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Diffraction of fractal waves by simple apertures

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ABSTRACT

Berry's seminal work from over three decades ago established that plane waves (waveforms with 'flat' profiles) scattering from a complex object (e.g., a transparent mask with a random fractal phase modulation) may acquire fractal characteristics in their statistics [Berry, J. Phys. A: Math. Gen. vol. 12, 781 (1979)]. Here, we consider the diametrically-opposing paradigm for complexity in wave physics: the diffraction of a *fractal wave* from a *simple object*. Surprisingly, this rich and (potentially) highly fertile research ground has received almost no attention in the literature to date.

We will report on very recent research results concerning the scattering of fractal light from simple apertures. Attention is first paid to two historic Fresnel diffraction contexts: (i) a single infinite edge; (ii) a single slit (constructed from a pair of parallel edges). While classic analyses considered normally-incident planar (i.e., uniform) illumination, the novelty of our approach lies in accommodating an incident wave that possesses a very broad spatial bandwidth (i.e., a waveform whose Fourier spectrum extends over decimal orders of pattern scale-length). Exact mathematical descriptions of near-field diffraction patterns have been obtained using a prescription based on Young's edge waves. These preliminary calculations have formed the basis for analysing the diffraction of fractals at more sophisticated two-dimensional apertures such as squares, rectangles, and circles. The interaction of fractal waves with arrangements of slits and fully two-dimensional apertures (e.g., regular polygons) has implications, for instance, in novel unstable-cavity laser designs [Huang *et al.*, J. Opt. Soc. Am. A vol. 23, 2768 (2006)].