스펙클 위상도에서 광소용돌이 현상의 관측

Observation of optical vortices in speckle field

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Since Nye and Berry[1] showed that in free space the electromagnetic field could contain stable, propagating phase singularities termed "dislocations", optical dislocations have been extensively investigated in nonlinear optics and laser physics. As the wave propagates, the lines of constant phase surrounding a dislocation trace out a spiral in space or in time. So these phase singularities are now usually referred to as optical vortices. Baranova and her co-workers[2] have shown that in fully developed speckle patterns, there is, one optical vortex accompanying each speckle spot on average. Among these vortices there are networks in phasemap because only one phase is to be assigned in one point except optical dislocations having zero amplitude. Freund et al.[3] have been studied optical dislocation networks and simulations are compared with experimental results.

In our experiment, we observed optical vortices using phase-shifting interferometer.

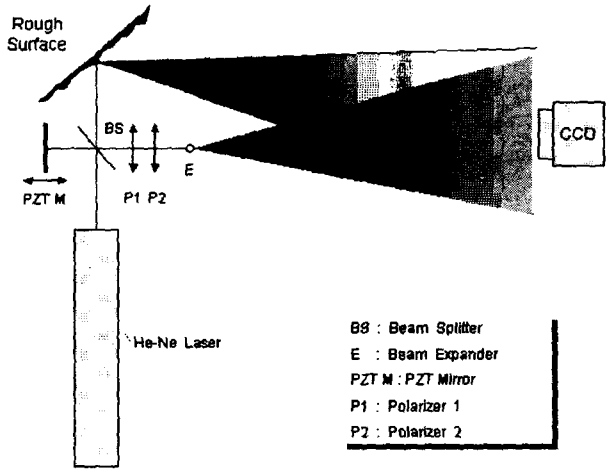

Fig 1. Experimental setup

Merely by adding a reference beam to the speckle pattern, we can see optical vortices locating in the dark area of speckle pattern. We have calculated the phase of a speckle field in each point from four CCD images. Also from the calculated phasemap of the speckle field, we can find the networks between optical vortices.

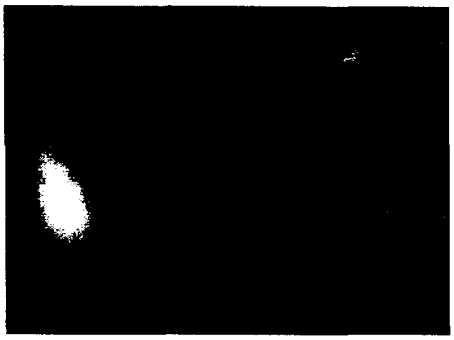

Fig 2. Speckle pattern without reference beam

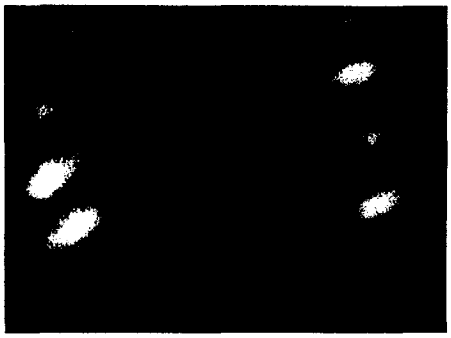

Fig 3. Speckle pattern with 0π-shifted reference beam

Fig 4. Speckle pattern with $\pi/2$-shifted reference beam

Fig 5. Speckle pattern with π-shifted reference beam

Fig 6. Speckle pattern with $3\pi/2$-shifted reference beam

Fig 7. Calculated phasemap of speckle field

1. J. F. Nye and M. V. Berry, "Dislocations in wave trains", Proc. R. Soc. London Ser. A 336. 165-190 (1974).
2. N. B. Baranova, B. Ya. Zel'dovich, A. V. Mamaev, N. Pilipetskii, and V. V. shkukov, "Dislocations of the wavefront of a speckle-inhomogeneous field (theory and experiment)", JETP Lett. 33, 195-199 (1981).
3. I. Freund, N. Shvartsman, and V. Freilikher, "Optical dislocation networks in highly random media", Opt. Commun. 101, 247-264 (1993).