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Spectroscopy with a mode-locked Femtosecond Laser Frequency Comb

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The Nobel prize winning technology involving a mode-locked femtosecond laser frequency comb (FLFC) has been at the epi-centre of a scientific revolution over the last two or so decades. Even though originally designed to count cycles in optical clocks, it has had a profound impact on other research areas, with a range of applications including spectroscopy, trace gas detection, signal processing, astrophysics and many others. In the near future most of these applications may be taken over by the compact monolithic micro-resonator generated frequency combs, there is, however, no doubt that mode-locked FLFC will continue growing their range of applicability over the next few decades.

We present a brief overview of two simple high-resolution high-precision spectroscopy experiments. One experiment is of caesium-133 atoms contained in a vapour cell, and the other molecular spectroscopy where multi-channels are simultaneously detected by a charge coupled device (CCD) camera with a specimen imprinting its unique fingerprint. In both experiments excitation is through radiation from a mode-locked FLFC.

In the caesium experiment the laser beam is set counter-propagating after the beamsplitting cube, focussed to a reasonable waist in the interaction region in the vapour cell, thereby exciting a multitude of low lying magnetic dipole and electric quadrupole transitions allowing the measurement of transition energies and hyperfine coupling coefficients for the $8S$, $9S$ and $7D_{3/2,5/2}$ states.

In the second experiment the comb is filtered by a Fabry-Perot cavity changing the repetition rate of the laser from 1 GHz to repetition rates in the range 3 - 15 GHz to match the resolution of the spectrometre. The spectrometre comprises of the Virtually Image Phased Array, the 2400 lines/mm reflection grating and the CCD camera.

We discuss, the spectrometre, the results of both experiments, and briefly some other possible applications of laser comb.

Level (Hons, MSc, PhD, other)?

PhD

Consider for a student award (Yes / No)?

No

Would you like to submit a short paper for the Conference Proceedings (Yes / No)?

Yes

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