# ORBITAL MOTION FROM OPTICAL SPIN: THE EXTRAORDINARY MOMENTUM OF CIRCULARLY POLARIZED LIGHT BEAMS

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The momentum of light, and the radiation pressure forces to which it gives rise, are usually thought to act parallel to the direction of propagation. However, recent work has indicated the existence of a spin dependent component to the momentum and an associated spin force, that arise in inhomogeneous light fields and tend to act in transverse directions [1,2]. Here we present powerful demonstration of the mechanical effects of spin momentum. We consider the underdamped motion of a microsphere in a circularly polarized, counter-propagating Gaussian beam trap, in vacuum. A series of distinct regimes are observed, depending on the ambient pressure and optical power. For very low optical powers (or higher pressures) the trap behaves conventionally, with the sphere attracted to the beam axis by optical gradient forces. In this state, the trap approximates the equipartition theorem, with the variance in Brownian motion being inversely related to the strength of the trap. As the optical power is increased, transverse spin forces bias the Brownian motion, conferring angular momentum to the trapped particle whose motion deviates increasingly from equipartition. If the optical power is increased further, the particle acquires sufficient orbital angular momentum for the centripetal force to balance optical gradient forces and deterministic orbits are formed. Ultimately, increases in optical power result in these orbits destabilizing before the particle is completely ejected. This system acts both as a powerful demonstration of spin momentum and spin forces, and as a test bed for elementary non-equilibrium thermodynamics.

*The research was supported by CSF (project GB14-36681G), MEYS CR (LO1212), its infrastructure by MEYS CR and EC (CZ.1.05/2.1.00/01.0017) and by CAS (RVO:68081731).*

[1] M. Antognozzi, C. R. Bermingham, R. L. Harniman, S. Simpson, J. Senior, R. Hayward, H. Hoerber, M. R. Dennis, A. Y. Bekshaev, K. Y. Bliokh, F. Nori, *Nature Physics* **12**, *731–735 (2016)*

[2] Konstantin Y. Bliokh, Aleksandr Y. Bekshaev, Franco Nori, *Nature Communications* **5**, *3300 (2014)*