The Impact of Evanescent Waves on the Time-Average Power for Intersecting Beams

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In this talk, we will revisit the topic of orthogonality of the total time-average power passing through a plane transverse to the direction of propagation for two electromagnetic field distributions traveling in opposite directions. The time-average powers contained in the two separate field distributions, in the absence of the other field, are orthogonal if they add up to the total time-average power. In general, this is not the case and there exists an additional term that we refer to as the cross term between the two field distributions. In D. M. Kerns' monograph, *Plane-Wave Scattering-Matrix Theory of Antennas and Antenna-Antenna Interactions*, a general formula is presented for the total time-average power for the situation described above. We will present a slightly different formula that is equivalent to Kerns'. For both formulas, it is clear that the cross term only contains evanescent waves of the two electromagnetic field distributions, and the cross term is zero if one or both of the field distributions do not contain any evanescent waves. An additional case will be presented when the cross term is zero when both distributions contain evanescent waves. This topic is worth revisiting because of the recent interest in near-field applications, such as near-field scanning optical microscopy, where the evanescent waves are significant.

A line source above a dielectric slab is a practical example where two electromagnetic fields propagate in opposite directions, i.e., the incident and reflected fields. In this talk, we will use the formula discussed above for this example. We will show that the cross term for the total time-average power passing through a plane between and parallel to the slab and the source is equivalent to the total time-average power contained in the guided modes of a lossless dielectric slab.