Report on the "4th International PhD School on Selected Topics in Applied Electromagnetics"

The Method of Moments:
From Basics to Large-Scale Applications

The Fourth Doctoral School on selected topics in Electromagnetics, organized by the Italian Society of Applied Electromagnetics (SIEm), was held on September 16th and 17th, 2004, in Cagliari, on the beautiful island of Sardinia. This year the chosen topic was the Method of Moments (MoM), which was presented in three half-day lectures given by Prof. Donald R. Wilton from the University of Houston, USA, an indisputed world-class expert on the MoM. The School was held in the "Cittadella dei Musei", the museum quarter located inside the *Arsenal*, in the historical *Citadel* of Cagliari. The *Arsenal* was built in 1552 under Spanish rule, but the area was inhabited also during the Phoenician-Punic and Roman Eras, as evidenced by two reservoirs. It was then transformed into the "Cittadella dei

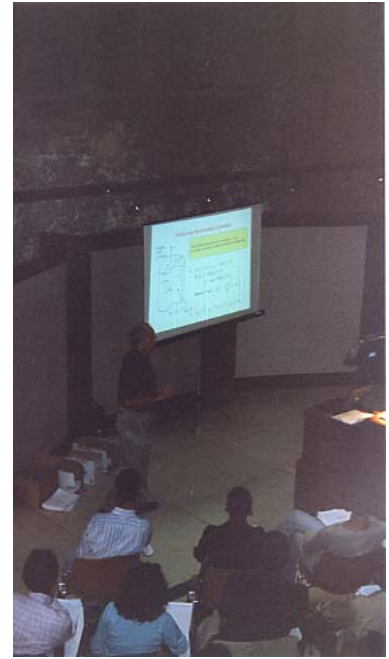*The Doric gateway, leading into the Arsenal.*

Musei" in 1979.

The event was the fourth in a series of annual international PhD schools organised and financed by SIEm. This year the school was co-financed by the Central and South Italy Section of IEEE and supported by the Antenna Center of Excellence (ACE), a Network of Excellence within the Sixth Framework Program (FP6) of the European Union. The members of the Steering Committee of the School were composed by Prof. T. Isernia (University of Naples), Prof. S. Maci (University of Siena), Prof. G. Manara (University of Pisa), Prof. R. Sorrentino (University of Perugia) and Prof. G. Vecchi (Polytechnic of Turin). The University of Cagliari

The medieval tower of San Pancrazio in the Citadel.

(Prof. G. Mazzarella) organized the school locally, in connection with the Italian National Meeting of Applied Electromagnetics (RiNEm). The ACE support was related to the Activity 3.1, Training and Education, and in particular to the Workpackage 3.1-1, namely the European School of Antennas. The school was actually intended to be a first pilot course to test the future organization and activation of short-term schools scattered all over Europe. In particular, all the costs for the PhD students coming from ACE partners were covered by the ACE budget; thus, the organization of the school has also provided a first cost estimate for student travel grants.
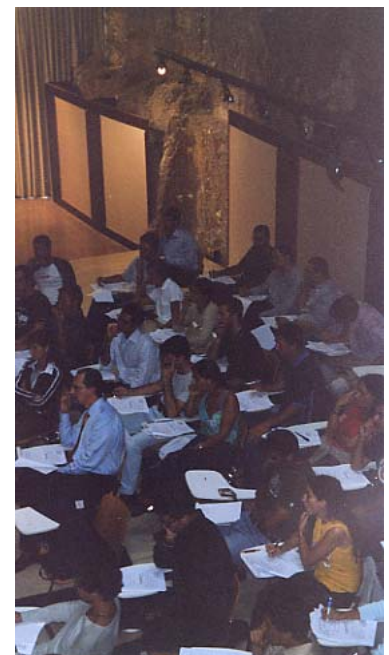
The aim of the three half-day lectures given by Prof. Wilton was to provide attendees with a working knowledge of the MoM and enough information to understand the basics of its recent extensions to large-scale problems. Here follows a brief summary of the topics covered by the lectures:

Prof. D. R. Wilton.

1. Electric, Magnetic, and Combined Field Integral Equation Formulations,

   A. Scattering by cylinders — oblique incidence (2.5-D Formulation),

   B. Formulation for 3-D scattering and integral equation solution;

2. The Helmholtz Equation,

   A. 2.5- and 3-D formulations,

   B. Mesh termination—hybrid formulations;

3. Wires and Wire-to-Surface Junctions;

4. Formulation of Aperture Problems (Planar and Non-Planar);

5. Dielectric and Piecewise Homogeneous Scatterers (PMCHWT Formulation);

6. Introduction to Fast Methods,

   A. Principles of Fast Methods,

   B. Summary of AIM, polynomial interpolation, QR matrix compression, MLFMA, and MLFDA approaches.

The lectures introduced fundamental numerical methods, emphasizing practical calculations for electromagnetic research problems. The approach proposed by Prof. Wilton to introduce the key features of the MoM started with the scattering by obliquely illuminated 2-D conducting cylinders. This approach not only builds

During a lecture.

Prof. and Mrs. Wilton with Prof. Vecchi, during the SIEm banquet on September 15th.
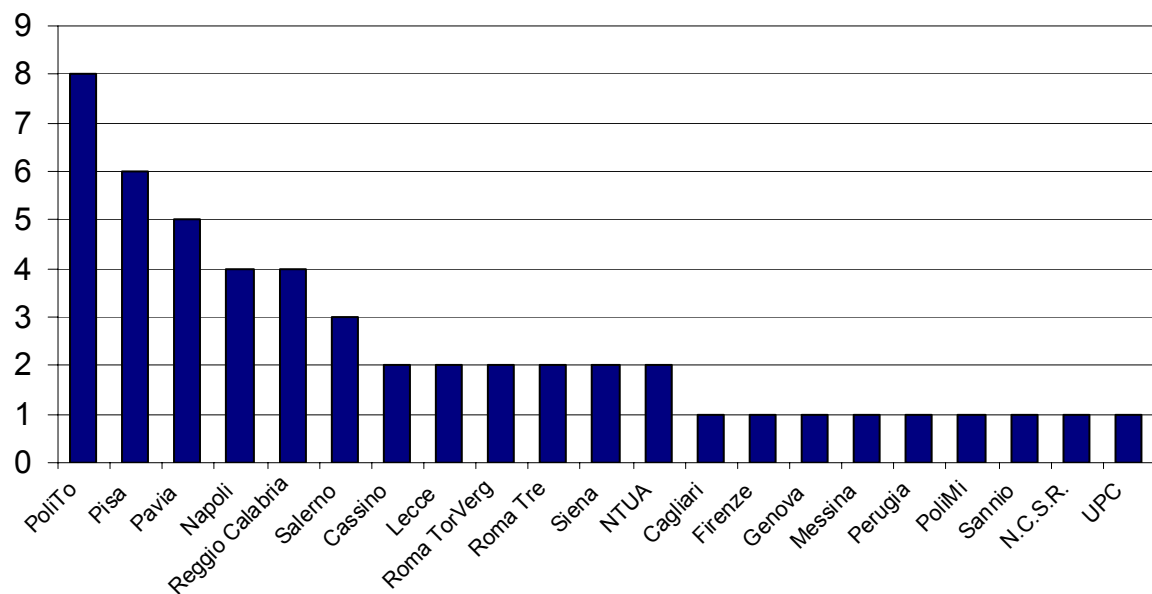
a solid foundation for introducing a 3-D integral equation analysis, but also leads to practical schemes for analyzing guided wave structures. The standard electric, magnetic, and combined field integral equations were presented and applied to 3D conducting surfaces and wire structures, planar and non-planar apertures, and piecewise-homogeneous objects.

Moreover, he presented the finite element approach for solving the Helmholtz equation. Notational consistency was maintained to emphasize both similarities and differences between moment methods and finite element formulations. Throughout the lectures, emphasis was given to the philosophy behind the construction of the global system matrix, which results by assembling the element matrix contributions: "Think globally, act locally".
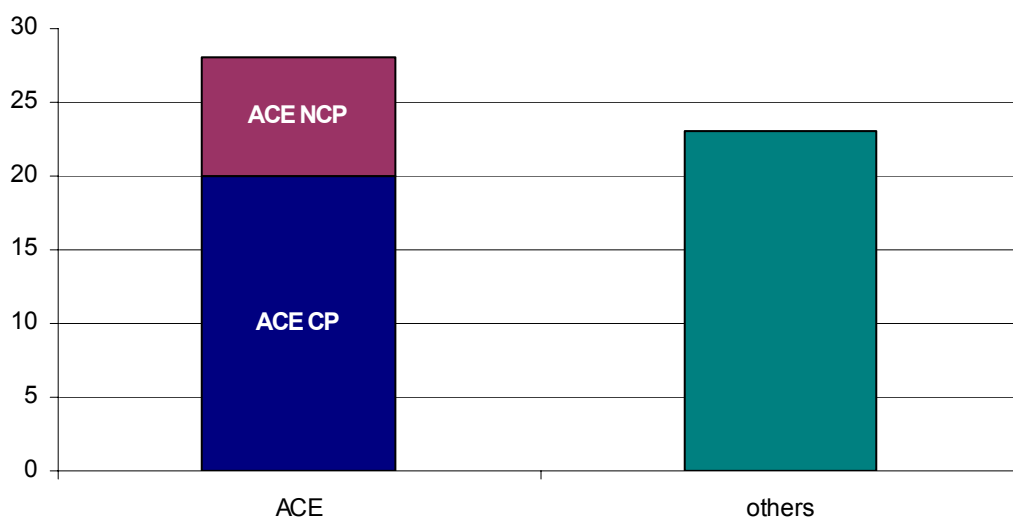
This 4th PhD course was very well attended, with more than 50 PhD students and researchers, from several European countries who actively participating in the lectures. Most of them are affiliated with ACE partner institutions, both contractual (20) and non-contractual (8), as sketched in the tables below. To this regard, it is worth noting that the 2nd Doctoral School organized by SIEm in Ancona in 2002, which was structured in three half-days like the one recently held in Sardinia, had only about half the participants (27, still a considerable number), who were all affiliated with Italian institutions.

The audience.

Number of participants per institution.

Number of participants coming from ACE partner institutions,

both contractual (CP) and non-contractual (NCP), and from non-ACE institutions.

During a break.