



**HAL**  
open science

## Low-high frequency inspection of composite multi-layers and MUSIC-type electromagnetic imaging

Giacomo Rodeghiero, Ping-Ping Ding, Yu Zhong, Marc Lambert, Dominique  
Lesselier

► **To cite this version:**

Giacomo Rodeghiero, Ping-Ping Ding, Yu Zhong, Marc Lambert, Dominique Lesselier. Low-high frequency inspection of composite multi-layers and MUSIC-type electromagnetic imaging. IPTA 2014, Aug 2014, Bristol, United Kingdom. hal-01101693

**HAL Id: hal-01101693**

**<https://hal-centralesupelec.archives-ouvertes.fr/hal-01101693>**

Submitted on 9 Jan 2015

**HAL** is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

# Low-high frequency inspection of composite multi-layers and MUSIC-type electromagnetic imaging

Giacomo RODEGHIERO<sup>1\*</sup>, Ping-Ping DING<sup>1</sup>, Yu ZHONG<sup>2</sup>, Marc LAMBERT<sup>1</sup>, and  
Dominique LESSELIER<sup>1</sup>

<sup>1</sup> Département de Recherche en Electromagnétisme – Laboratoire des Signaux et Systèmes  
UMR8506 CNRS-SUPELEC-Univ. Paris Sud, 3 rue Joliot-Curie, 91192 Gif-sur-Yvette, France

<sup>2</sup> A\*STAR, Institution of High Performance Computing, 138632 Singapore

## Abstract

Non Destructive Testing-Evaluation (NdT-E) of complex multi-layer composite panels for problems of quality, viability, safety and availability of complex systems involving manufactured parts (in aeronautics and in automotive industry, as a good example) is becoming an interesting and challenging task nowadays.

From eddy-currents to microwaves, there is the need to make available modeling and imaging procedures that will be robust, fast, accurate and useful to potential end-users: this requires a sound description of the panels. At a first level of modeling, these aforementioned panels can be considered as a succession of planar slabs which are laying one over the other; each slab is usually formed by a bundle of fibers, whose orientation is parallel with the interfaces and usually it is differing from one to the next. Those fibers may exhibit either electromagnetic isotropy or anisotropy: in the isotropic case, the material parameters are described by scalar space-dependent (and frequency-dependent in most cases) quantities while the anisotropic case leads to tensor quantities. From a modeling perspective at an enough large scale (compared to the local wavelength in propagative case or to the skin depth in diffusive case), the assumption leads to consider a given slab as homogeneous, i.e., its electromagnetic parameters tensor is locally averaged.

Based on [1-2], it is proposed herein a method to compute in an effective fashion the dyadic Green's functions (DGF) for such structures within the framework of contrast-source integral equations.

Damages or disorders, which those composite may suffer from, are of many kinds: voids, fluid-filled cavities, delaminations, etc., with obvious consequences on their electromagnetic and geometric parameters. That is, the task of making available to end-users some images of the possibly damaged parts. The MUSIC-type (MUltiple Signal Classification) algorithm [3] is a good candidate to find the position of small defects.

## References

[1] Y. Zhong *et al.*, "Electromagnetic response of anisotropic laminates to distributed sources", *IEEE Trans. Antennas Propag.*, **62** (2014), pp. 247-2560.

---

\* Corresponding author. E-mail address: giacomo.rodeghiero@lss.supelec.fr

- [2] G. Rodeghiero *et al.*, “Fast calculation of electromagnetic scattering in anisotropic multilayers and its inverse problem”, ENDE’2014: 19th International Workshop on Electromagnetic Nondestructive Evaluation, Xi’an, June 2014 – in preparation.
- [3] H. Ammari *et al.*, “MUSIC-type electromagnetic imaging of a collection of small three-dimensional inclusions”, *SIAM Journal of Scientific Computing* **29** (2007), pp. 674–709.