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COHERENT TRANSIENT EFFECT STUDIES OF RYDBERG ATOMS.(U)

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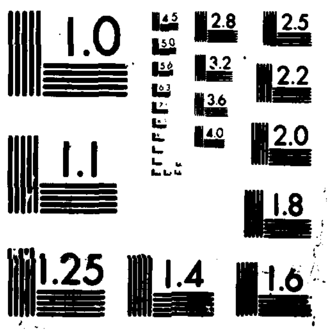

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Report N00014-79-C-0488

COHERENT TRANSIENT EFFECT STUDIES OF RYDBERG ATOMS

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

New techniques for making time-resolved studies of atoms in highly excited (Rydberg) states will be developed. In particular, the absorption or emission of radiation by Rydberg-state atoms will be monitored on a nanosecond time scale during and after irradiation by various laser pulse sequences. The signals thus produced (known as coherent transient effects), will be studied in order to provide both information about collisional relaxation processes in Rydberg atoms and other spectroscopic data.

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Contract Description

New techniques for making time-resolved studies of atoms in highly excited (Rydberg) states will be developed. In particular, the absorption or emission of radiation by Rydberg-state atoms will be monitored on a nanosecond time scale during and after irradiation by various laser pulse sequences. The signals thus produced (known as coherent transient effects), will be studied in order to provide both information about collisional relaxation processes in Rydberg atoms and other spectroscopic data.

Scientific Problem

A detailed knowledge of collisional relaxation and energy transfer in atomic Rydberg states is important in a variety of areas, ranging from atomic plasma behavior to the construction of atomic Rydberg lasers and the use of Rydberg atoms as single quantum detectors of microwave radiation. Although there is currently a great deal of activity in the field of Rydberg atoms, almost all of our knowledge about their collisional relaxation comes from line-broadening studies rather than from direct time-resolved experiments. We are attempting to do direct experiments of this sort. We anticipate that these studies will yield much more detailed information about collisional cross sections for specific relaxation channels as well as other useful spectroscopic data such as absolute values for Rydberg transition dipole matrix elements.

Scientific and Technical Approach

In order to study Rydberg states with coherent transient effects, the following approach is being employed: A pair of synchronously-pumped pulsed dye lasers will excite ground-state atoms to a Rydberg level via resonant two-step excitation. At the same time, the atoms will be illuminated with a cw CO_2 laser which can be brought into resonance with the Rydberg transition of interest by an electric field applied to the sample. Immediately following the dye laser excitation, transient effects will be produced in the sample by pulsing the electric field in order to shift the Rydberg atoms in and out of resonance with the CO_2 laser. By monitoring the transmitted CO_2 laser beam, effects such as photon echoes, optical nutation, adiabatic rapid passage, and others can be observed, depending on the pulse sequence one applies. We hope to be able to measure absolute transition dipole matrix elements, accurate Stark shift coefficients, Rydberg transition frequencies, and cross-sections for specific collisional relaxation processes. In addition, we hope to measure collisional velocity redistribution effects and the velocity dependence of collisional relaxation rates.

Progress

This contract involves building up an entirely new apparatus to do experiments of a type never tried before on Rydberg atoms. As a result, it has been necessary to construct a great deal of equipment, and the past nine months have been devoted to doing this. Specifically, we have finished building two stable nitrogen-pumped pulsed dye lasers of our own design (based on a concept first proposed by Littman and Metcalf). These lasers are now operating satisfactorily, giving a diffraction-limited output beam with 5-nsec pulse widths and ~6% efficiency. The spectral width of the pulse has not been measured yet, because a suitable optical spectrum analyzer was not available until recently. The stable CO_2 laser to be used in these experiments has also been reactivated and is operating satisfactorily. A beam line which combines the three laser beams and directs them into the sample cell has also been constructed. The sample cell itself is now about 80% complete. The design of this cell has been modified several times as a result of further thought and some construction problems, and we now feel that we have a good, workable design. A high-vacuum station for pumping the cell and handling the alkali atom samples has been constructed as well.

Our current efforts are concentrated on finishing the sample cell, and we hope to try our first experiments sometime this summer. We plan to try looking at sodium first, largely because its transitions fall in a very convenient frequency range for both the dye and CO_2 lasers.

Publications: None as yet

Unspent Funds: We do not anticipate any funds to remain unspent at the end of the current contract period.

Graduate Students: Doreen Weinberger

Carl Gaebe

No degrees awarded as yet.

Contract Support of Principal Investigators

R. L. Shoemaker:

1. NSF CHE-7824085 , "Fundamental Studies of Molecular Relaxation and Coherent Transient Effects," $135,000 from 6/1/79 to 11/30/82; 20% effort.

   (R. L. Shoemaker, Principal Investigator)

2. HEW R01CA24466-01, "Ultrafast Scanner Microscope in Laboratory Automation," $556,209 from 5/1/78 to 4/30/81; 25% effort.

   (R. V. Shack, Principal Investigator)

3. AFOSR F49620-80-C-0022, "Research in the Optical Sciences," $500,000 from 10/1/79 to 9/31/80; 13% effort.

   (P. A. Franken, Principal Investigator)

4. ONR N00014-79-C-0488, "Coherent Transient Effect Studies of Rydberg Atoms," $125,539 from 6/1/79 to 5/31/81; 17% effort.

   (R. L. Shoemaker and W. H. Wing, Co-principal Investigators)

   (THIS CONTRACT)

5. NSF PHY-7915302, "Modern Spectroscopy and Collision Studies of Fundamental Atomic and Molecular Systems," $140,000 from 11/1/79 to 4/30/80; 3% effort.

   (W. H. Wing and R. L. Shoemaker, Co-principal Investigators)

W. H. Wing

1. NSF PHY-7915302, "Molecular Spectroscopy and Collision Studies of Fundamental Atomic and Molecular Systems," $140,000 from 11/1/79 to 4/30/81; 25% effort.

   (W. H. Wing and R. L. Shoemaker, Co-principal Investigators)

2. Petroleum Research Fund (American Chemical Society) 12206, "Laser Spectroscopy and Collision Studies of Molecular Ions," $30,000 from 3/1/80 to 8/31/82; 3% effort.
   (W. H. Wing, Principal Investigator)

3. ONR N0014-79-C-0488, "Coherent Transient Effect Studies of Rydberg Atoms," $125,539 from 6/1/79 to 5/31/81; 12% effort.
   (R. L. Shoemaker and W. H. Wing, Co-principal Investigators)
   (THIS CONTRACT)