Seminar on

Asymptotic High Frequency (HF) Ray and Beam Methods

by

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Abstract

The geometrical optics (GO) ray field consists of direct, reflected and refracted rays. GO ray paths obey Fermat's principle, and describe reflection and refraction of HF EM waves, but not the diffraction of waves around edges and smooth objects, etc. Consequently, GO predicts a zero EM field within shadow regions of impenetrable obstacles illuminated by an incident GO ray field. Early attempts by Young to predict edge diffraction via rays, and by Huygen, Fresnel and Kirchhoff to predict diffraction using wave theory will be briefly reviewed. Unlike GO, the wave based physical optics (PO) approach developed later requires an integration of the induced currents on the surface of an impenetrable obstacle illuminated by an external EM source in order to find the scattered field. The induced currents in PO are approximated by those which would exist on a locally flat tangent surface, and are set to zero in the GO shadow region. If the incident field behaves locally as a plane wave at every point on the obstacle, then it can be represented as a GO ray field; the resulting PO calculation constitutes a HF wave optical approach. PO contains diffraction effects due to the truncation of the currents at the GO shadow boundary; these effects may be spurious if there is no physical edge at the GO shadow boundary on the obstacle, whereas it is incomplete even if an edge is present at the GO shadow boundary. In the 1950s, Ufimtsev introduced an asymptotic correction to PO; his formulation is called the physical theory of diffraction (PTD). PTD = PO + Δ, where Δ is available primarily for edged bodies. In its original form, PTD is not accurate near and in shadow zones of smooth objects without edges, nor in shadow zones for bodies containing edges that are not completely illuminated or visible. At about the same time as PTD, a ray theory of diffraction was introduced by Keller; it is referred to as the geometrical theory of diffraction (GTD). GTD was systematically formulated by generalizing Fermat's principle to include a new class of diffracted rays. Such diffracted rays arise at geometrical and/or electrical discontinuities on the obstacle, and they exist in addition to GO rays. GTD = GO + Diffraction. Away from points of diffraction, the diffracted rays propagate like GO rays. Just as the initial values of reflected and refracted rays are characterized by reflection and transmission coefficients, the diffracted rays are characterized by diffraction coefficients. These GTD coefficients may be found from the asymptotic HF solutions to appropriate simpler canonical problems via the local properties of ray fields. Most importantly, the GTD overcomes the failure of GO in the shadow region, it does not require integration over currents, and it provides a vivid physical picture for the mechanisms of radiation and scattering. In its original form, GTD exhibits singularities at GO ray shadow boundaries and ray caustics. Uniform asymptotic methods were developed to patch up GTD in such regions. These uniform theories are referred to as UTD, UAT, spectral synthesis methods, and the equivalent current method (ECM). The pros and cons of *wave optical* methods (PO, PTD, ECM) and *ray optical* methods (GO, GTD, UTD, UAT) will be discussed along with some recent advances in PO and UTD. A UTD for edges excited by complex source beams (CSBs) and Gaussian beams (GBs) will also be briefly described; the latter may be viewed as constituting *beam optical* methods. A hybridization of HF and numerical methods will be briefly discussed as well.

Biography

Prabhakar Pathak: received his Ph.D (1973) from the Ohio State Univ (OSU). Currently he is Professor (Emeritus) at OSU. He is regarded as a co-developer of the uniform geometrical theory of diffraction (UTD). Currently his interests are in the development of new UTD solutions, as well as fast Beam and Hybrid methods, for solving large antenna/scattering problems of engineering interest. He was an IEEE (AP-S) Distinguished Lecturer from 1991-1993. He received the 1996 Schelkunoff best paper award from IEEE-AP-S; the ISAP 2009 best paper award; the George Sinclair award (1996) from OSU ElectroScience Laboratory; and, IEEE Third Millennium Medal from AP-S in 2000. He is an IEEE Life Fellow, and a member of URSI-commision B.

Date : 11 Jun., 2013 (Tuesday)
Time : 04:00pm – 05:00pm
Venue : LT C, Chow Yei Ching Building,
The University of Hong Kong

***** ALL ARE WELCOME *****

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