université PARIS-SACLAY

ÉCOLE DOCTORALE
Ondes et Matière (EDOM)

Title : Dual-frequency optically-pumped semiconductor laser for atomic clocks based on coherent population trapping of cesium atoms

Keywords : Semiconductor laser, metrology

Abstract : Atomic clocks using the coherent population trapping (CPT) technic are excellent candidates to obtain frequency references that are stable, compact and with a low power consumption. In the case of cesium atomic clocks, this technic require a dual-frequency laser field either at 895 nm (D1 transition) or 852 nm (D2 transition) and whose frequency difference is equal to 9.19 GHz, the frequency splitting between the two hyperfine levels of the fundamental state. Here we present a new concept for generating this type of laser field using a unique dual frequency and optically-pumped laser with a dual-polarized emission.

In this manuscript, we study the conception of such a laser source with an emission tunable at the D2 transition of cesium atoms. We detail the design of the intracavity elements and the semiconductor active structure. Then we describe the experimental set-up and characterization of a first prototype. We present the stabilization set-up of the laser based on two different servo-loops, one used to lock the optical frequency onto the cesium transition and the other to lock the frequency difference onto the frequency generated by a local oscillator. We report a complete simulation and characterization of the main laser noises: the laser intensity noise, the optical frequency noise, and the phase noise of the radiofrequency signal generated by the beatnote of the two laser modes. We show the first experimental results of coherent population trapping obtained with the prototype. Finally we establish a noise budget of a CPT atomic clock by estimating the impact of each laser noises. After we identify the system limits, we propose different ways to improve the dual-frequency which rely on the reduction of the intensity noise and the modification of the semiconductor structure design.

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