SHORT COURSE PROPOSAL TO EUCAP2011, ROME, ITALY, 2011

1. COURSE HEADER:

a. **Course Title**: Domain Decomposition, High Frequency, Beam, and Hybrid Methods for Electromagnetic Applications
b. **Course Type**: Full Day
c. **Contact Person**: Prof. Jin-Fa Lee, 1320 Kinnear Rd., ElectroScience Lab., Electrical and Computer Engineering Department, The Ohio State University, Columbus, OH 43212, USA. E-mail: lee.1863@osu.edu, Phone: +1-614-292-7270

2. COURSE DESCRIPTION:

a. **Who should attend this course and why**:
   - Engineers who are interested in modeling and simulating electrically large electromagnetic problems, multi-scale EM devices and components, EMC effects of antennas on large platforms, and signal integrity and package analyses.
   - Engineers seeking to understand the variety of high-frequency asymptotic methods and software available for fast EM analysis.
   - Engineers designing reflector antennas, measurement ranges, wireless communications systems, and low-observable structures.
   - Computer programmers involved in multi-scale EM simulation and software development.
   - The lectures will introduce the attendees the basic principles of the domain decomposition methods, the high frequency methods, and the framework in which general hybrid methods can be constructed.

b. **Course topics and names of instructors**:

Part I: Domain Decomposition Methods for Electromagnetic Applications, Prof. Jin-Fa Lee

This short course details non-conformal domain decomposition methods for solving large electromagnetic problems such as large finite antenna arrays, frequency selective surfaces (FSS), metamaterials, and EMC effects of antenna arrays on large platforms etc. With recent revolutionary breakthroughs, it is now possible to solve electromagnetic problems with hundreds or even billions of finite and boundary element unknowns on simple PCs without compromise of the solution accuracy. Topics included in this short course are:

- Non-conformal DDMs for repetitive structures: Geometrically non-conformal DDMs with high order transmission conditions provide robust, fast converging, and efficient solutions for multi-scale EM problems.

- Non-conformal DDMs for Method of Moment: One of the most stunning developments in CEMs recently is the non-conformal DDM for method of moment.
- Multi-region/Multi-solver DDMs: For solving EMC effects of antennas on large platforms, it is extremely beneficial to apply different CEM solvers for different parts of the problem. Recent breakthrough allows the PDE solvers, such as finite element region, to be placed right next to MoM solver regions without introducing artificial gaps between them.

Part II: High Frequency, Beam and Hybrid Methods for Electromagnetic Applications, Prof. Prabhakar Pathak

- The theory and application of high-frequency ray and integral methods, as well as beam methods, and hybrid methods, respectively, are presented at a practical level for electromagnetic (EM) analysis and design. Purely numerical methods in EM, such as the method of moments, finite element method, and finite difference methods, provide high accuracy for complex geometries, but are (in their conventional form) severely limited as the frequency increases since computational requirements increase exponentially, so analysis of structures larger than a few wavelengths may become intractable by such methods. High-frequency ray methods, on the other hand, become more accurate as the frequency increases, and the efficiency is relatively independent of frequency, and they remain surprisingly accurate down to even moderately high frequencies where they can overlap with numerical methods. Most importantly, ray methods have the additional benefit of providing physical insight into EM radiation, propagation, and scattering. Several popular high-frequency methods are briefly described and compared, including geometrical optics, physical optics, shooting and bouncing rays, iterative physical optics, physical theory of diffraction and the uniform geometrical theory of diffraction. The strengths and weaknesses of each method are compared in terms of accuracy, efficiency, physical insight, applications, and ease of implementation. Advanced topics based on complex source beams (CSBs), Gaussian beams (GBs), and hybrid high-frequency/numerical techniques will also be discussed. Beams generated by complex sources are exact solutions of Maxwell's equations; as such they provide useful basis functions/propagators for EM waves. GBs are paraxial approximations to complex source beams (CSBs). Beam methods can overcome some of the limitations of ray methods, while hybrid methods which combine the best features of one or more of the above techniques, as well as those hybridizations which combine high frequency and/or beam methods with numerical methods for analysis of multi-scale wave problems, will be briefly described. *Typical applications of the above mentioned methods include reflector antenna design, in-situ antenna/antenna array performance analysis (gain pattern and EMI/EMC) on complex platforms, wireless propagation, etc..*

c. **Means of instructions**: PowerPoint slides lectures/presentations.

3. COURSE INSTRUCTORS:

a. Names, full institutional/professional affiliation, postal and e-mail address, phone numbers:

Prof. Jin-Fa Lee
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b. Short bio.:

Short Bio of Prof. Jin-Fa Lee: Jin-Fa Lee received the B.S. degree from National Taiwan University, in 1982 and the M.S. and Ph.D. degrees from Carnegie-Mellon University in 1986 and 1989, respectively, all in electrical engineering. From 1988 to 1990, he was with ANSOFT Corp., where he developed several CAD/CAE finite element programs for modeling three-dimensional microwave and millimeter-wave circuits. From 1990 to 1991, he was a post-doctoral fellow at the University of Illinois at Urbana-Champaign. From 1991 to 2000, he was with Department of Electrical and Computer Engineering, Worcester Polytechnic Institute. He joined the Ohio State University at 2001 where he is currently a Professor in the Dept. of Electrical and Computer Engineering. Prof. Lee is an IEEE fellow and is currently serving as an associate editor for IEEE Trans. Antenna Propagation.

Short Bio of Prof. Prabhakar Pathak: Prabhakar H. Pathak received his Ph.D degree from the Ohio State Univ., Columbus, Ohio, USA, in 1973. Currently he is a Professor Emeritus at the Ohio State Univ. Professor Pathak's main area of research is in the development of uniform asymptotic theories (frequency and time domain) and hybrid methods for the analysis of electrically large electromagnetic (EM) antenna and scattering problems of engineering interest. He is regarded as a co-contributor to the development of the uniform geometrical theory of diffraction (UTD). Presently, he is developing new UTD ray solutions, for predicting the performance of antennas near, on, or embedded in, thin material/metamaterial coated metallic surfaces. Recently his work has also been involved with the development of new and fast hybrid asymptotic/numerical methods for the analysis/design of very large conformal phased array antennas for airborne/spaceborne and other applications. In addition, he is working on the investigation and development of Gaussian Beam summation methods for a novel and efficient analysis of a class of large modern radiation and scattering problems including the analysis/synthesis of very large space borne reflector antenna systems. Professor Pathak has presented several short courses and invited lectures both in the U.S. and abroad. He has often chaired and organized technical sessions at national and international conferences. He was invited to serve as an IEEE (Institute of Electrical and Electronics Engineers) Distinguished Lecturer from 1991 through 1993. He also served as the chair of the IEEE Antennas and Propagation Distinguished Lecturer Program during 1999-2005. Prior to 1993, he served as an Associate Editor of the IEEE Transactions on Antennas and Propagation for two consecutive terms. He has published over a hundred journal and conference papers, as well as authored/co-authored chapters for seven books. He received the 1996 Schelkunoff best paper award from the IEEE Transactions on Antennas and Propagation. In 2009 he received the best paper award from ISAP. He received the George Sinclair award in 1996 for his research contributions to the O.S.U. ElectroScience Laboratory, and the Lumley Research Award in 1990, 1994 and 1998 from the O.S.U. College of Engineering. In July 2000, Prof. Pathak received the IEEE Third Millennium Medal from the Antennas and Propagation Society. He was elected an IEEE Fellow in 1986, and is an elected member of US Commission B of the International Union of Radio Science (URSI). Currently he is serving as an elected member of the IEEE Administrative Committee (AdCom) for the Antennas and Propagation Society.