PhD in Information Technology and Electrical Engineering

Università degli Studi di Napoli Federico II

PhD Student: Giovanni Gravina

XXXIV Cycle

Training and Research Activities Report – Third Year

Tutor: Prof. Carlo Forestiere

1. Information

a. Giovanni Gravina , MSc in Electronic Engineering – University of Naples Federico II
b. XXXIV Cycle- ITEE – University of Naples Federico II
c. Without fellowship - Air Force Officer at 10^{th} Aircraft Maintenance Unit (Lecce)
d. Tutor: Prof. Carlo Forestiere

2. Study and Training activities

a. Courses (credits in brackets)

"Nanotechnology for Electrical Engineering" (9)

"Introduzione ai Circuiti Quantistici" (9)

b. External Courses (credits in brackets)

27^{th} Production Test Personnel Course (Flight Experimental Center- Pratica di mare)

"Avionics" (2) (10h)

"Performance" (2) (20h)

"Propulsion" (2) (15h)

"Flying and Handling Qualities & Flight Control System" (2) (20h)

"Armament System" (2) (10h)

"Flight Test " (4) (35h)

	Credits year 3							
	1	2	3	4	5	6	7	
	bimonth	bimonth	bimonth	bimonth	bimonth	bimonth	Trimonth	**Summary**
Modules	9	9	10	0	4	0	0	**32**
Seminars	0	0	0	0	0	0	0	**0**
Research	7	7	7	7	7	7	6	**48**
	16	16	17	7	11	7	6	**80**

3. Research activity

The guiding thread of my research activity has been the development of new spectral methods for the solution of full-wave electromagnetic scattering problems. Specifically, both sub-domain and entire-domain type bases have been used and compared. During the first year, the electromagnetic modes and the resonances of homogeneous, finite size, two-dimensional bodies had been examined in the frequency domain by a rigorous full wave approach based on an integro-differential formulation of the electromagnetic scattering problem. During the second year, the research was directed to the development of a static base that could simplify the numerical solution of electromagnetic scattering problems from a given object at multiple frequencies. The general approach had been outlined: starting from the RWG sub-domain basis set, by exploiting two more sub-domain coupled sets (loop and star), the entire domain static basis had been introduced.
It is the union of two current-mode sets

- the irrotational and non-solenoidal eigenmodes of an electrostatic surface integral operator.
- the solenoidal and non-irrotational eigenmodes of a magnetostatic surface integral operator.

During my third year, the introduced approach has been fully developed and exploited to solve scattering problem. The surface currents of the Poggio-MIller-Chang-Harrington-Wu-Tsai Surface Integral Equation have been expanded in terms of the static surface modes and then solved via Galerkin-projection scheme.
The decomposition of the retarded green function into the static Green function and a proper difference has allowed the diagonalization of the integral integro-differential operator recurring.
In addition, the use of the static modes expansion combined with an appropriate rescaling and rearranging of the unknowns makes this formulation immune from the low-frequency breakdown problem, a common plague in SIE formulation.
The method has been validated by means of different scattering problems involving

- a sphere, in order to compare the solution obtained with the analytical one
- a rod, which is a shape often recurring in nano-optics contexts.

In all investigated cases, for particles of dimensions comparable to the incident wavelength, it has been proved that only a few modes are required to describe the electromagnetic scattering response.

4. Products

C. Forestiere, G. Gravina et al. “Static surface mode expansion for the full-wave scattering from penetrable objects”, IEEE Trans. Antennas Propag. (submitted), arXiv:2201.11058 (2022).