Interference of axially-shifted Laguerre-Gaussian beams and their interaction with atoms

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Abstract: Counter-propagating co-axial Laguerre-Gaussian beams [1] are discussed, not in the familiar situation where the focus planes coincide at z=0, but when they are separated by a finite distance d. We consider the simplest case in which the beams are both linearly polarized and explore the characteristics of the interference fields, both in terms of total amplitude distribution and total phase and the influence of such field distributions on the trapping and dynamics of atoms immersed in this field [2].

The interference of counter-propagating Laguerre-Gaussian light beams is considered in a scenario in which the focus planes of the two beams are separated axially by a finite distance d. The total field is shown to possess novel interference properties, most notably in that the combined phase function depends on both the amplitude functions and the original phase functions of the two beams.

The superposition is shown to give rise to a standing wave spanning the axial region between the focus planes. For doughnut modes the field created arising from the superposition represents a finite ring lattice. When the beams are highly twisted, both the Gouy phase and the curvature play significant roles in the interference. The ring lattice represents a finite set of annular optical potentials which by varying the intensity can be made sufficiently deep to trap atoms.

The variations of the finite lattice properties are examined for changes in the characteristic parameters, namely the beam winding number, the magnitude of the beam waist in units of the optical wavelength and the separation of the focus planes. The interaction of atoms such as sodium and rubidium with such a ring lattice is discussed. For counter-propagating beams possessing winding numbers of the same sign or of opposite signs relative to the laboratory observer, the atoms would experience rotational as well as axial forces which can be controlled by choice of parameters and can be enhanced or diminished. The results are illustrated with examples involving typical parameter values and extensions to more complex beam geometries briefly discussed [3].

References

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