Mirrorless lasing for remote magnetometry

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The interaction of resonant laser light with atomic vapor is at the heart of one of the most sensitive methods to measure magnetic fields. Alkali-based magnetometers are used in a wide range of applications from biomagnetic measurements to material science. Since initialization and read-out of the resulting atomic spin evolution can be performed optically and therefore contactless, this method offers a unique way of measuring magnetic fields remotely.

Most recently, this technique was used to measure the local magnetic field in the mesosphere [1]. At 85 to 100 km above the earth surface the atmosphere contains some amount of atomic sodium. Shining a resonant laser beam into this layer causes the sodium atoms to emit fluorescence, which can be observed with ground-based telescopes. Astronomers use this light as a reference to sample and compensate the effects of atmospheric turbulence in astronomical observations. In addition, if the laser beam is intensity modulated at a frequency around the local Larmor precession frequency of sodium in the atmosphere, an increase in fluorescence can be observed. The resultant magnetic resonance can be used to infer the strength of the magnetic field.

Fundamentally, the sensitivity of this method depends on the amount of collected photons. For isotropic fluorescence the number of collected photons scales with the solid angle subtended by the receiver. For a 1 m^2 aperture telescope in 90 km distance from the emitting layer the fraction of collected photons is on the order of 10^{-11}. The possibilities of generating directional light emission from the sodium layer [2,3] could considerably boost the sensitivity of atmospheric magnetometry and enable interesting new applications, like real-time mapping and monitoring of Earth magnetic field in the mesosphere over a wide area.

I will give an overview of the rapidly developing field of remote magnetometry and discuss recent developments by our group and collaborators.

REFERENCES

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