Application of Optical Single Sideband Generation in Raman Atom Interferometry

C. Rammeloo[1], L. Zhu[1, 2], Y.-H. Lien[1], C. Macrae[1], M. Khan[1], K. Bongs[1], M. Holynski[1]

Y.-H. Lien

[1]y.lien@bham.ac.uk, School of Physics and Astronomy, University of Birmingham, Birmingham B15 2TT, UK

[2]College of Artificial Intelligence, National University of Defense Technology, Changsha, 410073, China

Atom interferometry is increasingly being applied outside laboratory environments, for instance, in precision measurements of surveys of gravitational acceleration and on mobile platforms. This drives a demand for compact and efficient laser systems that address transitions between hyperfine split ground states in alkali atoms. Such precision measurements require two phase-stabilized laser beams at different frequencies for which several compact laser systems have been developed. The systems based on a 1560 nm telecomm laser using electro-optic modulator (EOM) and frequency doubling technique are very appealing because of compactness, robustness and mature supply chains. Nevertheless, the double sideband (DSB) spectrum generated by EOM also unavoidably drive weaker parasitic Raman transitions which induce spatial dependences of Rabi frequency and phase shift [1].

A frequency doubled I/Q modulator based optical single-sideband (OSSB) laser system is demonstrated for atomic physics research, specifically for atom interferometry where the presence of additional sidebands causes parasitic transitions [2]. The performance of the OSSB technique and the spectrum after second harmonic generation are measured and analysed. The additional sidebands are removed with better than 20 dB suppression, and the influence of parasitic transitions upon stimulated Raman transitions at varying spatial positions is shown to be removed beneath experimental noise. This technique will facilitate the development of compact atom interferometry-based sensors with improved accuracy and reduced complexity.

Reference:

[1] O. Carraz, R. Charrière, M. Cadoret, N. Zahzam, Y. Bidel, and A. Bresson, “Phase shift in an atom interferometer induced by the additional laser lines of a Raman laser generated by modulation”, Physical Review A **86**, 033605 (2012).

[2] L.-X. Zhu, Y.-H. Lien, A. Hinton, A. Niggebaum, C. Rammeloo, K. Bongs, and M. Holynski, “Application of optical single-sideband laser in Raman atom interferometry”, Optics Express **26**, 6542-6553 (2018).