Noise analysis of two single frequency solid state lasers as candidates for an optical atomic clock based on neutral calcium atoms

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Single frequency solid state lasers (SFSSL) are compact and robust solutions for high resolution spectroscopy and atomic cooling and nowadays a widely accepted alternative to expensive and cumbersome dye laser systems. Among the most used methods to achieve SFSSL in the visible are external cavity diode lasers (ECDL) and diode pumped rare-earth doped crystal hosts. While intracavity second harmonic generation of the $F_{3/2}$-$I_{13/2}$ transition of diode-pumped, Neodymium doped hosts for single frequency operation (ICSHG-DPSSL) has been widely addressed in the literature, much less reports exist for other neodymium transitions. Here we analyze two SFSSL candidates for a local oscillator in an optical atomic clock based on the $^1S_0$– $^3P_1$ inter-combination transition of neutral calcium atoms at 657 nm: one ECDL and one intracavity frequency-doubled, diode-pumped Nd:YLF ring laser, operating at the π-polarized $F_{3/2}$-$I_{15/2}$ (λ = 1314nm) transition and pumped by a high power, fiber-coupled diode laser (HPDL) at 806 nm (LIMO) [1-3]. The compact ECDL system consists of a 30 mW diode laser employed in Littman configuration and locked to a Fabry-Perot reference cavity by the Pound-Drever-Hall technique [4]. We compared the amplitude modulation (AM) and frequency modulation (FM) noise for both lasers at the same output power at 657 nm (20 mW), which is the maximum output power of the external cavity diode. For the AM noise, both laser beams were detected using a silicon photodetector with 50 MHz bandwidth (Thorlabs, PDA36A). The corresponding current fluctuations were recorded using a spectrum analyzer (Agilent, E4407B), see Figure 1.

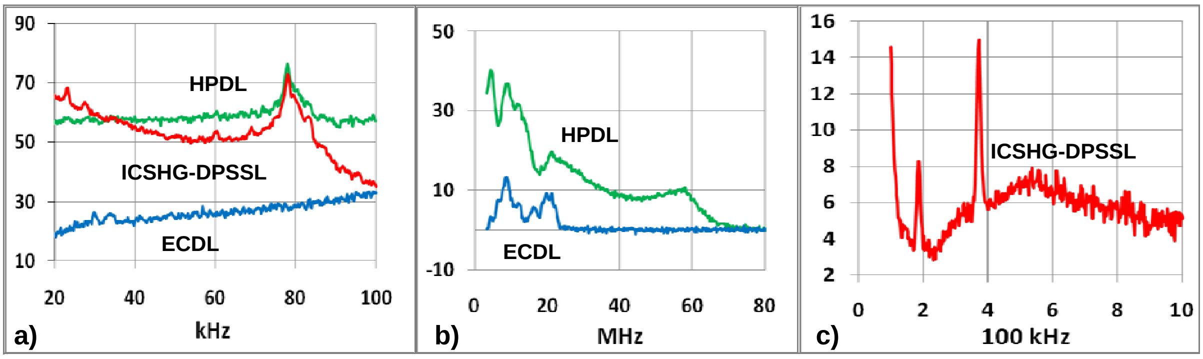

Fig. 1 Vertical axis is normalized amplitude noise (dBm); HPDL the high-power pump diode (green); ECDL the external cavity frequency doubled diode laser (blue) and ICSHG-DPSSL (red) the intracavity frequency-doubled and diode pumped Nd:YLF laser. Noise spectra are taken (a) from 0 – 100 kHz, (b) 0 – 80 MHz and (c) 100 kHz – 1 MHz.

From figure 1a we can see that the amplitude noise of the DPSSL is governed by the HPDL that inserts noise into the signal up to 80 MHz (figure 1b). Nevertheless, this noise is filtered by the DPSSL and a strong attenuation of approximately 50 dB exists already at 150 kHz (figure 1c). The ECDL shows lower noise up to 10 kHz (figure 1 a), which however extends to higher frequencies, compared to the DPSSL, showing a 13 dBm level at 24 MHz (figure 1b). Further details will be presented at the conference.

References

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