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MATTER-WAVE INTERFEROMETRY WITH LASER COOLED ATOMS

David McIntyre, Oregon State University, Corvallis, OR 97331

Summary Questionnaire, 1 June, 1992

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1. Research Description:

This program is investigating matter wave interferometry with laser cooled atoms. A slow beam of laser cooled rubidium atoms will be used as the matter wave source. The atom optical elements are microfabricated amplitude transmission gratings which will be used in a three-grating interferometer to split and recombine the rubidium beam. The interferometer will be a useful new tool for precision atomic physics and a sensitive inertial sensor.

2. Scientific Problem:

The principal tasks in this research program are production of a laser cooled rubidium atomic beam, fabrication of submicron amplitude transmission gratings, and construction and testing of the atomic interferometer. Several technical issues must be addressed in each task. The atomic beam must have high brightness to ensure adequate signal to noise ratio and a low temperature to ensure a long coherence length. The gratings must be phase coherent over their area so that the interferometer fringes are not washed out. The interferometer must be vibration isolated so that the fringes do not move appreciably during the signal integration time. Once these technical issues are resolved, the atomic interferometer will be a useful new tool with which to perform precision experiments in atomic physics, quantum optics, and gravitation.

3. Scientific and Technical Approach:

This research program will take advantage of and incorporate three new technologies. A beam of slow rubidium atoms will be produced by combining the techniques of chirped laser cooling, optical molasses, and magneto-optic trapping. The rubidium cooling transition at 780 nm will be excited with commercial diode lasers which are frequency stabilized using optical feedback

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from Fabry-Perot etalons or diffraction gratings. The cooled rubidium beam will have a de Broglie wavelength of 0.5 nm. The interferometer will use amplitude transmission gratings fabricated with high-resolution electron-beam lithography. The atomic interferometer will be similar to the three-grating Bonse-Hart interferometer used in neutron interferometry. The combination of laser cooled atoms and microfabricated gratings will allow for a compact and stable interferometer design.

4. a. Progress:

In the past year we have made progress on several fronts. We have built three new stabilized diode laser systems using grating feedback rather than the cavity feedback we have used before. These new systems are much easier to operate. We have cooled and trapped rubidium atoms in a room temperature vapor cell using a magneto-optic trap. We are presently trying to build an atomic funnel inside the vapor cell, which could then be used to form the slow atomic beam. We recently fabricated the amplitude transmission gratings at the National Nanofabrication Facility at Cornell University. These gratings have periods of 250 and 500 nm and have areas of $150\text{ }\mu\text{m} \times 1\text{ mm}$.

b. Special Significance of Results:

These results are not especially significant.

5. Extenuating Circumstances:

None

6. Publications:

A Rubidium Vapor Cell Trap: Applications to Atomic Interferometry (D. H. McIntyre, H. Delfs, and T. B. Swanson), Bull. Am. Phys. Soc. **37**, 1139 (1992); (abstract submitted for the 1992 Annual Meeting of the Division of Atomic, Molecular, and Optical Physics (DAMOP), Chicago, Illinois, May 20-22, 1992)

7. Unspent Funds:

I do not expect any unspent funds.

8. Other Government Support:

None

9. Major Equipment Purchases:

High Vacuum system (pumps and chambers) \$22733

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