Prof. Alexander I. Nosich

SCIENTIFIC REPORT FOR SHORT VISIT
to ENS de Cachan and University of Seville in October 2012 (1 week)
in the framework of the ESF Network "Newfocus"

Topic:
"Development of advanced integral-equation techniques for modeling of dielectric and metallic scatterers of quasioptical size"

Purpose of the visit to Cachan: collaboration with Dr. M. Lebental and Prof. J. Zyss

Description of the work carried out during the visit from 14 to 16 October 2012:
- discussions with Dr. M. Lebental and Prof. J. Zyss of the topics of common interest around the mathematical and numerical modeling of two-dimensional dielectric resonators using integral-equation technique with Nystrom discretization.
- work on a joint paper to be submitted to the well-reputed international technical journal, *Journal of the Optical Society of America B.*
- seminar presentation at the Laboratory of Quantum and Molecular Photonics on the modelling of dielectric and metal scatterers and resonators at LMNO of IRE NASU; the seminar was attended by Dr. M. Lebental Prof. J. Zyss, Dr. V. Shynkar, Prof. L. Martin-Moreno, Prof. I. Samuel, and other staff members and guests.

Purpose of the visit to Seville: collaboration with Professor F. Medina

Description of the work carried out during the visit from 17 to 20 October 2012:
- discussions with Prof. Medina of the ongoing research efforts around the two-dimensional (2-D) and three-dimensional (3-D) modeling of dielectric lenses and metallic reflectors,
- invited paper presentation at the Workshop on Integral Equations in Electromagnetics (Intelect-2012) on the modelling of dielectric and metal scatterers and resonators at LMNO of IRE NASU; the seminar was attended by Profs. F. Medina, R. Boix, F. Mena of the University of Seville, J. Mosig, and other participants.

Details of the topics discussed in Cachan and Seville:
Dielectric scatterers, resonators and antennas for millimeter-wave, sub-millimeter-wave and optical applications usually have dimensions comparable to and larger than the working wavelength, i.e. are quasioptical-size objects. This places considerable burden on the development of economic and still reliable computational tools for their modeling. Imperfect metallic scatterers can be viewed essentially as specific dielectric objects with corresponding frequency-dependent values of complex permittivity. Besides, such scatterers combine two different scales, in terms of the wavelength - one large as dictated by overall size and the other small as related to the local perturbations of the boundary. This makes geometrical and physical optics impractical and hence a full-wave numerical study is mandatory. The same holds about the modeling of the reflectors as thin, with respect to the wavelength, screens made of perfect or imperfect metal or dielectric materials. Reliable and economic computational instruments can be based on the boundary-integral-equation (BIE) techniques. The BIEs are intrinsically singular or hyper-singular that hinders their discretizations with simple meshing of the boundary because of the lack of convergence. Besides, the smoothness of the boundary and the (possibly singular) edge behavior of unknown surface currents influence on the convergence and has to be handled.

In the ongoing research, we consider the problems of electromagnetic wave scattering, absorption and emission by several types of two-dimensional and three-dimensional dielectric and metallic objects: arbitrary dielectric cylinder, thin material strip and disk, and arbitrary perfectly electrically conducting surface of rotation. In each case, the problem is reduced to a set of BIEs with smooth, singular and hyper-singular kernel functions. These equations are further discretized using polynomial approximations to the smooth factors in the surface currents and Nystrom-type quadrature formulas adapted to the type of kernel singularity and the edge behavior. Convergence of developed discrete models to exact solutions is guaranteed by general theorems. Practical accuracy is achieved by inverting the matrices of the size that is only slightly greater than the maximum electrical dimension of the corresponding scatterer.