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LASER COOLING AND TRAPPING OF NEUTRAL ATOMS. (U)
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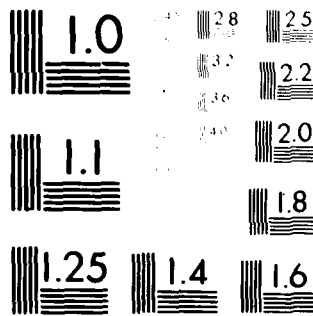
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Recent proposals for laser trapping of neutral atoms require that the trapped atoms have very low kinetic energy. We have studied the technique of cooling free neutral atoms using radiation pressure and have examined some of the processes which limit the cooling. In particular, we have found large and previously unexpected effects due to optical pumping which not only impair cooling but mask the effects of cooling, making the interpretation of experiments ambiguous. We propose methods for reducing the ambiguity in atom cooling experiments and for alleviating the effects of optical pumping which inhibit		

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cooling. Apparatus for a set of experiments using these new methods is under construction.

Interim Summary Report

on

Laser Cooling and Trapping of Neutral Atoms

Contract No. N00014-80-F-0035

for Fiscal Year 1980

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Principal investigator: William D. Phillips

Contract Description: We will perform an experimental investigation of the cooling of neutral atoms, and the use of cooled atoms in various types of electromagnetic neutral atom traps. Among the anticipated applications are improved frequency standards and improved high resolution spectroscopy.

Scientific Problem: At present, no investigators have reported successful optical trapping of atoms. The main difficulty is that optical traps are so shallow in energy that only very cold atoms can be confined; these cold atoms are not available from conventional sources. Therefore, cooling techniques are being attempted. Although investigators at the Institute for Spectroscopy (Moscow) claim to have cooled atoms, our experiments suggest that their data are ambiguous. The problem in cooling atoms as well as in interpreting data from cooling experiments lies in the optical pumping processes which occur during the cooling. By re-designing the Russian cooling experiment, we hope to avoid their problems with interpretation of data and perform an unambiguous cooling experiment.

Scientific and Technical Approach: Optical atom traps work by exerting forces on atoms through near resonant interaction of the atom with a laser beam. Just as a static dipole experiences a force in an inhomogeneous static field, an induced, oscillating dipole experiences a force in an inhomogeneous oscillating field. Radiation pressure provides another force which can be used in trapping. Radiation pressure--the transfer of photon momentum to atoms which absorb the radiation--can also be used to cool (or heat) atoms. If a near resonant laser beam is propagated against the direction of an atomic beam, momentum will be transferred and the beam will slow down. We intend to observe this change in momentum by velocity analysis using a second laser. This analysis will be done in the absence of light from the cooling laser beam.

Progress: During the past contract period we have completed installation of the laser system, atomic beam apparatus and detection apparatus needed

for these experiments. We have performed initial experiments which show that optical pumping processes greatly distort the absorption line shape when the laser beam interacts with the atomic beam long enough for significant cooling to occur. This effect masks the effects of the cooling, making interpretation difficult. We have designed and begun construction of several modified versions of the experiment which should eliminate the interpretation problem. We have also designed a system which we hope will eliminate the optical pumping problem altogether. Equipment to build this system is on order and construction should begin during the FY 81 contract period.

Publication: A report of preliminary results was given at the 7th International Conference on Atomic Physics as a poster.

Extenuating circumstances: We experienced a delay of several months while waiting for installation of cooling water needed to operate the lasers. The installation delay was caused by engineering difficulties and late material shipments to the Plant Division which designed and installed the cooling system.

Unspent funds: We expect no unspent funds at the end of the current contract.

Graduate students: No graduate students have worked on the project.

Other federal grant support: W.D. Phillips and three other investigators are supported by a \$15,000 grant from DoE for determination of the fine-structure constant.