SHORT COURSE PROPOSAL TO EuCAP 2014, The Hague, THE NETHERLANDS

Course title: Asymptotic High Frequency Methods for Solving EM Wave Problems-Focus on Ray Methods

The geometrical optics (GO) fields propagate along ray paths which obey Fermat's principle, and describe the incident, reflected and refracted EM waves at high frequencies. GO cannot predict waves diffracted by edges and smooth objects, etc.. Hence, GO predicts a zero EM field within shadow regions of impenetrable obstacles illuminated by an incident GO ray field, and the resulting GO shadow boundaries thus delineate the domains of existence of incident and reflected GO rays. Early attempts to predict edge diffraction via rays by Young, and via an approximate wave theory for apertures by Huygen, Fresnel and Kirchhoff, will be reviewed briefly. As is typical of wave based methods, the physical optics (PO) approach developed later requires an integration over the sources of the scattered field to find the latter. The sources or 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. The resulting PO calculation constitutes a wave optical approach. PO contains incomplete diffraction effects due to the sudden 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. In the 1950s, Ufimtsev introduced an asymptotic diffraction correction to PO; his formulation is called the physical theory of diffraction (PTD). Here, 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, because it does not contain creeping wave diffraction effects around smooth convex objects. At about the same time as PTD, a new 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 including creeping rays. Such diffracted rays arise at geometrical and/or electrical discontinuities on the obstacle, as well as at grazing on a smooth convex surface, 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 high frequency solutions to appropriate canonical problems due to the local properties of ray fields. The GTD overcomes the failure of GO in the shadow region, it does not require integration over currents as in wave optical approaches, and most importantly it provides a vivid physical picture (which is important for engineering design) in terms of rays for the mechanisms of radiation and scattering. GTD exhibits singularities at GO ray shadow boundaries and ray caustics. Uniform asymptotic methods such as UTD, UAT, spectral synthesis methods, and the equivalent current method (ECM), etc.. have been developed to patch up GTD in such regions. 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. Also, a UTD for edges excited by complex source beams (CSBs) and Gaussian beams (GBs) will be briefly described; the latter may be viewed as constituting *beam optical* methods or *UTD for beams*. Applications of *ray, beam* and *wave optical* methods will be presented.