Indigenous development of Coherent Population Trapped Rubidium Atomic Clock

Ashish Agarwal, G. M. Saxena, Anusha Krishna[1], Ajay Wasan[1], and Vasant Natarajan[1]

Time and Frequency Section,
National Physical Laboratory
Dr. K.S.Krishnan Road
New Delhi 110 012, India

[1]Department of Physics
Indian Institute of Science
Bangalore 560 012, India

Abstract:

The phenomenon of coherent population trapping (CPT) of atomic states has been known for a long time. It has several important applications such as in atomic clocks, laser cooling (velocity-selective coherent population trapping or VSCPT), electromagnetically-induced transparency, and precision measurements. In recent times, a lot of research work has gone into the development of CPT-based Rb atomic clock as it has several advantages: low cost, small size, and good frequency stability. In this paper, we discuss the development of such atomic clock in India. We are currently working with 1" diameter Rb absorption cell containing 1 mg of ^{85}Rb and nitrogen buffer gas at 50 torr. The Rb atoms are illuminated with a diode laser operating at 794.7 nm (D_1 line of Rb). The laser is frequency modulated (FM) by modulating the injection current into the diode. When the modulation frequency is 1.5 GHz, i.e. exactly half of the ^{85}Rb ground-state hyperfine interval, the FM sidebands couple both hyperfine levels to the excited *P* state. Due to destructive quantum interference between the absorption pathways, the atoms do not absorb the radiation and a dark resonance is created. This is the phenomenon of CPT. The linewidth can be very small because it is only limited by the decoherence time in the ground state. The use of buffer gases in the cell is to make the coherence time long. Furthermore, unlike conventional atomic clocks, the CPT clock does not use a microwave cavity, and hence there are no broadening or pulling effects due to the cavity. The CPT Rb clock is superior to the conventional laser pumped Rb atomic clock as it has good resonant signal strength and contrast, reduced light shift, and very low power requirement. The light shift broadening is also reduced as CPT gives rise to dark resonance.