Optical Archimedes Screw Along Arbitrary Trajectories

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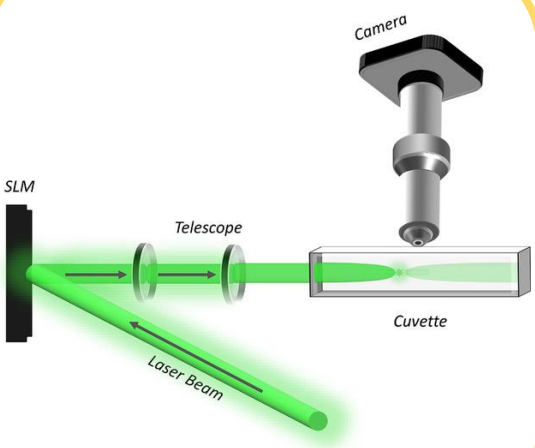
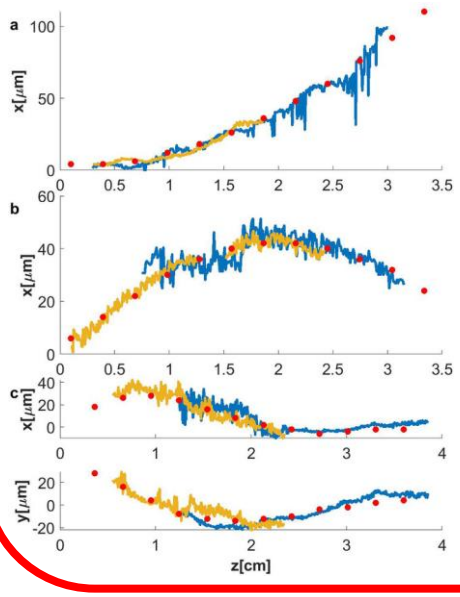
Optical conveyors of airborne particles were previously demonstrated using different techniques allowing particles to be conveyed along straight trajectories either down or upstream the laser radiation direction. Here, we demonstrate the operation of of an optical conveyor which has the geometry of an Archimedes screw whose central axis is a predefined arbitrary trajectory in 3D space allowing to convey particles along any desired paraxial trajectory.

Experimental setup.

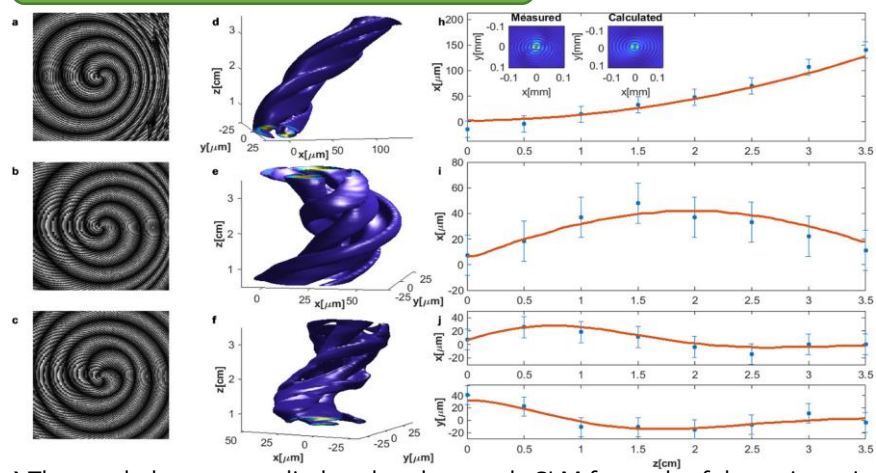


Screw-velocity-matched particle motion.



a) Planar parabolic trajectory.
b) Planar sinusoidal trajectory.
c) Volume trajectory.
Sampled points along the numerically simulated trajectory (red). Downstream particle motion (blue) and upstream particle motion (yellow).

Curved optical Archimedes' screw.



a–c) The mask that was applied to the phase-only SLM for each of the trajectories. **d–f)** Simulation of several iso-intensity surfaces of the beam in a volume after the 4f system. **g–i)** Numerically simulated theoretical trajectories (red) and experimentally recorded points along the trajectories (blue). Error bars indicate the quadrature of the measurement error. Insets in (h) are (right) the beam cross section in simulation and (left) as captured on a camera.

Discussion

This curved optical analog to the famous Archimedes' screw allows transfer of rotational movement of two Bessel-like beams to the curved focal axis movement of a trapped particle within the beam. We believe this method could be applied to low-index particles in suspension repelled by light due to a negative gradient force. Furthermore, the method of superposing two beams with different local axial wave vector and different OAM to achieve our beam should be applicable also to non-paraxial beams to achieve trajectories with steeper bending profiles.

Questions?

Keren Zhalenchuck, Barak Hadad, and Alon Bahabad, Optical Archimedes Screw Along Arbitrary Trajectories, Lasers & Photonics Reviews, 16, 2100621 (2022)