators with distributed memory.
For evolution problems, several solutions are possible [1]. The first consists in using a parallel solver to solve the equations in space at each time step of an implicit time scheme. The second approach consists in coupling subdomains not at each time step but simultaneously for all time steps. In this case, the most effective transmission conditions between subdomains are based on mixed type conditions. A third approach, a multigrid type scheme in time , known as "parareal" consists in independent integrations on sub time intervals after a prediction phase based on a time scheme with a coarse time step equal to the length of these subtime intervals. The coarse time scheme may be different from the fine time discretization scheme. A last recent approach of Maday and Ronquist [2] uses a tensorisation of the space time domain which generates a set of independent problems each having the complexity of a simple stationary problem.

The object of the master thesis will be to compare these methods on the unsteady 1D heat equation.

This master thesis can be followed by a thesis, as the study of such methods combining the various approaches of time space decomposition to be computed on massively parallel calculators is essential for industrial applications in aeroelasticity and vibroacoustics.

[1] *High Performance computing :Domain Decomposition and Multigrid algorithms*. Cours de L. Halpern http://www.math.univ-paris13.fr/~halpern/teaching/macs3.html
[2] *Parallelization in time through tensor product space-time solvers* ,Yvon Maday, Einar

M. Ronquist, C.R. Acad. Sci, Paris Ser. I (2007)

**PREREQUISITES**

**Studies : MASTER Numerical analysis**
**Interest in parallel computing**

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## PROPOSITION DE STAGE

## TITRE : Space Time Discontinuous Galerkin Diffusive flux computation

Laboratoire d'accueil à l'ONERA :
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## SUMMARY :

The Space Time discontinuous Finite Element Galerkin formulation generates high precision schemes well adapted to hyperbolic problems . But this functional space is much less immediately adaptable for diffusion terms. Bassi and Rebay[1] introduced a supplementary equation on the gradient of conservative variables to be solved in the same functional space. The diffusive flux is then computed as the convective flux.
In 2005 [2], Van Leer proposed a recovery technique where the discontinuous solution approximation is locally regarded as an L2 projection of a higher-order continuous function. This local "recovered" function couples neighboring cells and provides the information to compute the diffusive fluxes at their interface.
The aim of this master thesis will be to compare these two methods in terms of precision and cost.

[1] *A High-Order Accurate Discontinuous Finite Element Method for the Numerical Solution of the Compressible Navier–Stokes Equations* F. Bassi and S. Rebay
Journal of Computational Physics 131, 267–279 (1997)
[2] *Discontinuous Galerkin for Diffusion*, Bram van Leer and Shohei Nomura, AIAA paper, 2005-5108, 2005.

### PREREQUISITES

**Studies : MASTER Numerical analysis**
**Interest in numerical schemes and fluid mechanics.**