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Understanding self-similar beams in terms of rays: visible and hidden geometry

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ABSTRACT:

Self-similar beams are optical fields whose transverse intensity profile is preserved under propagation up to a rigid transformation (e.g. a scaling, rotation, or displacement). These include well-known paraxial solutions such as Hermite- and Laguerre-Gaussian beams, as well as beams that appear to follow curved paths (e.g. Airy beams) and/or to resist diffraction (e.g. Bessel beams). The apparently mysterious behavior of some of these beams (and their pulsed and/or nonparaxial counterparts) has lead to a large number of publications on the subject. This behavior, however, is greatly clarified when the much simpler ray-optical picture is used. It will be shown in this talk that the ray description of these beams is surprisingly rich in geometry, and that their main features can be understood pictorially. Therefore, very few equations are used in the presentation. Further, this treatment has direct analogues in other areas of physics, particularly in quantum systems described by two-dimensional harmonic oscillators.