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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.

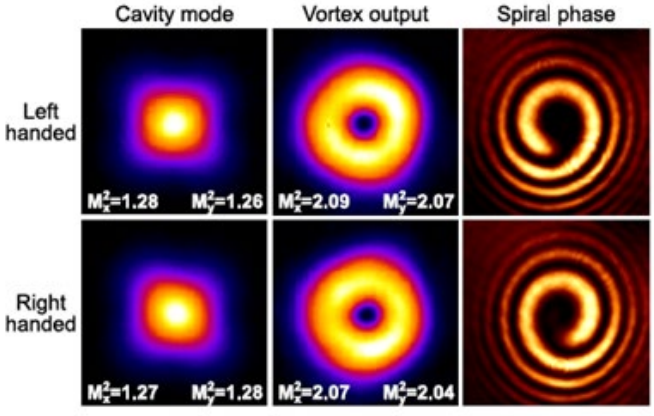

Figure 1 | Figure 1 shows spatial quality results of the internal cavity mode, mode transformed vortex output, and an interferogram of the vortex beam with a plane wave to display the spiral phase structure.

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 **vorticity** 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

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Intellectual property information

Patent : PCT/GB2019/052729

Links to published papers

Geberbauer, J. W. T., Kerridge-Johns, W. R., & Damzen, M. J. (2020). Q-switched laser with self-mode-filtering interferometric vortex output coupler. OSA Continuum, 3(2), 204-213.

Damzen, M. J., Kerridge-Johns, W. R., & Geberbauer, J. W. T. (2019). Vortex mode transformation interferometry. Journal of Optics, 22(1), 015604.

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Inventor information

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