QUASI-OPTICAL BEAM WAVEGUIDE ANALYSIS USING GAUSSIAN BEAM EXPANSION

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For reflector antennas and mirrors with diameters < 50 ? Physical Optics (PO) and the Physical Theory of Diffraction (PTD) are very fast and accurate calculation methods for determining the scattered fields. In optics where the diameter of the mirrors >> 1000 ? ray tracing methods are sufficient means of determining the scattered fields. However, in the Quasi-optical range in between these wavelengths neither analysis methods suffice. The computational time for PO+PTD increase with the frequency to the fourth power and ray tracing methods become inaccurate or impractical. A fast analysis method useful for this wavelength range is the Gaussian beam analysis method.

Imbriale et. al. [1] expands the field in the beam waveguide in Gauss-Laguerre beams, which are used to propagate the field from one reflector to the next. On the next reflector the currents are calculated by the PO approximation. The scattered field of this reflector is found by making a new expansion in Gauss-Laguerre modes on an output plane in front of the reflector. This involves the calculation of orthogonality integrals with respect to the reflected field which is unknown at this stage. But by use of the reciprocity theorem the orthogonality integrals can be transformed to surface integrals on the reflector which only involves the known surface currents. The method is fast, but it has the major disadvantage that the Gauss-Laguerre expansion is only accurate in the paraxial region so that diffractions are not accurately described.

Parini et. al. [2] use a frame based expansion [3] consisting of fundamental Gaussian beam modes that are shifted and rotated in space. Reflector scattering is computed by GO and GTD using Gaussian beam diffraction techniques. Hereby the scattered field is found on an output plane on which a new frame expansion is made. In contrast to [1] the method is also able to compute non-paraxial fields since only the fundamental Gaussian beam modes are used in the expansion. The major drawback is the use of GO and GTD for computation of the scattered field which involves ray-tracing and may be inaccurate if the surface or rim has a complicated shape (e.g. a rectangular rim).

In this paper a method is presented which combines the features of [1] and [2] avoiding the major disadvantages of the two methods. The frame based expansion that consists of the fundamental Gaussian modes that are shifted and rotated in space is used to describe the field, and the reciprocity theorem is used instead of GO+GTD analysis. The method has been implemented in a computer program for analysis of a sequence of 3D reflectors with arbitrary shapes. If a sufficiently large number of expansion functions is included the accuracy of the new method is comparable to PO also outside the main beam but the computation time may then be longer than for PO. However, a good accuracy close to the main beam can be obtained with a few numbers of expansion functions and a considerable saving of computation time with respect to PO is reached.

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