SE-06-03

Advances in optical frequency comb technology and its impact on atomic and molecular sensing

Hajime Inaba

National Institute of Advanced Industrial Science and Technology

Abstract

Optical frequency comb is a light whose comb-shaped spectrum consists of laser modes at equal frequency intervals and is sometimes called an "optical ruler" due to its frequency precision. When they first appeared at the end of the 20th century, their main application was absolute frequency measurement for lasers, but 25 years later their applications have greatly expanded. It is also closely related to atoms and molecules. Here I will introduce the frequency comb and talk about our comb research related to atoms and molecules.

The first topic concerns the application to optical clocks, such as optical lattice clocks. Optical clocks require many frequency-stabilized lasers to cool the atoms. They also use the forbidden transitions of the atoms as clock transitions, and use highly stable lasers to observe their narrow spectral widths. These are very compatible with optical combs.

The second topic concerns an application called "dual-comb spectroscopy", which is mainly used for molecular gas analysis. Dual-comb spectroscopy uses two frequency combs and has the advantages of high resolution, wide bandwidth, and high speed, and it has been enthusiastically studied in recent years with the aim of practical application.

The third topic concerns the frequency comb for wavelength calibration of astronomical spectrograph, known as "astro-comb". To measure the wavelengths of absorption and bright lines of atoms and molecules with high precision using a spectrograph, the spectrograph is used while being calibrated in real time with a frequency comb. Since the resolution of a spectrograph is typically 10 GHz or higher, an optical comb with a repetition frequency sufficiently higher than 10 GHz is required.