Diffraction of fractal light by simple apertures

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Berry's seminal work from over three decades ago [J. Phys. A **12**, 781 (1979)] established that plane waves scattering from complex objects (e.g., a transparent mask with a random fractal phase modulation) may acquire fractal characteristics in their statistics. Here, we consider the diametrically-opposing paradigm for optical complexity: 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.

In this presentation, we will report on very recent research results concerning the scattering of fractal light from simple apertures. Attention is paid to two historic configurations that underpin both theoretical and experimental studies of diffraction: (i) a single infinite edge, and (ii) a single infinite slit (constructed from a pair of parallel edges). While classic analyses considered normally-incident plane-wave illumination, the novelty of our approach lies in accommodating an incident optical field that possesses a very broad spatial bandwidth (i.e., a waveform whose Fourier spectrum extends over decimal orders of pattern scalelength). Exact mathematical descriptions of near-field (Fresnel) diffraction patterns have been obtained using a prescription based on Young's edge waves [Silverman and Strange, Am. J. Phys. **64**, 773 (1996)]. Furthermore, far-field (Fraunhofer) predictions emerge asymptotically in the limit of vanishing Fresnel number.

These preliminary analyses have been supplemented by further considerations, namely the propagation of fractal wavefronts that have been modulated by finite-waist beams. Key – and somewhat unexpected – results will be presented that address, for the first time, the effect of finite aperturing on the propagation of scalar fractal light waves. Our findings have implications for, and applications in, a diverse range of fields such as fractal antenna engineering [Werner and Ganguly, IEEE Antenna Prop. Mag. **45**, 38 (2003)] and surface-roughness measurement techniques [Wada *et al.*, Opt. Commun. **166**, 163 (1999)].