Laboratory experiments on a zonal flow in a rotating annulus yielded insight into the phenomenon of blocking in the atmosphere (where the jet stream is deflected poleward by blocking anticyclones that persist for 10 days or longer). With two symmetric ridges on the bottom of the laboratory annulus, the resulting flows were nearly zonal at high forcing, blocked at low forcing, and intermittently switched between zonal and blocked flows at intermediate forcing. These observations provide new criteria by which topographic effects on low-frequency atmospheric flows can be distinguished from thermal effects.

A model of one-dimensional random walks was examined in which the probability distribution functions for forward and backward steps were both power laws but with different exponents. Relations were derived between the exponent for the variance of the displacement and the exponents for the probability distribution functions for forward and backward steps and for sticking events. The results for this model agree with observations of tracer particles in a multi-vortex flow in a laboratory rotating annulus.

Another study developed a genetic algorithm that produces neural feedback controllers for chaotic systems. The computer program to implement the algorithm is available on the World Wide Web at http://chaos.ph.utexas.edu/~weeks/dsane/
ANNUAL PERFORMANCE (TECHNICAL) REPORT
OFFICE OF NAVAL RESEARCH

PART I

PUBLICATIONS/PATENTS/PRESENTATIONS/HONORS REPORT

Contract/Grant Title: "Turbulence in Two and Three Dimensions"
Principal Investigator: Harry L. Swinney
Mailing Address: University of Texas at Austin
                 Center for Nonlinear Dynamics
                 Austin, TX 78712
Phone Number: 512-471-4619
Fax Number: 512-471-1558
E-mail Address: swinney@chaos.ph.utexas.edu
http address: chaos.ph.utexas.edu

a. Number of papers submitted to refereed journals, but not published: 1

b. Number of papers published in refereed journals: 4


c. Number of books or chapters submitted, but not yet published: 1

d. Number of books or chapters published: 1

e. Number of printed technical reports/non-refereed papers: 0

f. Number of patents filed: 0

g. Number of patents granted: 0

h. Number of invited presentations: 11

6/30/97 G.I. Taylor Symposium, Northwestern University, Chicago
9/12/97 Natural Sciences Foundation Advisory Council, UT-Austin
11/14/97 5th Chemical Congress of North America, Cancun
11/25/97 Physical Chemistry Seminar, U of California, Berkeley
2/3/98 Department of Physics Colloquium, U of Houston
3/20/98 Annual Spring Meeting, Texas Sections-AAPT/APS, U of Incarnate Word, San Antonio
3/26/98 Interdisciplinary Lecture Series, UT-Austin
i. Number of submitted presentations: 6

j. Honors/Awards/Prizes for contract/grant employees: 1
   Center for Nonlinear Dynamics ranked first in nonlinear dynamics programs

k. Total number of full-time equivalent graduate students and postdoctoral associates
   supported during this period, under this project number:
   Graduate students: 1.5
   Postdoctoral Associates: 1
   Female Graduate Students: 0
   Female Post-doctoral Associates: 0
   Minority Graduate Students: 0
   Minority Post-doctoral Associates: 0
   Asian Graduate students: 0
   Asian Post-doctoral Associates: 0

l. Other funding:

   Department of Defense, Navy (AASERT)
   "Turbulence in Two and Three Dimensions"
   $95,000 (total)
   8/1/96 - 5/31/99
   Relationship to ONR grant: student training on this ONR project

   Department of Energy
   "Complex Spatiotemporal Patterns in Nonequilibrium Systems"
   $158,000 (current year)
   $1,171,829 (total)
   9/1/97 - 8/31/02
   Relationship to ONR grant: None (concerns granular and
   chemical media)

   National Aeronautics and Space Administration
   "Experiments and Theory on Instability in Surface-Tension-Driven
   Benard Convection (Marangoni Convection)"
   $125,000 (current year)
   $500,000 (total)
   6/1/96 - 5/31/00
   Relationship to ONR grant: Very little. An ONR-purchased
   infrared camera is used in convection studies.

   National Science Foundation - International Programs
   (Cooperative Program with FONDECYT, Chile)
   "Pattern Formation in Vertically Oscillated Granular Materials"
   $31,008 (U. S. Budget - total) This grant is for travel only.
   1/15/95 - 12/31/98
   Relationship to ONR grant: None
PART II

a. Program Objective: To understand basic mechanisms of instability and turbulence in rotating fluids in two and three dimensions.

b. Significant results during last year:

Laboratory experiments on a zonal flow in a rotating annulus yielded insight into the phenomenon of blocking in the atmosphere (where the jet stream is deflected poleward by blocking anticyclones that persist for 10 days or longer). With two symmetric ridges on the bottom of the laboratory annulus, the resulting flows were nearly zonal at high forcing, blocked at low forcing, and intermittently switched between zonal and blocked flows at intermediate forcing [1,2]. These observations provide new criteria by which topographic effects on low-frequency atmospheric flows can be distinguished from thermal effects.

A model of one-dimensional random walks was examined in which the probability distribution functions for forward and backward steps were both power laws but with different exponents [3]. Relations were derived between the exponent for the variance of the displacement and the exponents for the probability distribution functions for forward and backward steps and for sticking events. The results for this model agree with observations of tracer particles in a multi-vortex flow in a laboratory rotating annulus.

Another study developed a genetic algorithm that produces neural feedback controllers for chaotic systems [4]. The computer program to implement the algorithm is available on the World Wide Web at http://chaos.ph.utexas.edu/~weeks/dsane/

c. Summary of plans for next years work:

We will examine two-dimensional (2D) turbulence in a rapidly rotating annulus where the flow is constrained to be 2D by the Taylor-Proudman theorem. The velocity field will be determined by particle imaging velocimetry and the results will be compared with predictions for 2D turbulence. The transition from 2D to 3D flow will be produced by either reducing the rotation rate of the annulus or by increasing the strength of the forcing. The observed properties of the 2D to 3D transition will be compared with theory and numerical simulations.

d. Graduate students and post-doctoral currently working on the project:
   Brendan Plapp, postdoctoral fellow
   Charles Baroud, graduate student
July 16, 1998

Office of Naval Research
Program Officer Michael F. Shlesinger ONR 331
Ballston Centre Tower One
800 North Quincy Street
Arlington, VA 22217-5660

Dear Michael,

Enclosed is my annual report and reprints of our papers from the current grant year. We are especially pleased with the results on atmospheric blocking phenomena (Science reprint is enclosed).

Reprints are also enclosed on our work on strongly asymmetric random walks, and on a neural network algorithm for controlling chaotic systems.

Let me know if you have any questions. With best wishes.

Sincerely,

Harry L. Swinney

HLS/df
enclosures

✓ Copy - Defense Tech Info Ctr. (2)