BIOGRAPHICAL SKETCH

Tommaso Isernia graduated (with honors) in Electronic Engineering at Università di Napoli Federico II in 1988.

After a short industrial experience at Ansaldo Trasporti, he joined the Applied Electromagnetics group of the Federico II University. In particular, he was there a PhD student (1989-1992) under the supervision of Prof. R. Pierri, and then Assistant Professor (1992-1998), and Associate Professor (1998-2003).

Since 2003 he is a Professor of Electromagnetic Fields at Università Mediterranea di Reggio Calabria, where from October 2018 to January 2023 he has been the Head of 'Dipartimento di Ingegneria dell'Informazione, delle Infrastrutture e della Energia Sostenibile' (DIIES). In December 2022 the Department has been included in the restricted list of 'Dipartimenti di eccellenza' by the Italian Ministry for research.

He founded and actually leads the 'LEMMA (Lab for ElectroMagnetics Methods and Applications) @Università Mediterranea. All research products (papers) presented by LEMMA in the last 'Valutazione della Qualità della Ricerca' (2014-2019) by the Italian Ministry for Research have been classified as 'Excellent and extremely relevant'. Notably, just three research groups in Italy (including all areas and sectors) have achieved such a 'all products in Class A' evaluation.

He is also an Associate Researcher of IREA, an Institute on the Italian Consiglio Nazionale delle Ricerche, as well as of INFN (Istituto Nazionale di Fisica Nucleare).

The activities of Tommaso Isernia have considered the theoretical, algorithmic and experimental aspects of the problems dealt with, with particular reference to the problem of the possible occurrence of false solutions when solving the considered non-linear problems. The interest of the scientific activities of Tommaso Isernia, who is a Fellow of the IEEE since 2022, is witnessed by over 150 publications on scientific peer reviewed (and well reputed) journals, and by an h-index equal to 44 (Scopus, January 2023). He has been the coordinator or scientific responsible of several research projects financed by Regione Campania, Italian Ministry of research, the European Defence Agency, and the European Space Agency.

Full Professor of Electromagnetics since 2005, he has been the Dean of the studies in Ingegneria dell'Informazione at Università Mediterranea di Reggio Calabria, where he also served as an elected member of 'Consiglio di Amministrazione' of the whole University. He has also been an elected member (from 2014 to 2019) of the Board of Administrators of CNIT (the Italian Universities Consortium for Telecommunications, which joins 37 Italian Universities active in Telecommunications and Electromagnetics), as well as the Coordinator of the PhD studies in 'Ingegneria dell'Informazione' (XXXI, XXXII, XXXIII and XXXIV cycles) at Università Mediterranea. He also has served in 'Senato Accademico' of Università Mediterranea.

As a young researcher, he was the recipient of the 'Barzilai Award' of the Italian Electromagnetics Society (SIEM) in 1994. Later, several his PhD students have been also awarded with the same recognition (Crocco and D'Urso 2004, Morabito and Laganà 2012, Bevacqua and Scapaticci 2014, Palmeri 2022) as well as with other IEEE or CNIT or SIEM recognitions. He has been the advisor or co-advisor of roughly 15 PhD students.

A BRIEF SYNOPSIS OF SCIENTIFIC ACTIVITIES

The scientific activities of Tommaso Isernia have been mainly concerned with the solution of non-linear inverse problems in applied electromagnetics, with particular reference to:

i. the analysis of the properties and representations of e.m. fields radiated or scattered from objects of known dimensions, and their impact on antennas measurement and synthesis and on inverse scattering problems;

In such a framework, the main achieved results include:

- the demonstration that the radiation operator is compact, so that fields radiated from finite dimension finite energy sources can ALWAYS be represented within any approximation error by a finite number of parameters [PhD Thesis, 1991]. Such a result allowed to correct a previous theory on the effective representation of radiated fields, leading at the end at the concept of 'reduced radiated field' (and inherent sampling representations) by O.M. Bucci and co-workers ;

- an evaluation, with O.M. Bucci, of the actual amount of information which is available in (2D) inverse scattering problems, and the corresponding limitations on the amount (and kind) of information which one can hopefully retrieve [19] ;
- an evaluation of the information one can hopefully achieve in inverse scattering problems when using near proximity sources and probes [22];
- a derivation of the properties of the fields radiating from the so called 'Orbital Angular Momentum' antennas (or vortex antennas), including the degrees of freedom of the field associated to each vortex. Notably, the discussion allows to understand the (often overlooked) limitations of such a kind of sources [119].

ii. *Phase retrieval of radiated fields from phaseless measurements, with application to diagnostics of antennas, laser sources, SAR imaging, as well as to lensless optical microscopy.*

In such a framework, he has introduced three new effective solution approaches.

- In the first one, developed with R. Pierri and G. Leone, the problem is conveniently formulated as the inversion of a quadratic operator. Notably, the approach allows some analysis of the inherent 'false solutions' problems, and gives useful rules on the number of independent data which is needed as well as guidelines and procedures in order to overcome such a problem [PhD Thesis], [23], [14] ;
  Such a first approach has been successfully exploited in very many different applications;
- In the second, more recent one, [100], [131] the problem is reduced to the constrained maximization of a functional. Also in this case the approach, resulting in two alternative procedures, is able to understand and tackle in an effective fashion the so called 'false solution' problem.
- In the third and very recent approach 2D phase retrieval problems are solved by means of a surprising and useful analogy with 'cross-words' problems. In fact, it exploits deterministic tools available for 1D problems, and congruence arguments. Note the approach allows to reduce to the minimum the amount of data, which can be as low as the one guaranteeing theoretical uniqueness. Also note the approach is able to track the different solutions in case the solution is not unique [143,149]. The more recent result (in [I]) overcomes the computational complexity of previous approaches [143,149] by a suitable choice and organization of the intersecting curves.

Additional activities on such a topic involve the exploitation of compressive sensing techniques for array antenna diagnostics by a small number of phaseless measurements [105], [121], including the near field case [II].

iii. *Antenna power pattern synthesis problems, with reference to the optimal synthesis of both pencil and shaped beams*

In such a framework, the activities of Tommaso Isernia have been mainly concerned with 'optimal' synthesis, i.e. the finding of the solution optimizing performances for given dimensions (or number of elements), or viceversa the minimization of dimensions (or number of elements) for given performances. In particular, he has given some relevant contributions for a number of canonical problems. In detail :

- He has been the first to show [Conference paper Riunione Nazionale di Elettromagnetismo 1996] that in case of (whatever) fixed geometry arrays, the optimal synthesis of pencil beams subject to arbitrary sidelobe constraints can be formulated as a Convex Programming problem. The approach was originally published in the international literature as a letter in [20], and then refined in [24] and [31]. Then, the same kind of results has been demonstrated for (non superdirective) continuous sources [59] as well as to the case of difference patterns [26], and to the case of the optimal compromise amongst sum and difference patterns ;

- He has been the first to show [at Riunione Nazionale di Elettromagnetismo 1994] that in case of linear equispaced arrays the optimal synthesis of shaped beams subject to arbitrary lower and upper bounds can be conveniently formulated as the solution of a linear programming problem followed by the factorization of a polynomial [21]. Notably, the approach is able to find a multiplicity of solutions to the given problem. By further developments it has been shown that the same kind of approach and results can be fruitfully applied to the case of 1-D continuous sources, to the case of even sources [28],

as well as to the case of circularly symmetric sources [41]. The more recent result on such a topic shows that, by expanding the active element patterns in Fourier harmonics, one can exploit the same kind of approach also for the case of (linear) arrays where (because of non-uniform spacing and/or mutual coupling and/or mounting platform effects) one cannot even define an array factor [6];

- The capability to solve in a globally optimal fashion the two canonical problems above also has allowed progress on other canonical problems. In fact, the above (ability) to find a multiplicity of solutions (if any) also has allowed the development of convenient methods for the optimal synthesis of easily reconfigurable arrays (including phase only reconfigurability) [57]. Also, the capability to find optimal continuous sources for the problems at hand has allowed the development of new methods (based on the emulation of these sources) for the synthesis of sparse isophoric arrays [67,51,47,44] or anyway of arrays having a number of control points as low as possible [65];

- The latest result deal with the canonical (open) problem of solving in a globally optimal fashion the synthesis of shaped beams by means of generic fixed geometry arrays. The proposed approach is able to formulate the problem as the global optimization of a few samples in the shaped zone, which allows to take actual advantage from the often overestimated potentialities of global optimization techniques [133]. The approach, which relies on nested optimizations where the inner one deals with convex problems, is similar in spirit to the hybrid approaches introduced [97],[90],[84] for solving other more specific synthesis problems.

iv. *Inverse scattering and inverse obstacle problems in electromagnetics, both from a theoretical point of view and developing new effective inversion procedures. These latter have been successfully applied to a number of applications such as subsurface sensing and biomedical imaging*.

Contributions on quantitative inverse scattering include
- an understanding of the role of the ratio amongst the number of independent equations one can consider (see point (i) above) and the number of unknowns [29];
- the proposal of tools to quantify the 'degree of non-linearity' (and hence the difficulty) of the problem at hand, [102];
- new formulations of the scattering equations such to reduce such a degree ([100], [68] and, more recently, [b]);
- the introduction of the so called 'virtual experiments' framework, which allows to introduce some new effective approximations of the internal fields (or of the contrast sources), which in turn allows a number of new effective solutions for the inverse problem [61], [39] [37], [34], [24];

Recent activities on such a topic include the determination of the electrical parameters of human tissues from complex or phaseless data in microwave imaging or Electrical Property Tomography using hard priors [12],[9], as well as applications to plasma diagnostics [7].
The most recent activities include a number of convenient rewriting of the scattering equations such to reduce the degree of non-linearity of the relationship amongst the unknown scatterers profiles and the scattered fields [142,144].

As far as the determination of the support of unknown scatterers is concerned, T. Isernia
- has furnished (with L. Crocco and I. Catapano) a physical interpretation of the popular Linear Sampling Method, which has provided a bridge from purely mathematical results to physical understanding, and hence generalizations and useful engineering applications [88] ;
- has introduced (with M. Bevacqua) a new effective inversion method based on equivalence principles and the joint consideration (through the joint sparsity concept) of different inverse source problems [22,16];
- has given further insight into the so called Orthogonality Method which allows to better understand and generalize the method at hand, and emphasizes the inherent capability of detecting discontinuities inside the target [134] ;
- has proposed, with M.T. Bevacqua, an effective non approximated method based on the Contrast Integral Equation model [V].

v. *Field or field intensity optimal synthesis in 3D non homogeneous regions of space*,

The problem is of the outmost interest in situations as different as Magnetic Resonance Imaging, Hyperthermia, Near field focusing, Wireless Power transfer, tele-activation of ingestible devices, and many other.

On such a topic, T. Isernia and co-workers have shown that:

- the optimal focusing of scalar fields subject to arbitrary upper bound elsewhere can be conveniently dealt with as a Convex Programming problem [50],[49],[45]. Such a result has been later extended to the focusing of the Specific Absorption Rate in case of multifrequency applicators [19];
- the optimal focusing of the intensity of vector fields subject to arbitrary upper bound elsewhere can be conveniently dealt with as a global optimization over the possible polarizations of the field in the target point. In fact, for any fixed polarization the problem can be solved according to the strategy above [36];
- the optimal shaping of the field intensity of scalar field in an arbitrary volume of space can be reduced to a finite number of Convex Programming problems [17] or to the global optimization of a few real unknowns given by the phase shifts amongst the values of the field in a restricted number of 'control points' [I].

Recent publications on medical Journals [5],[10] using clinical data confirm the applicative interest of the achieved result in the area of hyperthermia. The more recent methodological development allows a relevant reduction in computational complexity by using suitable auxiliary models based on the combination of a few focused fields (and their interference) [150].

vi. *Inverse scattering as a design tool for metamaterials based devices*

By taking advantage from the above interests and skills, and driven by the very recent interest for metamaterials based devices, T. Isernia has also recently pursued the exploitation in design problems of theories and tools from retrieval problems. The recent activities on such a topic include

- The realization of innovative lens antennas by using inverse scattering tools (and without using homogenization theories) [14];
- New fast and flexible approaches to the design of invisibility cloaks [4], [20]
- New possible approaches to invisibility, and determination of the expected limitations ;
- New possibilities for the effective design of Photonic Band Gap devices [140].

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I. G. Battaglia, A.F. Morabito, R. Palmeri, T. Isernia 'Effective Non-Iterative Phase Retrieval of 2-D Bandlimited Signals with Applications to Antenna Characterization and Diagnostics', *IEEE Trans. on Antennas and Propagation,* revised version submitted on february 2023

II. R. Palmeri, S. Costanzo, G. Battaglia, T. Isernia, A.F. Morabito 'Array Fault diagnosis from a small number of near field phaseless measurements' *IEEE Transactions on antennas and propagation*, major revisions due

III. S. Zumbo, S. Mandija, F. Meliadò, P. Stijnman, T. G. Meerbothe, C.A.T. van den Berg, T. Isernia, M. T. Bevacqua 'Unrolled Optimization via Physics-assisted Convolutional Neural Network for MR-based Electrical Properties Tomography',

IV. M. Ambrosanio, M.T. Bevacqua, T. Isernia, J. LoVetri, V. Pascazio 'In-vivo Electrical Properties Estimation of Biological Tissues by means of Qualitative and Quantitative Inverse Scattering Methods'

PAPERS IN PREPARATION

V. M.T. Bevacqua, T. Isernia 'NIE for inverse scattering as a new effective support estimation technique'

VI. G. Battaglia, T. Isernia, R. Palmeri, A.F. Morabito 'Four modes array antennas for target localization applications'

OTHER RELEVANT PUBLICATIONS

PhD Thesis :

T. Isernia 'Sulla determinazione di sorgenti complesse da misure di solo modulo' supervisors R. Pierri and G. Leone. Thesis successfully defended in front of a National Committee in Rome, April 1992

Contributions to volumes and books

A. T. Isernia, G. Leone, R. Pierri (1990). 'A quadratic Inverse problem : the phase retrieval' *in: P.C. Sabatier Ed. Inverse Methods in Action. p. 285-291,* BERLIN, Springer Verlag, ISBN: 9780387519944

B. T. Isernia, G. Leone, R. Pierri (1991). 'The phase retrieval in near zone as a non linear inverse problem : the planar scanning' *in: G. Franceschetti, R. Pierri Eds. Italian recent advances in applied electromagnetics. p. 117-134,* NAPOLI:Liguori, ISBN: 978-88-207-2159-6

C. T Isernia , V. Pascazio, R. Pierri, G. Rubinacci, A. Tamburrino (1997). 'Reconstruction of permittivity and conductivity profiles via quadratic models' in: *Electromagnetic Nondestructive Evaluation. Amsterdam:IOS Press*, ISBN: 9051993250

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E. M.T. Bevacqua, L. Crocco, L. Di Donato, Isernia T, R. Palmeri (2017). 'Virtual Experiments and Compressive Sensing for Subsurface Microwave Tomography' in: *C.H. Chen, Compressive Sensing of Earth Observation. Boca Raton, FL (USA):CRC Press,* ISBN: 9781498774383, doi: https://doi.org/10.1201/9781315154626

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LIST OF PhD AND OTHER RELEVANT STUDENTS STILL INVOLVED IN ELECTROMAGNETICS RESEARCH

Tommaso Isernia has been the supervisor or co-supervisor of the PhD students :

1. Lorenzo Crocco, now 'Dirigente Di Ricerca' at IREA-CNR Napoli Italy
2. Michele D'Urso, now Head of Leonardo Finmeccanica plant in Fusaro (Bacoli), Napoli area, Italy
3. Fabrizio Cuomo, now Manager at Leonardo Finmeccanica, Napoli area, Italy
4. Andrea Morabito, now Associate Professor at Università Mediterranea di Reggio Calabria
5. Loreto Di Donato, now Associate Professor at Università di Catania
6. Martina Bevacqua, now Assistant Professor (with Tenure track) at Università Mediterranea di Reggio Calabria
7. Gennaro G. Bellizzi, formerly Researcher at Erasmus MC, Rotterdam, The Netherlands, now moved to different activities
8. Rosa Scapaticci, now researcher at IREA-CNR Napoli
9. Giuseppe Torrisi, now researcher at Istituto Nazionale di Fisica Nucleare (Catania)
10. Roberta Palmeri, now Researcher at IREA/CNR, also lecturer at Università Mediterranea
11. Domenica Anna Maria Iero, who recently moved to a different kind of activity
12. Antonia Rita Laganà, who recently moved to a different kind of activity
13. Giada Battaglia, (presently research associate @ Università Mediterranea)
14. Sabrina Zumbo (now with Università Federico II as 'Assegnista di Ricerca')
15. Luigi Caccavale (left at the end of the second year after some journal publications)
16. Nicola Cardace (left at the end of the second year after some journal publications)

Moreover, T. Isernia has also been also the advisor or co-advisor of roughly two hundred Master and/or Bachelor theses including

17. Ilaria Catapano, PhD in ElecroMagnetics (EM) at Università di Cassino, now 'primo ricercatore' at IREA-CNR

18. Maria Grazia Labate, PhD in EM at Seconda Università di Napoli, researcher at the Jodrell Bank Observatory, working on the Square Kilometer Array Project
19. Giuseppe Labate, PhD in EM at Politecnico di Torino, now working with Wave up, a spin-off (from S. Maci et al.) of the University of Siena
20. Pasquale Nicolaci, PhD in EM at Università Mediterranea, now Antenna Designer at Ticra
21. Flavio Meliadò (now pursuing PhD in MRI at Utrecht Medical Center, defending the Thesis soon)

SERVICE TO THE ACADEMIC COMMUNITY

Tommaso Isernia has led an intensive activity of service to the Community since from his early stage, where he has been a representative of PhD students at the Department level, and a representatative of Assistant Professors in the Engineering Faculty at Università di Napoli Federico II. More recently (going back in time) :

1. Director (Head) Dipartimento di Ingegneria dell'Informazione, delle Infrastrutture e dell'Energia Sostenibile della Università Mediterranea di Reggio Calabria (October 2018-January 2023);

2. Member of ' Senato Accademico' of Università Mediterranea as the representative of the Directors of Engineering Departments (December 2018-January 2023);

3. Elected member of the 'Board of Governors' of Consorzio Nazionale Interuniversitario per le Telecomunicazioni, a Consortium which joins 37 Italian Universities active in the Telecommunication and Applied Electromagnetics areas. (from 2014 til 2019)

4. Member of the National Committee for the evaluation for the achievement of 'National Scientific abilitation' (which is needed for any Associate or full professorship in Italy) for the Electromagnetic Fields area (2016-2018)

5. Coordinator of the PhD Courses in 'Ingegneria dell'Informazione' at Università Mediterranea (roughly 2015-2021) ;

6. Coordinator of 'Corso di laurea in 'Ingegneria dell'Informazione' at Università Mediterranea di Reggio Calabria (from March 2013 to september 2014) ;

7. Member of one of the Committees of Italian National Research Council (the one for Engineering) for selecting 117 researchers (2013) ;

8. Coordinator of 'Consiglio di Corso di Classe in Ingegneria dell'Informazione' at Università Mediterranea di Reggio Calabria (from november 2007 to June 2010). The Council had the responsability to coordinate all Bachelor and Master degrees courses in ICT at Università Mediterranea.

9. Representative of Full Professors in the Board of Governors of Università Mediterranea di Reggio Calabria (2005-2007)

10. Member of several Selection Committes for Professorships (Politecnico di Torino, Università di Siena, UNICUSANO, Univ. of Salerno, Università della Campania, other)

11. Member of the Board of European School on Antennas

12. He gives classes at both the undergraduate and graduate level since 1996. He has given courses on Basic electromagnetics, Microwave Circuits and Devices, Antennas, Radiopropagation.

13. Particular care has been given to teaching for Doctoral studies. In particular, he has been the first (with S. Maci and G. Vecchi) to organize specific courses in Italy, Then, under the European School of Antennas framework, he has been the (co) organizer of several PhD Schools. In particular, he has organized (and given lectures at) the first Courses on

    - Antenna synthesis (with O.M. Bucci)
    - Microwave Imaging and Diagnostics (with A. Massa and, more recently Lorenzo Crocco)
    - Compressive Sensing in Electromagnetics (with A. Massa)

    He has given classes in roughly fifteen of these Schools, as well as in other (conference related) short courses.