Insight into scattering and caustics from the evolution of glare points and wavefronts

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In the 1970s M. V. Berry and J. F. Nye developed catastrophe optics as a framework for classifying caustics and associated wavefields. Bright regions in short-wavelengths far-field scattering are often associated with a caustic corresponding to an absence of curvature of an outgoing wavefront. The discovery of far-field cusp and hyperbolic-umbilic scattering patterns in the rainbow region of oblate acoustically levitated drops in the 1980s helped to motivate the application of generalized ray tracing to the analysis of the curvature of scattered wavefronts. Associated glare points are visible when viewing levitated drops through an aperture within the angular region spanned by such caustics. In certain symmetric situations not only is it possible to approximate caustic and wavefield properties, the dependence of glare points on drop shape can also be predicted. The merging of glare points is related to the caustics in a predictable fashion. One analytical approach utilizes methods for evaluating the principal curvatures of wavefronts in optical systems developed by J. A. Kneisly and O. N. Stavroudis in the 1960s and 1970s. Lip-shaped caustics are visible in the backscattering region for sufficiently oblate drops. When viewing higher-order rainbow regions, complicated patterns can be produced with only small deformations of a drop. Related investigations include the nature of glory scattering by gas bubbles in liquids and the relation of caustics and polarization of the scattering to bubble shape.