Novel Vortex Laser

A high-power and high-efficiency new methodology for laser vortex creation that enables new devices and applications with vortex spatial format.

Proposed use
The invention can be used to create new bespoke vortex lasers and could retrofit existing lasers (e.g. solid-state, fibre) to provide vortex output. Higher-order vortices and mode superposition can be generated if the laser operates itself on an internal mode that is vortex: useful for optical trapping, levitation and manipulation of micro- and macro-particles. Vortex beams can enhance the efficiency of laser manufacturing processes, provide advantages in free-space communications being more robust to atmospheric turbulence and offer improved data encryption.

Problem addressed
Relatively little progress has been made for high power vortex generation and even less for high efficiency, robust and compact systems. The generation of vortex beams is predominantly done by converting a Gaussian beam externally to the laser using mode conversion techniques. The spatial light modulator (SLM) has become a primary technology for generating almost any light pattern one could want, but they have very low power-handling capability and high expense which are major limitations.

Technology overview
The invention is a low-cost, high-power and high efficiency new methodology for vortex creation: an interferometric output coupling methodology that spatially transforms the output of the laser.

**Benefits**
- Vortex laser beam generation at much **higher power** and **pulse energy** than most commonly used mode transformation elements (SLMs, Q-plates)
- **Direct generation** from a laser with **high efficiency**
- Enables the creation of **new bespoke vortex lasers**
- Allows existing non-vortex (Gaussian) laser systems to be **directly retro-fitted** into a vortex laser with **little adaptation**
- **Handedness** of the vortex can be **controlled, selected or switched**
- Output transmission of the laser into the vortex mode can be **continuously controlled** allowing optimisation of power and efficiency of system
- **Selectivity** of the interferometric output coupler can “**clean-up**” the quality of the internal laser mode during the vortex generation
- **Low-cost** vortex output coupler

**Figure 1** shows spatial quality results of the internal cavity mode, mode transformed vortex output, and an interferogram of the vortex beam with a plane wave to display the spiral phase structure.

---

Dr. Marcio Siqueira  
Director of Industry Partnerships and Commercialisation  
Faculty of Natural Sciences  
e: m.siqueira@imperial.ac.uk  
t: +44 (0)207 594 5505  
Technology reference: 9033
Intellectual property information
Patent: PCT/GB2019/052729

Links to published papers


Inventor information
Professor Michael Damzen and Dr William Kerridge-Johns