

## Traditional and Non-traditional Numerical Methods, with Applications in Photonics

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I am very pleased to be visiting Prof. Chew's group for the period of May 14 – June 10 at his kind invitation. To explore the overlaps in our interests, an overview of several directions of my research will be presented. The topics lie in the intersection of theory, computational methods and applications in photonics.

1. **Theory.** The mechanism of negative refraction (electromagnetic waves bending the “wrong” way at material interfaces) and backward waves (phase velocity at an obtuse angle with group velocity) is examined. Explicit lower bounds for the cell size of metamaterials and photonic crystals capable of supporting backward waves are established and numerical examples are given.
2. **Computational methods.** The generalized finite-difference calculus of Flexible Local Approximation MEthods (FLAME) is reviewed and various examples are presented. FLAME often dramatically improves the accuracy by incorporating local analytical approximations of the solution into the difference scheme. For instance, in the computation of Bloch bands FLAME can produce 6–8 digits in the (generally complex) Bloch wavenumber on Cartesian grids of very modest size. New boundary-difference methods for wave scattering will be introduced as well.
3. **Applications** include Bloch mode analysis in periodic structures with or without frequency dispersion, plasmonic field enhancement in optical “nanolenses” and in near-field microscopy. A new application is subwavelength “superfocusing” by plasmonic/dielectric nanolayers; the focus can in principle be arbitrarily sharp.

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### Biography

Igor Tsukerman is Professor of Electrical and Computer Engineering at the University of Akron, Ohio, USA, where he has been a faculty member since 1995. His research is focused on the simulation of nanoscale systems, applied electromagnetics and photonics. He teaches a variety of undergraduate and graduate courses (Signals & Systems, Circuits, Electromagnetic Fields, Digital Signal Processing, Random Signal Analysis, Simulation of Nanoscale Systems, and others). Tsukerman has about 150 refereed publications and is the author of a monograph recently published by Springer (*Computational Methods for Nanoscale Applications: Particles, Plasmons and Waves*). Another book, *Plasmonics: Analysis, Experiments and Applications*, co-edited with Prof. Gennady Shvets, is scheduled to be published in 2010 by World Scientific. Financial support by the NSF, NSF-NIRT, Air Force, DARPA, Baker Hughes, Rockwell Automation is gratefully acknowledged.



Before coming to the University of Akron, Tsukerman worked at the Department of Electrical & Computer Engineering, the University of Toronto (1990–1995). A joint project with GE Canada involved electromagnetic field analysis and noise reduction in large electric motors. The software developed in the course of the project is still being extensively used by GE. Tsukerman's academic degrees are from the Polytechnic University of Leningrad, Russia: a combined B.Sc. / M.Sc. degree with honors in Control Systems (1982) and a Ph.D. in Electrical Engineering (1988).