SINGULAR OPTICS

Singular Optics With Polychromatic Light

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During the past few years, a great deal of attention has been paid to the structure of wave fields in the neighborhood of points where the field amplitude has zero value. At such points, the phase of the wave is singular. Studies of phenomena associated with phase singularities are gradually developing into a new branch of physical optics, sometimes called singular optics.[1] It is a rich subject, because many different kinds of behavior—such as wave-front dislocations and optical vortices—may exist near singular points.

The majority of publications concerned with singular optics deal with monochromatic waves. We have recently studied the spectral structure of light near phase singularities in the focal region of a spatially fully coherent but polychromatic, converging, spherical wave.[2] We found that in this region, the spectrum changes drastically from point to point along a closed loop around the singularity. In particular, when the spectrum of the incident light consists of a single line of Gaussian profile centered at a frequency ω_0, the spectrum of the focused field on a closed loop around a phase singularity of the spectral component of frequency ω_0 is red-shifted at some points, blue-shifted at others and splits into two lines elsewhere, as shown in Fig. 1.

Our investigation demonstrates that the spectrum of light in the focal region has a complicated, nontrivial structure. Understanding this structure may be relevant to fluorescence microscopy, in which the exciting field can have a spectrum that varies strongly in the volume that is probed, leading to a higher resolution.

Since this research was carried out, it was discovered that this kind of behavior is not restricted to fields in the focal region but also takes place in the neighborhood of phase singularities in other kinds of fields.[3-5] Some of the theoretical predictions made in these papers were recently confirmed experimentally by G. Popescu and A. Dogariu. An account of these experiments is given in the summary that appears on p. 21.

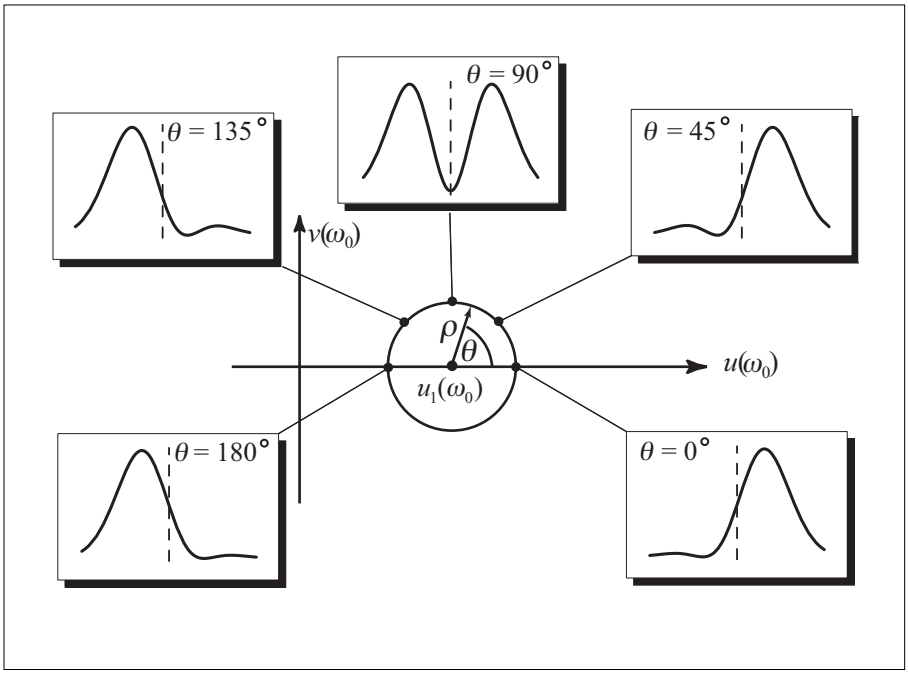

Figure 1. Schematic illustration of the spectrum along a loop encircling the first axial zero of the center frequency. [After G. Gbur, T. D. Visser and E. Wolf, Phys. Rev. Lett. **88** 013901 (2002).]

References

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