# Exchange of Angular Momentum between Paraxial Optical Vortex Beam and Atoms or Molecules: Mechanism and Applications

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**Abstract**

Exchange of orbital angular momentum (OAM) between Laguerre-Gaussian beam of light and center-of-mass motion of an atom or molecule is well known. In this thesis, we show that orbital angular momentum of light can also be transferred to the internal electronic or rotational motion of an atom or a molecule provided the internal and center-of-mass motions become coupled by light-atom or light-molecule interaction. However, this transfer does not happen directly to the internal motion, but via center-of-mass motion. If atoms or molecules are cooled down to recoil limit then an exchange of angular momentum between the quantized center-of-mass motion and the internal motion is possible during interaction of cold atoms or molecules with Laguerre-Gaussian beam. The orientation of the exchanged angular momentum is determined by the sign of the winding number of Laguerre-Gaussian beam. In interaction with atom, the field OAM can be transferred to the internal electronic motion only in electric quadrupole or higher order transitions. But in interaction with molecules, the field OAM influences the internal rotational, vibrational and electronic motion even in electric dipole transition making it important for many applications. We give numerical calculation of electric dipole and quadrupole Rabi-frequencies in interaction of an optical vortex beam with atomic Bose-Einstein condensate.

The transfer of orbital angular momentum from an optical vortex to an atomic Bose-Einstein condensate changes the vorticity of the condensate. The spatial mismatch between initial and final center-of-mass wavefunctions of the condensate influences significantly the electric dipole transition between corresponding states. We show that the transition rate depends on the handedness of the optical orbital angular momentum leading to optical manipulation of matter-wave vortices and circular dichroism-like effect. Based on this effect, we propose a method to detect the presence and sign of matter-wave vortex of atomic superfluids. Only a portion of the condensate is used in the proposed detection method leaving the rest in its initial state.

**Key words: Optical vortex beam; Optical orbital angular momentum; Laguerre-Gaussian beam, exchange of orbital angular momentum; LG beam and atom; LG beam and molecule; Bose-Einstein condensate; Two-photon Raman transition; Detection of vorticity; Matter-wave vortex.**