Atom Optics and Quantum Optics with a Ytterbium Gas

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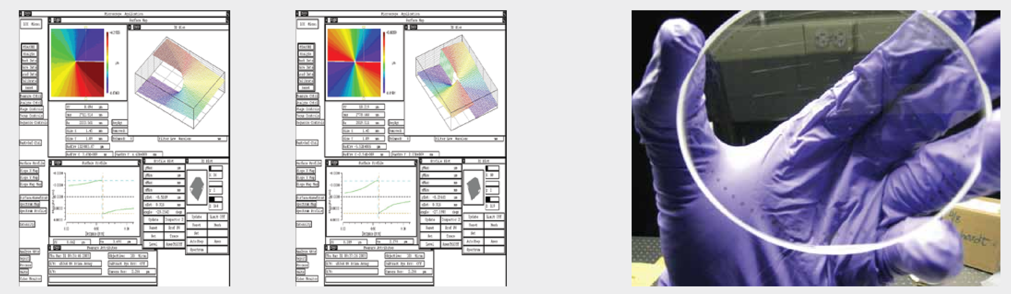
70 $^1S_0$
Yb
Ytterbium
173.04
$[Xe]4f^{14}6s^2$

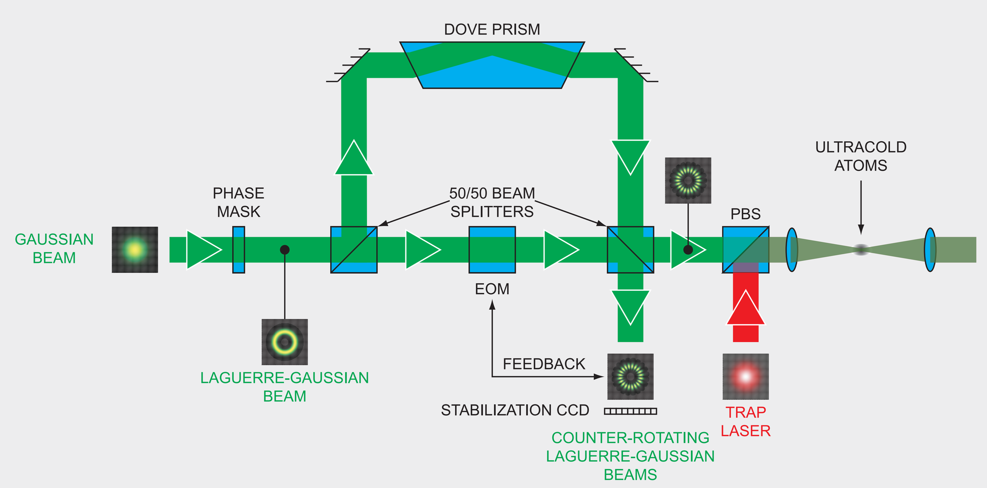
Optical Vortices

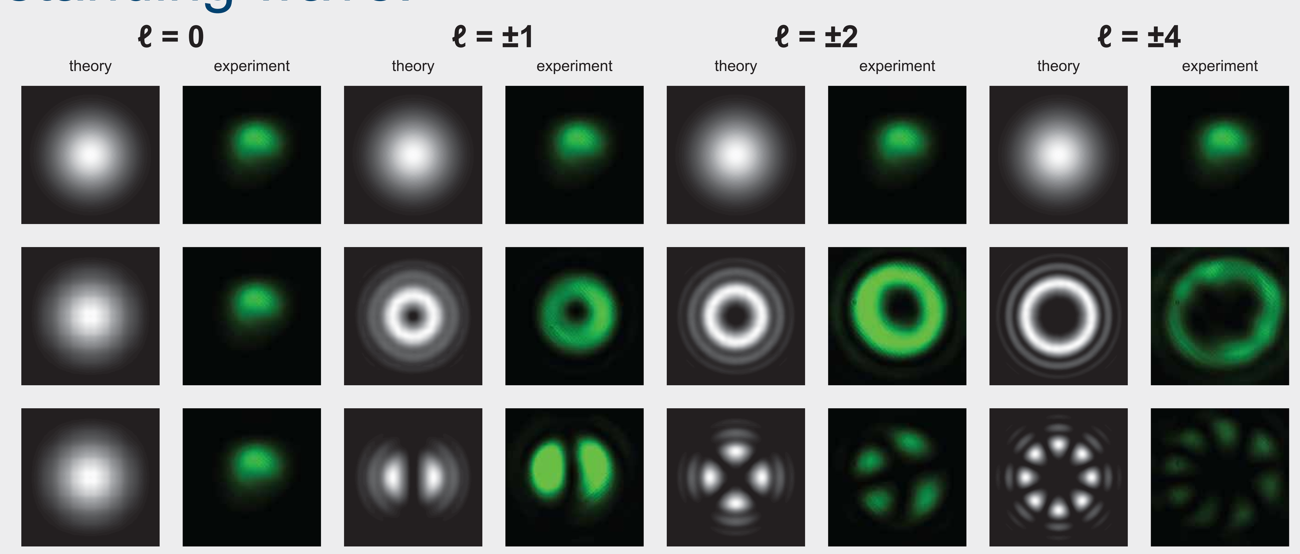
Applying an azimuthal phase winding, $e^{-i\ell\varphi}$, to a TEM_{00} laser beam generates photons with orbital angular momentum, $\ell\hbar$.

http://www.rpcphotonics.com/
charge 1 charge 2



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,

- $\Psi = \Psi_0 e^{-i\Theta} e^{+i\Theta\cos(2\ell\varphi)} = \Psi_0 e^{-i\Theta} \sum_n (+i)^n J_n(\Theta) e^{-i2n\ell\varphi}$,

with angular momentum per particle, $2n\ell\hbar$, n = 0,±1,±2...

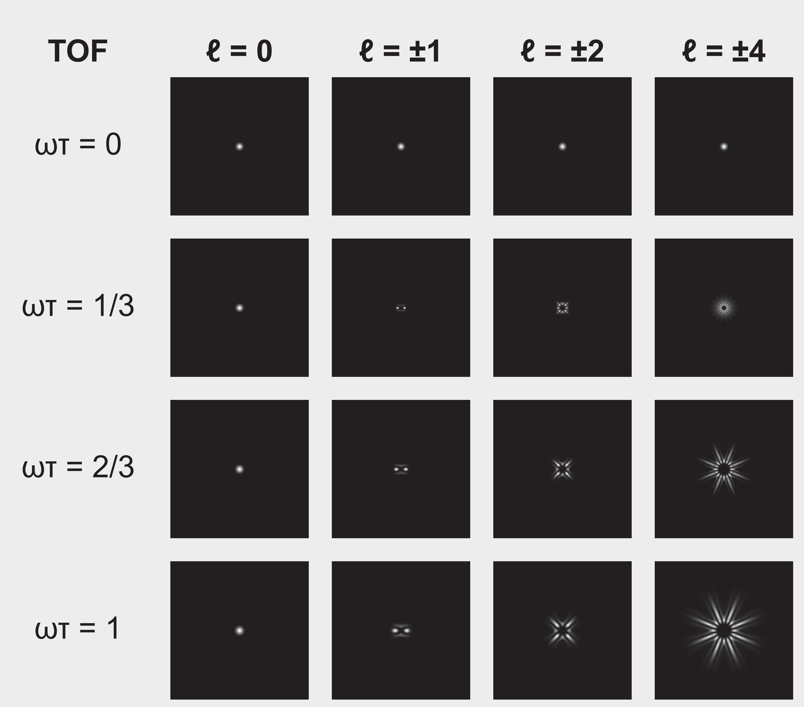
Counter-rotating vortices form a matter wave interference pattern that is sensitive to the Sagnac phase shift on a platform rotating at the rate Ω,

- $\Delta\varphi = 2m\mathbf{\Omega}\cdot\mathbf{A}/\hbar = 2T\mathbf{\Omega}\cdot\mathbf{L}/\hbar$.

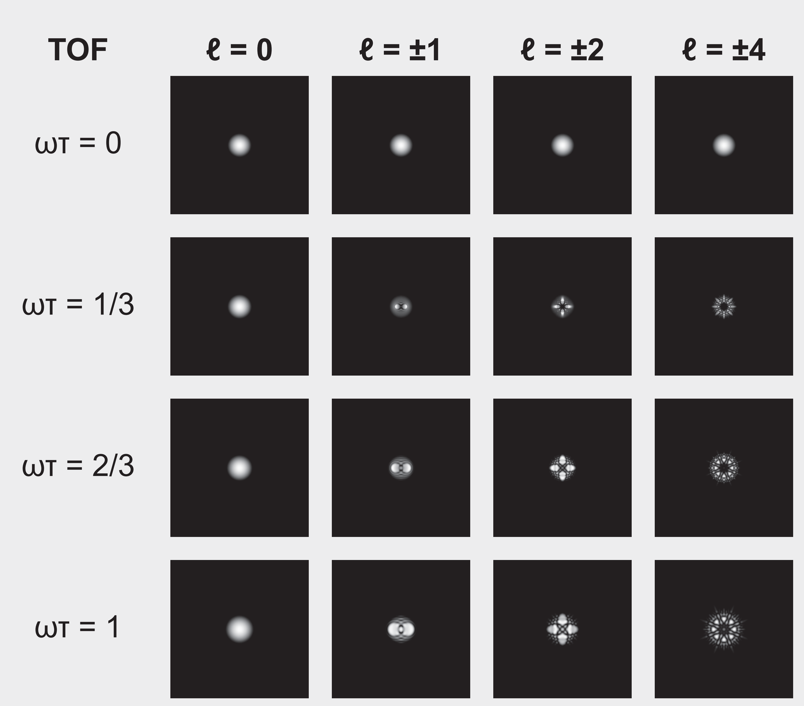
For vortices with an angular momentum per particle of $L = q\hbar$, the area enclosed by the vortex wavefunction is $A = q\hbar T/m$ for an evolution time T.

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

ideal gas (non-interacting atoms)



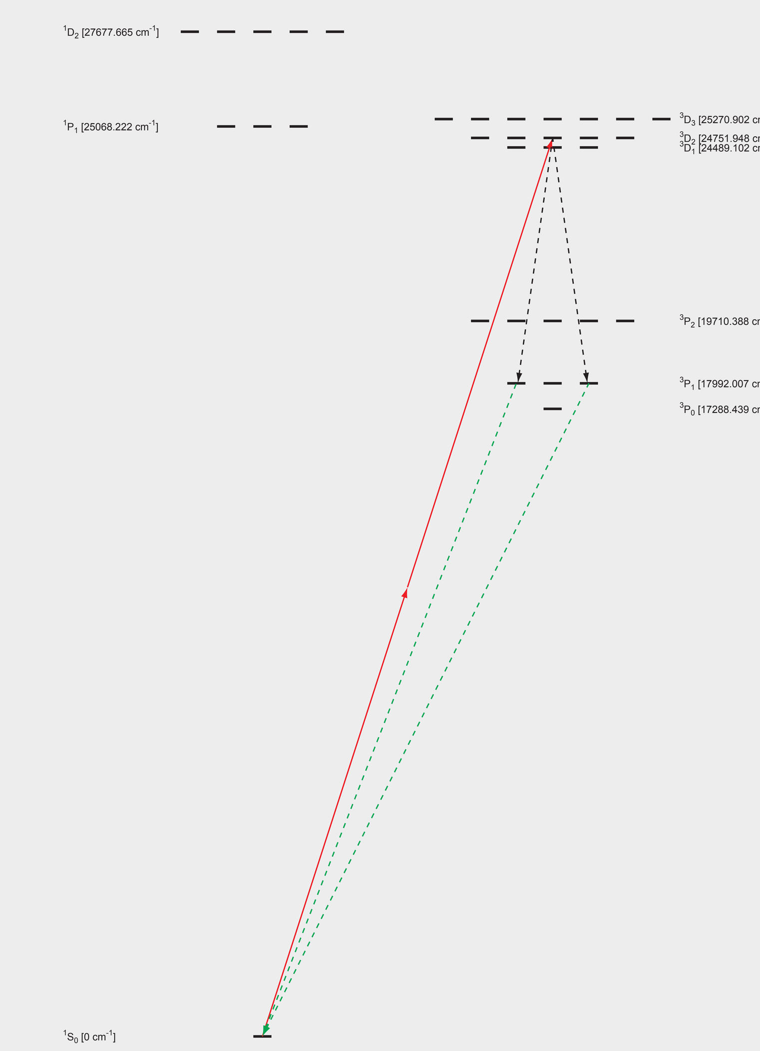
weakly interacting BEC

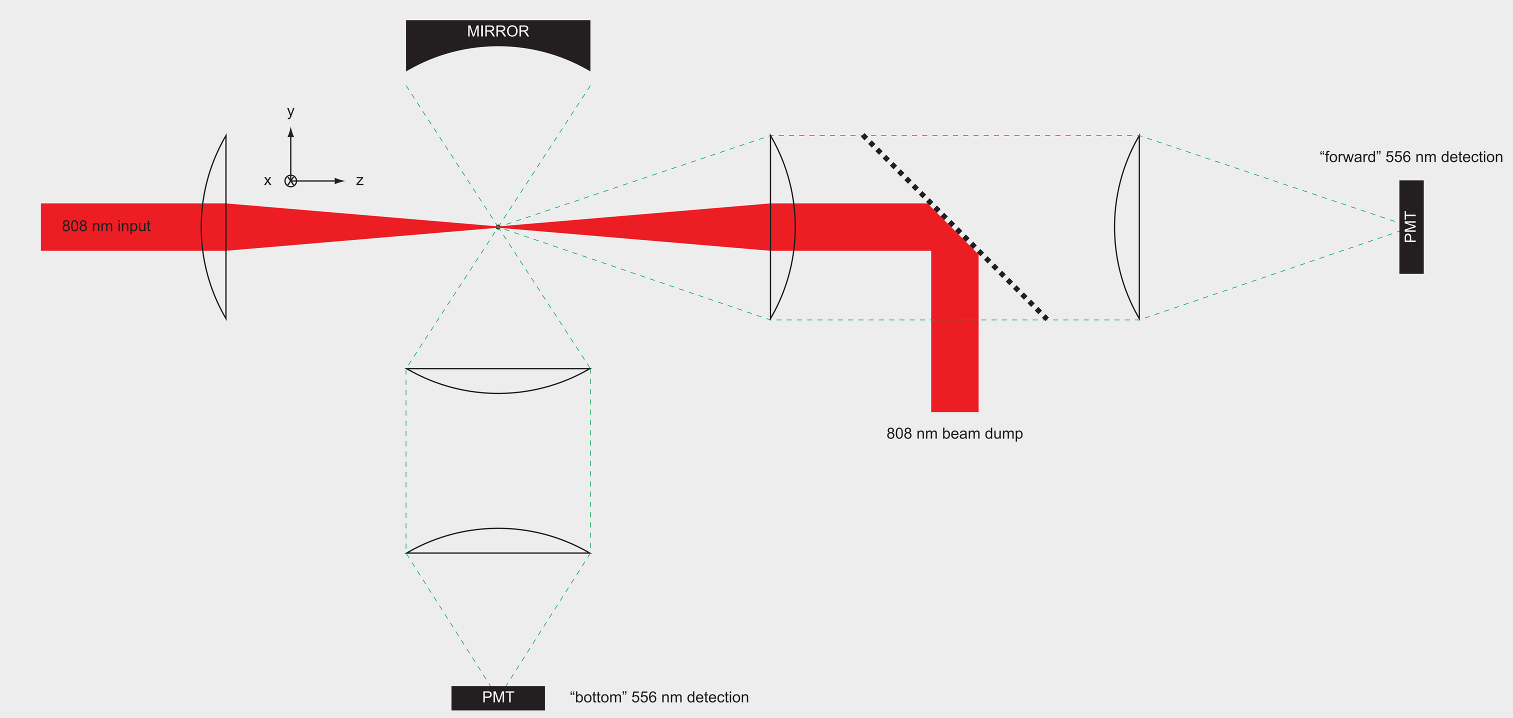


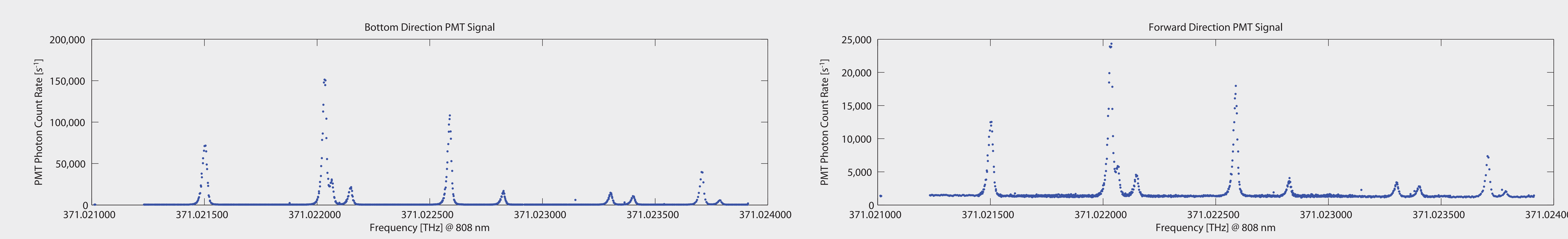
$^1S_0 \rightarrow {}^3D_2$ Two Photon Transition

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.



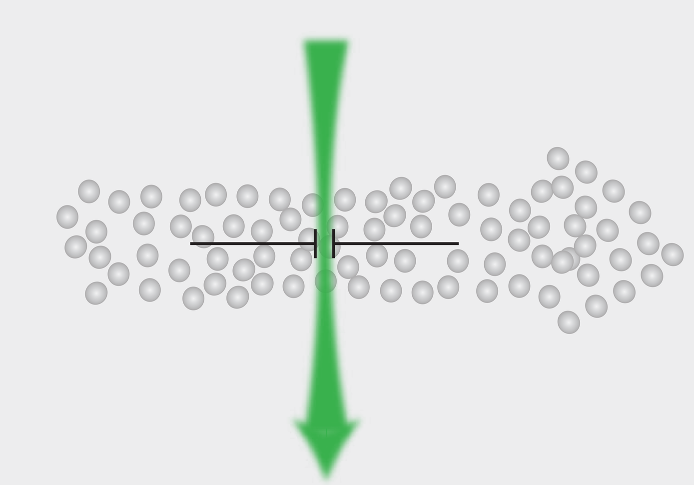




Yb Atomic Beam Fluorescence

The long lifetime (870 ns) of the metastable $^3P_1$ state allows Yb atoms excited on the $^1S_0 \rightarrow {}^3P_1$ 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.



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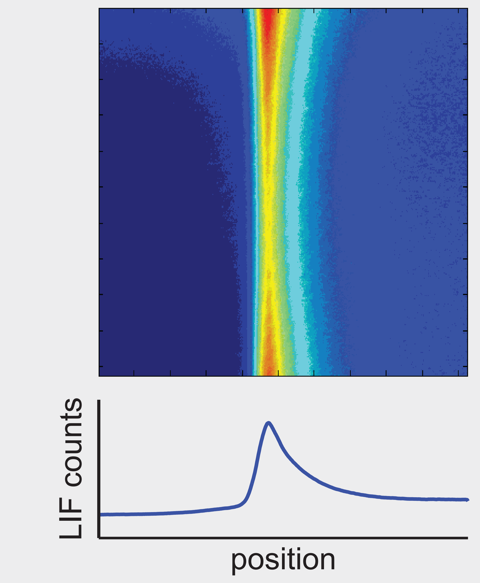

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http://www.umich.edu/~aehardt/