

Title : Pound-Dever-Hall Experiment for laser frequency stabilization

Author(s) : 1. Bawonnan Kuakulsong
2.
3.

Student ID : 640510385.

Student ID :

Student ID :

Major : Physics

Advisor(s) : 1. Assistant Professor Dr. Waranont Anukool
2. Dr. Parinya Udommai
3. Ms. Phatwarach Siriworakoonchai

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ABSTRACT

The project is part of the research to construct the quantum atom system for quantum computers, Where a highly stable laser is required in terms of both power and frequency. If the laser is unstable, it will affect the accuracy of the atomic excitation. Therefore, it is necessary to install a capable laser locking system to prevent discrepancies. This project uses the Pound-Drever-Hall (PDH) technique, which is highly effective in stabilizing laser frequency and is widely used in optical experiment systems. One crucial aspect for the PDH technique is the laser mode, specifically the Transverse Electromagnetic Mode₀₀(TEM₀₀), as it has the highest intensity and stability. The principle of the PDH technique begins with directing the laser beam into an electro-optical modulator to modulate the phase of light using a 20 MHz radiofrequency signal generated by a local oscillator. Another important aspect of this process is the calculation of the focus of the laser beam, which is focused accurately onto the planar mirror of the ULE cavity. The ULE cavity used in this experiment has a specified beam waist radius of 248.2 μm . The laser beam exiting the optical fiber has a waist radius of 2.00 mm, requiring convex lenses of 50 mm and 15

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mm to reduce the waist radius to 0.62 mm. Subsequently, a 500 mm convex lens is used to focus the beam onto the planar mirror of the ULE cavity. Once the laser enters the ULE cavity, it undergoes multiple reflections, forming a standing wave within the cavity to insertion of light. Part of the light transmits through the cavity, while some reflects back for mixing with the local oscillator, generating an error signal that is then feedback to stabilize the laser frequency. Outcomes from this study include the identification of the TEM modes of the laser , calculation for the optical beam focusing into the ULE cavity, installation of the optics experiment, operation of laser, and understanding of optical components. Additionally, this project enables precise determination of the laser beam radius at the point of entry into the ULE cavity, which is found to be 248.2 μm . In the next task, the reflection signal from the ULE cavity are to be electronically mixed with the local.

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