

Progress Report for the Office of Naval Research

"An Experimental Study of Quantum Chaos"

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RYDBERG ATOMS IN STRONG MAGNETIC FIELDS

We have continued experimental work on this project, extending our energy level maps and investigating states with $m = \pm 1$. We have also developed plans for a new generation of the apparatus, based on a split-pair superconducting magnet, and will begin construction as soon as funds for the new magnet are available.

Stimulated in large part by our measurements, a theoretical group at Ecole Normale in Paris headed by Jean-Claude Gay and Dominique Delande, has developed computational methods for calculating the spectrum of the diamagnetic hydrogen atom at positive energies. Their calculations are in remarkable agreement with our data: indeed, the agreement between theory and experiment is better than we thought possible. This is because our experiment is in lithium, while the calculations are for hydrogen. Although we believed that the difference would not be important, we had no reason to believe that it would be essentially negligible. The development of calculational techniques provides a new tool for the study of this problem and a possible key to physical understanding of effects that we have discovered such as the presence of orderly energy levels in a strongly mixed regime that is believed to be classically chaotic. The appearance of such orderly levels suggests the existence of long period classical orbits in a region that is believed to be strongly chaotic. The search for such orbits is part of the next phase of this research. In addition, we have discovered a superstructure of extremely fine oscillations on some of the Rydberg lines. We hope to discover what these oscillations signify, and their implications for classical dynamics.

A joint letter has been submitted to Physical Review Letters: it is listed below.

THESES

Chun-Ho Iu, Ph.D. Thesis, MIT, September 1990: "Energy Level Structure of Atoms in Magnetic Fields"

PUBLICATIONS

Daniel Kleppner, Chun-ho Iu, and George Welch, "Positive Energy Spectroscopy of the Diamagnetic Lithium System", Comments in Atomic Physics, November, 1990 (in press)

"The Diamagnetic Rydberg Atom: Confrontation of Calculated and Observed Spectra", Chun-ho Iu, George. R. Welch, Michael M. Kash, Daniel Kleppner, D. Delande and J.C. Gay, submitted to Physical Review Letters.

OTHER

The P.I. delivered invited lectures on diamagnetic Rydberg research at the University of Sao Carlos, Brazil (Jan. 23-25, 1990); New York University (Stanley H. Klosk lecturerer, Feb. 20-23, 1990); the College de France (visiting professor, March, 1990); the Summer School of Theoretical Physics, (Les Houches, France, July 1-15, 1990); the Gordon Conference on the Dynamics of Simple Systems in Chemistry and Physics (Proctor Academy, August 15, 1990); The Symposium on Quantum Aspects of Nonlinear Systems (Essen, Germany, July 16-20, 1990); and The Research Conference on Quantum Optics, (Davos, Switzerland, October 3-5, 1990). An invited talk will be presented at the Optical Society of America annual meeting on Nov. 8, 1990.

Dist. "A" per telecon Dr. Peter Reynolds.
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