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SUMMARY OF WORK ON 'COOLED ION FREQUENCY STANDARD.'(U)
MAY 78 D J WINELAND, F L WALLS N00014-77-F-0046
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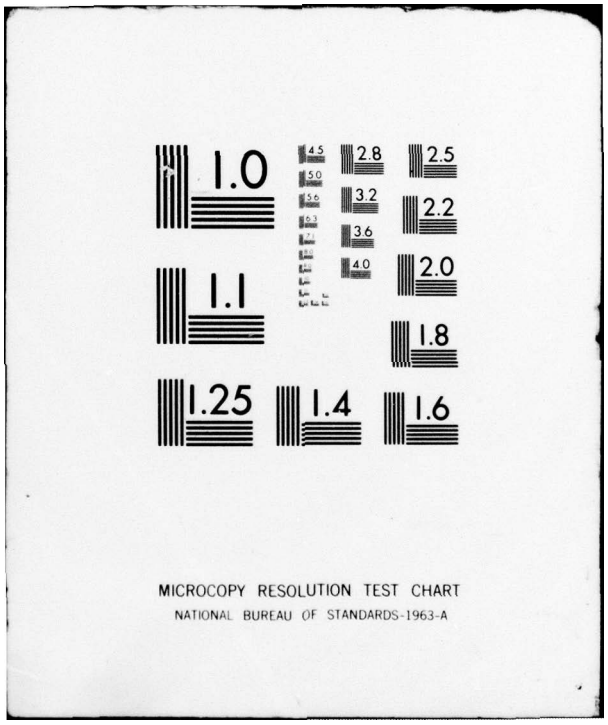
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MICROCOPY RESOLUTION TEST CHART
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The purpose of this work is to develop techniques to overcome the fundamental limits of present frequency standards--the second and residual first-order Doppler shifts. To this end ~~we study~~ are studied suitable frequency reference transitions in ions which are stored in electromagnetic traps and cooled by radiation pressure to < 1K.

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SUMMARY OF WORK ON

"COOLED ION FREQUENCY STANDARD"

ONR Contract No. N00014-77-F-0046

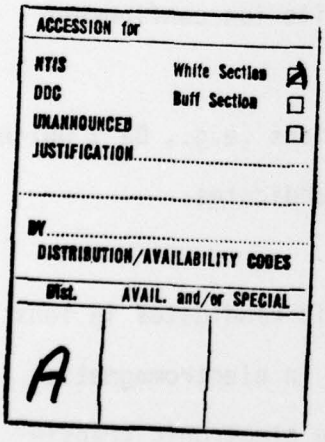
Co-Principal Investigators

D. J. Wineland
Time and Frequency Division 524
National Bureau of Standards
Boulder, Colorado 80303

FTS: 323-4286
(303) 499-1000, ext. 4286

F. L. Walls
Time and Frequency Division 524
National Bureau of Standards
Boulder, Colorado 80303

FTS: 323-3207
(303) 499-1000, ext. 3207



Contract Description

The purpose of this work is to develop techniques to overcome the fundamental limits of present frequency standards--the second and residual first-order Doppler shifts. To this end we study suitable frequency reference transitions in ions which are stored in electromagnetic traps and cooled by radiation pressure to < 1K.

Scientific Problem:

Although we have now demonstrated the radiation pressure cooling effect, there are many refinements which must be made. We must first demonstrate that cooling to < 1K is possible and also demonstrate the use of this in high-resolution spectroscopy. We propose to observe the resonance fluorescence on Mg II ions as a first step in this direction. Measurements of cooling < 1K, isotope shifts, $^{25}Mg^{+}$ h.f.s., g_J factors, S/N in optical-double resonance detection with stored ions, and demonstration of indefinite ion confinement times in Penning traps all appear possible.

In addition, we propose to study other interesting ions (e.g., Ba^{+}) which may make suitable cooled stored ion frequency standard candidates.

Scientific and Technical Approach

The search for possible high-resolution spectroscopic candidates in ions has currently centered on those ions which can be stored in electromagnetic traps (Penning traps in our experiments so far) and whose electronic transitions can be accessed by the output or frequency-doubled output of single-mode tunable dye lasers. At this point it is difficult to identify the ultimate candidate for a frequency standard; however, Ba^{+} has very attractive features in this regard.

Mg^+ ions will continue to be studied in the Penning traps as important problems relevant to possible frequency standards can be investigated (see above). Many improvements are possible in the area of trap design, and new traps will be constructed to study Ba^+ and other ions which appear attractive. The study of Ba^+ will necessitate the use of a second dye laser (to relax the metastable D states) and possible additional microwave radiation to relax the ground state levels and study their spectroscopy.

Progress

Most significantly we have demonstrated for the first time that ions stored in electromagnetic traps can be significantly cooled using radiation pressure. For our first experiments we have stored a cloud of approximately 5×10^4 Mg II ions in a Penning electromagnetic trap. These ions were cooled to < 40K, using only 8μW of power from a frequency-doubled dye laser. This experiment was a crucial first step in the overall program in that the cooling allows a significant reduction in the first- and second-order Doppler shifts and therefore allows us to contemplate a cooled ion frequency standard with accuracies much better than those of any other existing or proposed standards.

Publications:

1. "Radiation pressure cooling of bound resonant absorbers," D. J. Wineland, R. E. Drullinger, F. L. Walls. Submitted to Phys. Rev. Letters.

Conferences

1. "High Resolution Spectroscopy by Radiative Cooling of Bound Resonant Absorbers," D. J. Wineland, F. L. Walls, R. E. Drullinger. Summary to be published in the Technical Digest of the Tenth I.Q.E.C., Atlanta, Georgia, May 1978.

Personnel:

Principal Investigators:

Dr. D. J. Wineland (Staff, Time and Frequency Division)

Dr. F. L. Walls (Staff, Time and Frequency Division)

Additional:

Dr. R. E. Drullinger (Staff, Time and Frequency Division)

Dr. Wayne Itano (post-doctoral researcher, Time and Frequency Division - starts fall, 1978)

C. Klepper (co-op student, Denver University, summer and fall, 1977, 1978)