UNIVERSITY OF BIRMINGHAM

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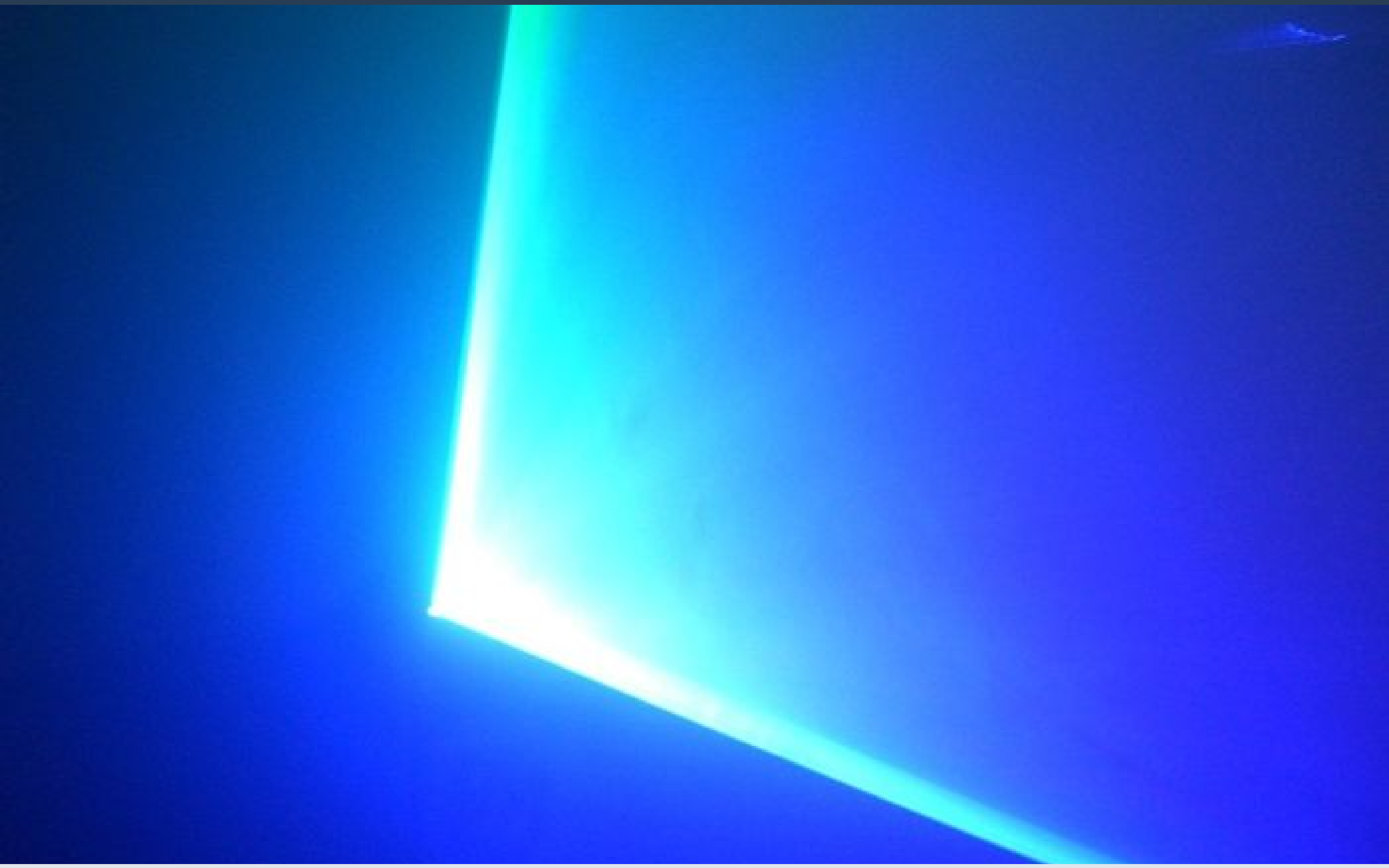
Optical Frequency Manipulation

Stable laser frequency pair using an optical IQ modulator configured to produce a single sideband.



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IP Status

Provisional patent, Patent application submitted

Seeking

Licensing, Development partner, Commercial partner

About **University of Birmingham**

At the University of Birmingham our research leads to new inventions and fuels innovation and business growth.

Background

To obtain compact and mobile quantum sensors for use outside of a laboratory environment (e.g. in super high-precision navigation instruments or local gravity sensors), it is necessary to generate a stable laser frequency pair with coherent phase. The noise levels generated by current two-photon laser systems are presently too high and can significantly obscure any useful signal readings. Other solutions tend to be complicated or bulky.

Academics at the University of Birmingham have developed an optical subsystem to generate a stable laser frequency pair using an optical IQ modulator configured to produce a single sideband at a modulation frequency higher or lower w.r.t. the carrier frequency.

Two-photon stimulated Raman transition, as a tool to coherently manipulate particles with light, has been widely used in quantum information, quantum optics, atomic spectroscopy, laser cooling and atom interferometry. In relation to light-pulse atom interferometry, this technique promotes the development in measurements of local gravity, gravity gradients, rotation, fine-structure constants, magnetic field gradients and the Newtonian gravitational constant, G. Recently much effort has been made to enhance the compactness and mobility of such quantum sensors, aiming to open their applicability outside the laboratory environment. One aim is to design a compact and robust laser system to generate a Raman frequency pair. Phase noise between the two lasers for generating the pair is directly incorporated into the phase of the atom interferometry output, which limits the sensitivity of the atom interferometer.

Tech Overview

Academics at the University of Birmingham have developed a novel apparatus and technique for optical frequency manipulation employing an optical IQ modulator to realize the required phase modulation while outputting only an optical single sideband with full carrier (OSSB-FC) or an optical single sideband with suppressed carrier (OSSB-SC).

The technique offers the capabilities of coherent manipulation of quantum states and optical frequency flexibility. Applications of the invention include atom interferometry and in simple robust constructions of cold atom based devices.

An advantage of the invention is that additional laser lines can be suppressed to negligible levels by using the optical IQ modulator. This technique can for example be used to generate Raman laser frequencies to drive two-photon Raman transition with low phase noise, and any interference caused by additional laser lines can be eliminated. A further advantage is increased power efficiency compared with conventional ODSB modulation.

The IQ modulator is configured to produce a single sideband at a modulation frequency higher or lower with respect to the carrier frequency, being the frequency of the light from the laser source. The IQ modulator may be configured to modulate light from the laser source to additionally produce a carrier at a carrier frequency, i.e. for an OSSB-FC scheme. In such a scheme, the IQ modulator may be configured to suppress a second sideband at a second sideband frequency by at least 20 dB relative to the power of the carrier frequency. Other sidebands at multiples of the modulation frequency may also be suppressed by at least 20 dB relative to 5 the power of the carrier frequency.

In alternative embodiments, the IQ modulator may be configured to suppress at the power of the carrier frequency by at least 20 dB relative to the single sideband, i.e. for 10 an OSSB-SC scheme.

The optical subsystem may comprise a nonlinear optical frequency converter coupled to an output of the IQ modulator and operable to convert the modulated light. The nonlinear frequency converter allows the modulated light to be raised to a frequency range compatible for manipulating the atomic sample, for example for use with twophoton stimulated Raman transition. The nonlinear optical converter may be configured as a bandpass filter to suppress the generation of undesired optical frequencies.

Benefits

Generation of a laser frequency pair with:

- Coherent manipulation of quantum states and optical frequency flexibility;
- Extremely low phase noise;
- Easy & compact set-up;
- No undesirable contamination with side-product frequency pairs;
- Flexible light treatment for various applications;
- Increased power efficiency.

Applications

This technology wil be of interest to companies making:

- customised equipment incorporating optical modulation
- lab equipment incorporating optical modulation
- optical subsystems

Patents

- GB provisional application no. 1712072.6, filed 27 July 2017.
- International PCT application no. PCT/GB2018/052115, filed 27 July 2018.