Optical Vortices

Applying an azimuthal phase winding, e^{-iθ}, to a TEM_{00} laser beam generates photons with orbital angular momentum, ℏ. Interfering co-propagating, counter-rotating optical vortices creates an azimuthally varying intensity profile, i.e. an angular standing wave.

"Angular" Kapitza-Dirac Scattering

A pulsed angular standing wave diffracts atoms into a superposition of angular momentum eigenstates,

\[ \Psi = \psi_0 e^{-i\theta} e^{i\Theta \cos(2\phi)} = \psi_0 e^{-i\theta} \sum_n (-i)^n j_n(\Theta) e^{-2n\phi}, \]

with angular momentum per particle, 2nℏ, n = 0,±1,±2...

Counter-rotating vortices form a matter wave interference pattern that is sensitive to the Sagnac phase shift on a platform rotating at the rate Ω,

\[ \Delta\phi = 2m\Omega \cdot A / \hbar = 2T\Omega \cdot L / \hbar. \]

For vortices with an angular momentum per particle of L = qℏ, the area enclosed by the vortex wavefunction is A = qℏT/m for an evolution time T.

2D simulations of the nonlinear Gross-Pitaevskii equation to derive the time evolution of the weakly interacting BEC wavefunction for angular Kapitza-Dirac scattering.

\[ 1S_0 \rightarrow 3D_2 \text{ Two Photon Transition} \]

Polarization-entangled photon pairs at 1479 nm and 556 nm are expected to be emitted along the polarization axis of the pump laser.

Retro-reflect 808 nm laser for doppler-free two-photon excitation.

Yb Atomic Beam Fluorescence

The long lifetime (870 ns) of the metastable 3P₁ state allows Yb atoms excited on the 1S₀ → 3P₁ transition to propagate several hundred microns at thermal speeds before radiating.

Potentially study atom-surface interactions in the excited state including coupling of atoms, photons, and surface plasmons for metastable atoms propagating through sub (optical) wavelength apertures.