Diffraction by a rough thin layer on an arbitrary shaped object: the periodic and random cases

Pierre BOULOGNE, CEA-CESTA - Le Barp **Sonia FLISS**, POEMS - Palaiseau
Laure GIOVANGIGLI, POEMS - Palaiseau
Justine LABAT, CEA-CESTA - Le Barp

We are interested in the time-harmonic scattering by a bounded regular object coated with a thin rough layer. Although this problem can be solved numerically, computational costs become prohibitive when the layer's thickness is small compared to the object's characteristic size and the incident wavelength. However, this scale separation can be exploited to derive effective models that avoid meshing the thin layer.
Effective models for arbitrary objects coated by thin layers of constant thickness on one hand or for planes coated by rough thin layers on the other hand are well established in the literature. By contrast, objects of arbitrary shape coated by rough layers require additional tools. Such models can be derived when the roughness (i.e. the surface variations of the layer) is of the same order as the layer's thickness and is either periodic or random and stationary ergodic.
Assuming a two-dimensional setting governed by the Helmholtz equation, we derive homogenized models of any order for the periodic case and of order 1 and 2 for the random case. The derivation relies on a multi-scale asymptotic method that yields correctors defined on a "cell" and effective solutions, that depend on the roughness properties and on the geometry of the object. The correctors capture the near-field behavior of the solution, while the effective solutions satisfy an equivalent boundary condition around the object, providing accurate approximations of the far-field behaviour. We establish quantitative error estimate between the true solution and the effective models at different orders. Numerical simulations for a range of geometries and coatings validate the theoretical convergence rates.

Contact : pierre.boulogne@ensta.fr