THE HALFSPACE MATCHING METHOD : A NEW METHOD TO SOLVE SCATTERING PROBLEM IN COMPLEX MEDIA

SONIA FLISS

Abstract. This is a joint work with Anne-Sophie Bonnet-Ben Dhia (POEMS), Patrick Joly (POEMS), Yohanes Tjandrawidjaja (POEMS), Antoine Tonnoir (Université de Rouen.)

We are interested in the scattering of time-harmonic waves in infinite complex media. The complexity of the media comes from the nature of the equations (Maxwell's or elasticity equations), its physical characteristics (periodic or anisotropic coefficients) and/or even its geometry (infinite 2D or 3D media or 3D plates). Solving time harmonic scalar waves equations in infinite homogeneous media is an old topic [1] and there exist several methods. They are all based on the natural idea of reducing the pure numerical computations to a bounded domain containing the perturbations (achieved using for instance Finite Element methods), coupled with, for example, integral equation techniques, transparent boundary conditions involving Dirichlet-to-Neumann operators or the PML techniques. However it seems that all these methods either do not extend to complex media or do extend but with a tremendous computational cost.

By contrast, our method is based on a simple and quite general idea: the solution of halfspace problems can be expressed thanks to its trace on the edge of the half-space, via the Fourier transform in the *transverse direction* in the homogeneous case or via the Floquet-Bloch Transform in the periodic case. The idea in 2D is then to split the whole domain into five parts:

- a square that includes the defect (and all the inhomogeneities) in which we will use a Finite Elements representation of the solution,
- and 4 half-spaces, parallel to the four edges of the square in which the medium is "not-perturbed", i.e. homogeneous or periodic.

We have then to couple the several integral representations of the solution in the half-spaces with a Finite Element (FE) computation of the solution in the square. By ensuring that all these representations match in the intersections, we end up with a system of equations coupling the traces of the solution on the edges of the half-spaces with the restriction of the solution in the square. In the case of a dissipative medium, the continuous formulation is proved to be coercive plus compact, and the convergence of the discretization is ensured [2, 3].

In this presentation, we present the method and its analysis on a toy problem and we will explain how it extends to more complex situations.

References

[1] D. Givoli. Numerical methods for problems in infinite domains. Vol. 33. *Elsevier*, 2013.

[2] A. S. Bonnet-Ben Dhia, S. Fliss and A. Tonnoir. The halfspace matching method: A new method to solve scattering problems in infinite media. *Journal of Computational and Applied Mathematics*, 338, 44-68, 2018.

[3] A. S. Bonnet-Ben Dhia, S. Fliss and Y. Tjandrawidjaja. Numerical analysis of the Half-Space Matching method with Robin traces on a convex polygonal scatterer. *hal-01793511*, 2018.

POEMS, UMR 7231 ENSTA-CNRS-INRIA
E-mail address: sonia.fliss@ensta-paristech.fr