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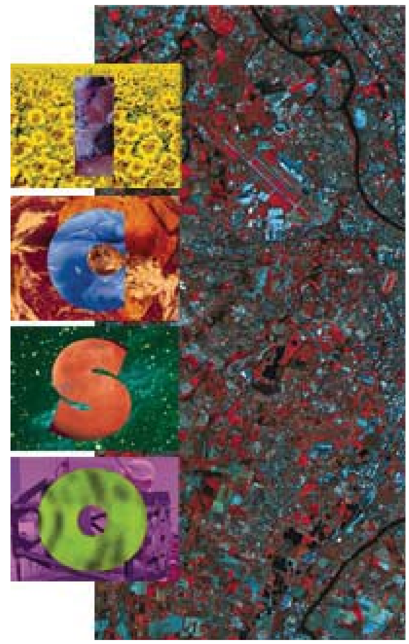

Study of key components for pharao laser source :extended cavity laser and acousto-optic modulator

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ABSTRACT

Study of key components for PHARAO Laser Source : Extended Cavity Laser and Acousto-Optic Modulator

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The new generation of atomic clocks, using cold atoms, require laser beams with high spectral quality and very fine frequency control. In the PHARAO Project, these laser beams are generated by a subsystem called «Laser Source », using a lot of various optical components, mechanisms and electronic devices.

This device requires laser oscillators having a very low spectral width (~ 100 kHz) and a very high frequency stability. The concept commonly used to obtain such a spectral width is the Extended Cavity Laser (ECL), which is made of a laser diode in an external cavity. The laser frequency is controlled by the polarisation current and moreover by the temperature of the laser diode and the length of the external cavity. Some actuators are used to control this length. A servo-loop locks the laser frequency on an saturated absorption line of Caesium atoms.

Various optical and mechanical designs can be used for an ECL. For a space application, we have to insure the ability to find automatically a good operating point (right frequency with good spectral characteristics), before and after launching, ie in vacuum as well as in air. This implies a very strong optical and mechanical design, and a good thermal regulation.

Different interactions between laser beams and atoms are involved in PHARAO and require different laser frequencies. The « Laser Source » of PHARAO uses different Acousto-Optic Modulators (AOM) to precisely shift frequencies from the saturated absorption line chosen for the frequency locking. AOM components diffract the laser beam when an RF signal is applied, and modify its frequency and direction. The deflection angle is controlled by the design of the AOM, the RF frequency applied, the medium where the AOM is used. The temperature of the crystal, depending of the feeding RF power and the time during which the RF signal is applied, can also modify the output laser beam direction.

The good operation of PHARAO Laser Source requires an optimisation of the AOM design to determine the acceptable trade-off between the diffraction efficiency, the stability of the output beam angle and the electrical power consumption. We also have to characterise the operation in vacuum and in air when the RF signal is sequentially ON and OFF.

We present, for these two key components of PHARAO Laser Source (Extended Cavity Laser and Acousto-Optic Modulator), the studied concepts and their behaviour in vacuum as a function of the temperature. Such a behaviour and its influence on the laser beam characteristics are not easy to simulate in the optical model of the PHARAO optical bench. So we have experimented these components in larger optical ensembles representing the key functions of PHARAO Laser Source and characterised them to prove the feasibility.