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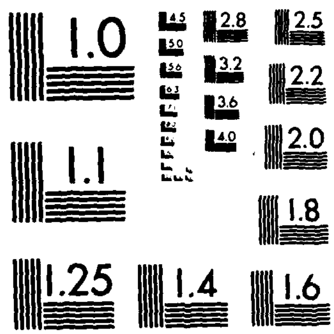

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ANNUAL SUMMARY REPORT

SBCONR4

ONR Contract # N00014-80-C-0240

ATOMIC HYDROGEN MASER INVESTIGATIONS OF HYDROGEN ATOM INTERACTIONS FROM 4 K to 12 K

March 1, 1983 - February 29, 1984

The President and Trustees
of Williams College
Williamstown, MAssachusetts
01267

Stuart Crampton
Department of Physics
and Astronomy

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Resonance, Surface Adsorption, Crygenic, Maser, Frequency Metrology, Atomic Beam, Solid Neon, Solid Hydrogen

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Techniques and data developed during previous studies of the ground state hyperfine resonance of hydrogen atoms intermittently adsorbed on molecular hydrogen surfaces are applied to the developemnt of a Very Low Temperature Atomic Hydrogen Maser incorporating a state-selected hydrogen atom beam with thermal speeds near 5 K. Studies are made of adsorption of hydrogen atoms on molecular hydrogen and atomic neon solid surfaces at 4 K to 12 K.

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ANNUAL SUMMARY REPORT

ONR Contract # N00014-80-C-0240

ATOMIC HYDROGEN MASER INVESTIGATIONS OF HYDROGEN ATOM INTERACTIONS FROM 4 K to 12 K

1. Principal Investigator: Dr Stuart B. Crampton
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Williamstown, MA 01267

2. Contract Description

A liquid helium temperature state-selected hydrogen atom beam is developed and incorporated into an atomic hydrogen maser operating with storage surface temperatures variable from 3 K to 15 K. The energy of adsorption of hydrogen atoms adsorbed on molecular hydrogen and atomic neon surfaces, the sticking coefficient for collisions of hydrogen atoms with these surfaces, and the perturbation of the ground state hydrogen atom hyperfine frequency while adsorbed on these surfaces is measured. The likely performance of an atomic hydrogen maser as a primary or secondary frequency standard at low temperatures with these surfaces is evaluated.

3. Scientific Problem

Recent experimental work motivated by prospects for observing the Bose Einstein condensation of atomic hydrogen gas at very low temperatures and high densities has produced techniques whereby useful densities of atomic hydrogen gas can be stored at low temperatures in containers coated with frozen inert gases. The relaxation times while stored are long enough for potential applications to frequency metrology and to useful measurements of atomic collision parameters in a temperature regime particularly sensitive to the details of the interatomic potentials.

4. Scientific and Technical Approach

Hydrogen atoms produced from molecules in a 180 MHz discharge cooled by liquid nitrogen are cooled to about 5 K in a copper tube cooled by heat conduction to a liquid helium bath. Atoms emerging from the copper tube are focused by a permanent six pole magnet into a 5 cm diameter storage bottle coated on the inside with frozen molecular hydrogen or neon. A short pulse of microwave energy at the hydrogen atom hyperfine frequency sets the atoms radiating at frequencies and with lifetimes indicative of their interactions with the surface materials while briefly adsorbed in between trips back and forth across the storage bottle. In addition to information from the frequencies and lifetimes, the amplitudes of the signals and the rate of level population recovery following a pulse contain useful information about the interactions of the hydrogen atoms with the surfaces and with each other. At temperatures of order 10 K the perturbations of the hydrogen frequency by adsorptions on atomic neon surfaces are small enough to offer the potential for improved frequency standard performance if the surfaces are both stable and reproducible. In additon, the storage of hydrogen atoms at these temperatures offers a useful environment for studying collision processes, in order to verify and exploit the theoretical prediction that electron spin exchange collision relaxation and frequency shift cross sections are appreciably smaller near 10 K than they are below 1 K.

5. Progress

Measurements of the adsorption of hydrogen atoms on neon surfaces from 6 K to 11 K are under way. Preliminary results indicate that the surfaces are stable and uniform over this temperature range, and that the energy of adsorption and the perturbation of the hyperfine frequency while adsorbed are favorable for frequency standard work.

6. Publications

Recent publications citing ONR support of this work include:

(a) S. B. Crampton, J. J. Krupczak and S. P. Souza, "Progress of the State-Selected Beam, Low Temperature Hydrogen Maser," Journal de Physique (Paris) Colloq. C8-181 (1981)

(b) S. B. Crampton, J. J. Krupczak and S. P. Souza, "Temperature Dependence of Hydrogen-Atom Adsorption on Molecular-Hydrogen Surfaces," Physical Review B25, 4383 (1982).

7. Extenuating Circumstances

The work has proceeded at reasonable speed for development work of this kind. Several aspects of the recent investigations are nearly ready for publication.

8. Unspent Funds

We have spent or committed to spend by the end of February 1984 over 90% of the contract funds available until then, and we do not anticipate any surplus.

9. Graduate Student Degrees

There is no graduate program at Williams College. Undergraduate students who have recently participated in this research during the period of ONR support have gone on to study at the University of Wisconsin, the University of Maryland, Columbia University and the University of Massachusetts at Amherst.

10. Ohter Federal Grant and Contract Support

NSF Grant PHY82-05886 currently provides parallel support of this research through May 1984.

Stuart B. Crampton
Principla Investigator