

In order to keep the average current of the P-I servo output zero, the PZT (piezo electric transducer) of the slave ECDL is controlled after integrating the output of P-I servo with a bandwidth of few 10 Hz. We measured the phase noise of PLL with a FFT (Fast Fourier transform) analyser (Stanford Research Systems, SR785) in the frequency from 1 Hz to 100 kHz and a phase noise analyser (Agilent, E5052B) in the frequency up to 20 MHz, respectively.

3. RESULTS AND DISCUSSION

The residual phase noise between phase-locked two ECDLs is shown in Fig. 2. The phase noise in the frequency from 1 Hz to 100 kHz is measured by using a FFT analyser for a base band signal from the analog phase detector. For an offset frequency between 100 kHz and 20 MHz, we measured the phase noise of downconverted 100 MHz signal with the phase noise analyser while PLL is activated. The spectrum of the phase noise shows that the PLL bandwidth of direct current feedback through the RF port of the bias-T reaches up to 8 MHz. Another servo bump at offset frequency near 1.5 MHz is due to the P-I servo loop with a medium bandwidth and a high gain. The phase noise reaches a plateau of $-125 \text{ dB rad}^2/\text{Hz}$ from 500 Hz to 200 kHz, and below a level of $-120 \text{ dB rad}^2/\text{Hz}$ from 100 Hz to 300 kHz. When the phase-locked laser system is applied to a cold atom interferometry, we need to consider a weighting function causing the phase noise of atom interferometer [6]. This weighting function acts as a low-pass filter whose cut-off frequency is around the Rabi frequency of the phase locked Raman laser pulse interacting with cold atoms [5,6]. Because of very low phase noise characteristics in high offset frequency up to 300 kHz, our laser system can be applicable for the atom interferometry with shorter Raman pulses, which will be lower the systematic effect on atom interferometry.

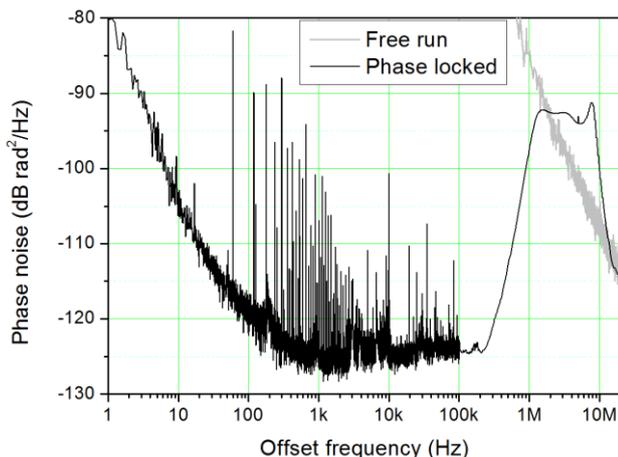


Fig. 2. Phase noise spectral density of PLL measured by FFT analyser (Stanford Research Systems, SR785) between 1 Hz to 100 kHz. For an offset frequency between 100 kHz and 20 MHz, the phase noise of downconverted 100 MHz signal is measured by a phase noise analyser (Agilent, E5052B). Phase noise of beat-note signal for free running state is measured by a RF spectrum analyser (Agilent, E4445A).

In summary, we have developed the heterodyne phase locked laser system with a PLL bandwidth of about 8 MHz. Moreover, the low residual phase noise level of below $-120 \text{ dB rad}^2/\text{Hz}$ in the offset frequency from 100 Hz to 300 kHz has been achieved, which is the lowest residual phase noise ever reported with two ECDLs. This laser system will be used for a cold atom gravimeter currently developing at KRISS.

4. REFERENCES

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