Prof. Alexander I. Nosich

SCIENTIFIC REPORT FOR SHORT VISIT
to University of Rome 3 and University of Rennes in April 2011
in the framework of the ESF Network "Newfocus"

Topic: *"Mathematical and numerical modeling of dielectric lenses, resonators, and lasers using boundary integral equations and eigenvalue problems"*

Purpose of the visit to Rome: collaboration with Professor G. Schettini

Description of the work carried out during the visit from 10th to 16th April 2010:
- seminar presentation at the University Rome 3 conceived as an overview of my recent research activities related to the topic indicated above; the seminar was attended by Prof. Schettini, students, and staff members,
- discussions with Prof. Schettini of the topics of common interest; an agreement was achieved that the scattering of waves by radiatively coupled plasmonic sub-wavelength wire scatterers can be an area of closer collaboration,
- attendance at the focused sessions on lenses and reflectors and on the ESF Network Project "Newfocus" at the European Conference on Antennas and Propagation.

Purpose of the visit to Rennes: collaboration with Professor R. Sauleau

Description of the work carried out during the visit from 17th to 23rd April 2010:
- discussions with Prof. Sauleau of the ongoing collaboration efforts around the three-dimensional modeling of reflector antennas, thin disklike dielectric lenses, and periodic arrays of electromagnetically coupled sub-wavelength metal and dielectric wires and strips,
- work on two joint papers to be submitted soon to the well-reputed international technical journals, *IEEE Antennas and Propagation* and *Micro and Nano Letters*.

Details of the topics discussed in Rome and Rennes:
Dielectric lens antennas are widely used in various millimetre-wave and THz-wave applications. Their basic design principles are suggested by geometrical optics, which states that all the rays that impinge on the lens front interface come together in the focal point. The reciprocity then tells that placing a point feed in the focus results in a sharp beam of the far-field radiation pattern. However, any finite-size lens has a focal spot whose size and shape vary with the lens size and material, as well as with the angle of incidence and polarization of the incident wave. The exact knowledge of the focusing ability and field in focal domain is very important for the design of lens-based sensors. Still any finite-size lens is simultaneously an open resonator, whose natural modes can spoil the lens performance, from the one hand. However, from the other hand dielectric resonators are ubiquitous building blocks of the wide variety of electromagnetic systems and sub-systems, across a wide range of frequencies.

Mathematical and numerical analysis of dielectric lenses and resonators is a challenging problem, the widely recognized underlying difficulty being a combination of the ray-like and the mode-like features in the electromagnetic field behaviour. There are several integral-equation (IE) formulations related to that class of problems, where the Muller equations stand aside as the Fredholm second kind IEs. A discretization scheme based on a Galerkin method with trigonometric polynomials as basis functions can be applied to obtain an infinite-matrix equation with favourable features. Alternatively, the same IEs can be discretized using a Nystrom algorithm and corresponding quadrature formulas for numerical integration.

The advantages of both algorithms that make them efficient and reliable tools for the analysis of dielectric scatterers are as follows: (i) controllable accuracy, i.e., possibility to minimize the computational error to a predicted number of digits for an arbitrary set of the problem parameters (i.e. lens size, shape and material) by solving progressively greater matrices; (ii) stability near and far from the sharp natural resonances, which is hard with conventional numerical approximations; (iii) low memory and time requirements; and (iv) absence of the false "numerical resonances" intrinsic to the IEs methods not based on the Muller IEs.

Microcavity lasers can be also modelled as dielectric resonators however with active regions. Here, very useful information can be obtained if all non-electromagnetic effects are neglected and the optical modes are viewed as solutions of the linear set of source-free Maxwell equations. Within the framework of the recently proposed approach, the lasing in open microcavities with active regions can be studied as a modified linear eigenvalue problem with exact boundary and radiation conditions. Material gain is introduced into the cavity material within the active region via the "active" imaginary part of the refractive index. By using Muller IEs discretized with Galerkin or Nystrom techniques, the problem is reduced to the search of roots of determinantal equations.

Numerical results on the wave scattering and focusing with dielectric lenses and the natural modes of dielectric resonators have been presented.

Prof. Alexander I. Nosich

TRAVEL EXPENSES FOR SHORT VISIT
to University of Rome 3 and University of Rennes in April 2011
in the framework of the ESF Network "Newfocus"

Air ticket from Kiev to Rome and from Paris to Kiev	EUR 412	(USD 585.19)
Air ticket from Rome to Paris	EUR 188.99	
Train from Kharkov to Kiev and bus from Kiev to Kharkov	EUR 23.32	(UAH 111.51+145=256.51)
Train from airport to Rome and bus from Rome to airport	EUR 20	(EUR 14+6)
Train from airport to Paris and from Paris to airport	EUR 19.15	(EUR 10.25+8.90)
Train from Paris to Rennes and from Rennes to Paris	EUR 127.80	(EUR 72+55.80)

Total:	EUR 791.26

Thus, travel expenses exceed standard level of 500 euro for a short visit however this is chiefly because the travel consisted of two visits, to Rome and to Rennes, instead of standard one destination. Still the total travel expenses are lower than possible expenses for two separate visits to the same destinations.

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Departure (KBP): April 10, 6:10 PM EEST (evening)
Arrival (FCO): April 10, 8:05 PM CEST (evening)

Class: Economy **Seat:** 00 | Your flight is confirmed. Seat is confirmed. You may
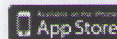

Sunday, April 24, 2011
Air France # 2552

Paris Ch. De Gaulle (CDG) to Kiev Borispol (KBP)
Departure (CDG): April 24, 12:50 PM CEST (afternoon)
Arrival (KBP): April 24, 4:55 PM EEST (afternoon)
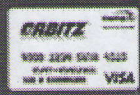
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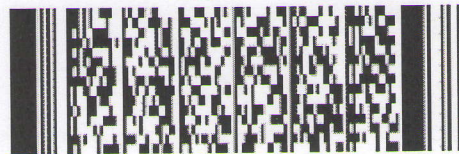Reserve your lounge now

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Arr **17 April 2011** 17:15
Flight 4248
Check in opens 17 April 2011 13:15
Check in closes 17 April 2011 14:35

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ЗН ВЖ7500018218   ПН 216229526575
        ЧЕК №   _____34591
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