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Field-Theory Revolution for Optics: Revisiting Momentum and Angular Momentum of Light

I will overview recent theoretical and experimental studies, which revisit fundamental dynamical properties of light: momentum, angular momentum, and helicity. I will show that the commonly accepted approach based on the use of the Poynting vector and the corresponding angular momentum does not work well for optical fields and laboratory experiments. An alternative approach requires revisiting the electromagnetic field theory and its connection with optics and quantum mechanics. It turns out that the canonical (rather than kinetic) field-theory picture of gauge-dependent momentum and spin densities of the massless electromagnetic field is perfectly consistent with the laboratory optical experience, provided that the Coulomb gauge is chosen.

The above analysis is not of purely theoretical interest. This new ‘canonical’ approach to the momentum, spin, and helicity of light has allowed us to predict qualitatively new types of the spin and momentum in structured optical fields. These are:
1. The transverse spin angular momentum, which is orthogonal to the wave vector and is independent of the helicity;
2. The anomalous transverse momentum, which depends on the helicity of light and exerts a weak anomalous optical pressure orthogonal to the wave vector.
Both these quantities have attracted considerable attention and have been described and measured experimentally in several optical systems. I will overview these new findings and experiments.

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