Diffraction of fractal light: new frontiers for the mathematics of edge waves

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The diffraction pattern produced by a plane wave (i.e., a perfectly uniform wavefront) scattering from an infinite hard edge is well-described by the Fresnel integral [1]. Such one-dimensional (1D) *edge waves* [see Fig. 1(a)] turn out to be truly elemental spatial structures in linear optical systems in the sense that patterns produced by other apertures [such as a slit – see Fig. 1(b)] can be decomposed into a sum of two interfering edge waves. Our group has previously established that such waves also play a fundamental role in the exact mathematical description of diffraction patterns generated from uniform illumination of polygonal apertures [2], whereby one superposes the waves from all constituent edges (each of which has, crucially, a *finite* length). Here, we report on the first steps taken toward considering a related but distinct physical problem, namely how a *fractal light wave* incident on an infinite edge is diffracted in both the near and far fields. Our method is based upon a Fresnel-type prescription, generalizing earlier analyses [1,2] to accommodate an illuminating field that comprises a spectrum with many distinct components (each spatial frequency contributes a characteristic scale length to the incident pattern). Our results can be readily applied to other classic 1D and 2D systems such as slits and polygons, respectively.

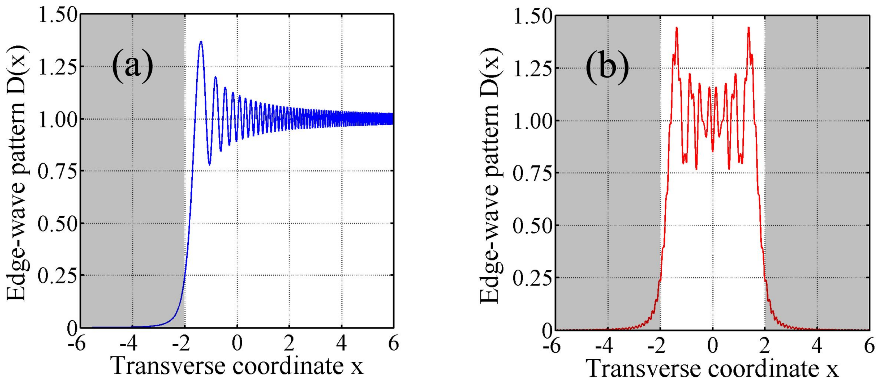

Figure 1. Classic Fresnel edge-wave (intensity) patterns for (a) a single infinite edge, and (b) a slit (constructed from two single edges with a finite space between them). The shaded areas correspond to the geometrical shadow, where the field decays rapidly (in the absence of diffraction, the pattern would have zero amplitude in these regions).

References

[1] M. P. Silverman and W. Strange, Am. J. Phys. **64**, 773 (1996).

[2] J. G. Huang, J. M. Christian, and G. S. McDonald, J. Opt. Soc. Am. A **23**, 2768 (2006).