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cc. Dr. X B Reed
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Report on the
Twelfth Symposium on Turbulence
September 24-26, 1990

X S Reed, Jr.
Professor of Chemical Engineering
University of Missouri-Rolla
Symposium Director and Chairman

Sponsored by
Office of Naval Research
and
University of Missouri-Rolla's
Department of Chemical Engineering
and Continuing Education

April 1992

93-01533
TWELFTH SYMPOSIUM ON TURBULENCE

The Twelfth Symposium on Turbulence was held at the University of Missouri-Rolla (UMR), with the technical sessions beginning on Monday morning, September 24, 1990, and ending at midday Wednesday, September 26, 1992; registration and a social get-together on Sunday evening preceded the technical program.

The Twelfth Turbulence Symposium was sponsored by the Office of Naval Research, without whose support it would not have been held. Dr. L.P. Purtell and Dr. Spiro Lekoudis shared the responsibility for this, with Pat attending the Turbulence Symposium and serving on the Steering Committee. The PI expresses his appreciation for ONR's support over the years when he has been responsible for the Turbulence Symposium.

The facilities of the University of Missouri-Rolla are made available for the Turbulence Symposium, with the Chemical Engineering Department and Continuing Education providing secretarial and other help. The Turbulence Symposia of 1983, 1984, 1986, 1988, and 1990 have been directed by X B Reed, Jr. of the University of Missouri-Rolla, with the assistance of his co-chairs, G. K. Patterson, now Associate Dean of Engineering, University of Missouri-Rolla, and J. L. Zakin, Chairman of Ohio State University's Chemical Engineering Department. Because of the reduced funding, Drs. Patterson and Zakin will become Honorary Co-chairmen.

The highlights of the technical program were:

"Vortical Structures and Their Central Role in Boundary Layer Turbulence"
by Stephen K. Robinson
NASA Langley Research Laboratory
Hampton, VA

"The Models of Free Shear Dynamics"
by Larry Redekopp
University of Southern California
Los Angeles, CA

"PDF Methods for Turbulent Flows"
by Steve Pope
Cornell University
Ithaca, NY
and

"New Developments in Understanding Supersonic Turbulent Boundary Layers"
by A. J. Smits
Princeton University
Princeton, NJ

There were 64 contributed papers distributed among eleven technical sessions. The full program follows (see Appendix A).

One of the features of the UMR Turbulence Symposium which has long been felt to be desirable (highly desirable, very important) by most attendees, as well as by the Steering Committee, has been the intimate nature of the Turbulence Symposium, especially its opportunities for technical discussions outside the formal Q&A/Comments interludes following each presentation. Until the 1988 Turbulence Symposium, simultaneous sessions had been avoided. With the advent in the late '70's and early '80's of decreased funding from federal agencies and of decreased funding for travel in universities, federal laboratories, and industrial R&D, attendance at the Turbulence Symposium began to decline. The trend has continued and has had especially deleterious effects for those not presenting papers. Efforts to halt the attendance erosion culminated in the 1988 Turbulence Symposium being characterized by simultaneous sessions for the entire Symposium, aside from the invited lecturers. That continued in the 1990 Turbulence Symposium and will doubtless continue into the foreseeable future. Simultaneous sessions have been apportioned, very roughly speaking, into fundamental versus applied sessions in an attempt to minimize conflict and in particular to continue to provide a full Turbulence Symposium of activity for attendees who want it to remain one emphasizing fundamental developments, while at the same time connecting them with strong applications.

There continue to be certain, not necessarily major, problems with having the manuscripts from the Turbulence Symposium published in the archival literature. There has been a relatively high rejection rate, but authors now rightly blame the journals, not the PT, the Turbulence Symposium, or the Steering Committee. Rather than appearing in a single issue of the journal, papers appear over a period of time, and worse, attribution to the Turbulence
Symposium is not always made. There were no papers from the 1990 Turbulence Symposium published in *Computers and Fluids*, so this journal is not a problem; but those from 1988 and 1990 published in *Physics of Fluids* often lacked the Turbulence Symposium designation.

The continued support of ONR by encouraging its funded (and proposal submitting) investigators to present papers at the Turbulence Symposium is an important ingredient in maintaining and increasing quality and attendance. It also provides ONR personnel additional first-hand opportunities to see the work of many of their past, present, and future supported investigators "in action" and to hear, as well as participate in, their evaluation during the Steering Committee discussions, as well as in the Q&A following presentations.

**Participant Response**

One-hundred participants attended the Twelfth Turbulence Symposium, with seventy-two from universities (up from 67 in '90), seventeen from governmental laboratories (up from 10), and eleven from industry (up from 10). There was, as is customary, a significant international contingent present, with Australia (1), Canada (1), Federal Republic of Germany (2), France (1), Netherlands (4), Switzerland (1), Hong Kong (1), India (1), Japan (1), United Kingdom (1), and Republic of China (3), represented. The list of participants appears in Appendix 3.

**Equipment Exhibits**

Each Symposium, ample space is made available for vendors of turbulence measurement, data acquisition, and analysis equipment, and various companies are invited. TSI and DANTEC, as always, brought large demonstration teams. They also provide tangible support, including underwriting the social hour, which we appreciate. New personnel from DANTEC expressed the strong opinion that they were not sufficiently given the opportunity to sell their wares.
Banquet

Zeno's Restaurant hosted the Turbulence Symposium banquet, and the excellent midwestern steaks at a modest price (banquet costs were $19) were widely complimented. The Collegium Musicum provided after-dinner entertainment. Mr. Basil Moore was the after-dinner speaker, and "The humor of Abe Lincoln" was indeed humorous.
Program Announcement
welth Symposium on Turbulence

September 24-26, 1990
Rolla, MO U.S.A.
Twelfth Symposium on Turbulence

September 23, 1990
-10 a.m. Registration and Social Hour. Zeno's Motel and Steak House
September 24, 1990
4:30-5:30 a.m. Registration—Miner Lounge. University Center-East, UMR
2:00-4:45 p.m. Symposium Opening—Welcoming Remarks—Centennial Hall-West
4:30-6:30 p.m. Announcements and General Information

Symposium Sponsors
Office of Naval Research
University of Missouri-Rolla

Symposium Chairman
J. S. Reed, Jr.
University of Missouri-Rolla
Chairman

Gary K. Patterson
University of Missouri-Rolla
Co-Chairman

Jacques L. Zakin
Ohio State University
Co-Chairman

Symposium Committee
Dr. R. J. Adrian
Professor of Theoretical and Applied Mechanics
University of Illinois
Dr. A. J. Smith
Professor of Mechanical and Aerospace Engineering
Princeton University

Dr. J. Z. Brock
Professor of Chemical Engineering
Ohio State University
Dr. C. G. Szegedi
ICASE
NASA Langley Research Center
Dr. R. J. Mars
Professor of Mechanical and Aerospace Engineering
Princeton University
Dr. J. D. Stock
Professor of Mechanical Engineering
Washington State University

Dr. R. H. Hansen
Naval Research Laboratory
Washington, D.C.
Dr. G. K. Patterson, Co-Director
Associate Dean of Engineering
University of Missouri-Rolla
Dr. W. G. Tiederman
Professor of Mechanical Engineering
Purdue University

Dr. G. S. Jones
Professor of Mechanical Engineering
University of Houston
Dr. J. L. Zakin, Co-Director
Professor and Chairman of Chemical Engineering
Ohio State University

Dr. S. Lenoues
Office of Naval Research
Arlington, Virginia

Dr. J. McMichael
Air Force Office of Scientific Research
Washington, D.C.
Dr. R. S. Miles
Professor of Mechanical and Aerospace Engineering
Princeton University

Dr. M. M. Reschman
Office of Naval Research
Arlington, Virginia

Dr. G. K. Patterson, Co-Director
Associate Dean of Engineering
University of Missouri-Rolla
Dr. X. B. Reed, Jr., Director
Professor of Chemical Engineering
University of Missouri-Rolla

Dr. M. M. Reschman
Office of Naval Research
Arlington, Virginia
Monday Morning, September 24, 1990


10:00 a.m. Coffee Break

A

Coherent Turbulence Structure—Centennial Hall-West
Chairmen: R. S. Brooke and A. K. M. F. Hussain


1 p.m. "Interaction of Coherent Structures within a Coaxial Jet." S. K. Tang and N. W. M. Ko, University of Hong Kong

B

Jets and Wakes—Mark Twain Room
Chairman: S. Lekoudis


10:40 a.m. "The Development of Twin-Jets Issuing into a Crossflow." P. J. Olseme, R. G. DiMarco, University of Cincinnati; N. Toy and E. Savory, University of Surrey

11:00 a.m. "Unified Theory of Turbulent Shear Jet and Wake Flows." W. C. Minh, Washington State University

Monday Afternoon, September 24, 1990

1:00 p.m. Invited Lecture, Centennial Hall-West. "The Models of Free Shear Dynamics." Larry Redekopp, Professor and Chairman, Aerospace Engineering, University of Southern California, Los Angeles, Calif.

A

Coherent Turbulence Structures (cont.)—Centennial Hall-West

B

Coherent Turbulence Structures—Education and Dynamics—Mark Twain Room
Chairmen: R. J. Adrian and X B Reed, Jr.
Tuesday Morning, September 25, 1990

8:00 a.m. Invited Lecture, Centennial Hall-West, "PDF Methods for Turbulent Flows," Steve Pope, Mechanical and Aerospace Engineering, Cornell University, Ithaca, N.Y.

A

Jar Transport—Centennial Hall-West
Chairmen: J. C. Hill and G. K. Patterson

3:00 a.m. "Use of a PDF Method in the Modeling of Turbulent Reacting Flow in a Jet-Stirred Reactor," D. Roekaerts, Koninklijke/Shell-Laboratorium, Amsterdam

3:30 a.m. "Optical Measurement of the Turbulent Scalar Field in a Gas Flow With and Without Combustion," K. Oberst-Lenn and W. Mierzchien, Universität Essen, West Germany

10:00 a.m. "Turbulent Transport of a Passive Scalar," R. C. Sanderson, A. D. Leonard, and J. C. Hill, Iowa State University

B

New Measurement Methods—Mark Twain Room
Chairmen: M. M. Reiseman and R. J. Adnan

9:00 a.m. "High-Speed Particle Image Velocimetry Interrogations Using Coarse Image Arrays," A. Prasad, R. J. Adnan, C. C. Langreth, and P. Gullfart, University of Illinois, Urbana


10:00 a.m. Investigating the Use of Stereoscopic Particle Streak Velocimetry for Measuring the Three-Dimensional Vorticity Field, S. K. Sinha, University of Mississippi; and P. S. Kuniman, University of Nebraska-Lincoln

10:20 a.m. Coffee Break

2:40 a.m. "Kinematics of the Reaction Zone in Homogeneous Turbulence," A. D. Leonard and J. C. Hill, Iowa State University

1:00 a.m. "Direct Numerical Simulation of a Parallel-Consecutive Reaction Pair in Homogenous Turbulence," M. Chakrabarti and J. C. Hill, Iowa State University

1:20 a.m. "Large-Eddy Simulation of Turbulent Reacting Plumes," R. I. Sykes, D. S. Henn, W. S. Lewellen, and S. F. Parker, ARAP Division of California Research and Technology, Inc.


12:00 noon Lunch—Centennial Hall-East
Tuesday Afternoon, September 25, 1990


A

Supersonic and Hypersonic Turbulence—Centennial Hall-West

Chairman: A. J. Smits, R. B. Miles, and C. G. Speziale

1:00 p.m.  “Convection Velocity in Supersonic Turbulent Boundary Layers,” E. F. Spina, Syracuse University; J. F. Donovan, McDonnell Douglas Research Laboratory; and A. J. Smits, Princeton University


1:30 p.m.  “Sound Propagation Issues in Compressible Turbulence,” D. Papamoschou, University of California, Irvine


2:00 p.m.  “Experimental Study of In-Plane Streamline Curvature Effects on a Supersonic Turbulent Boundary Layer,” C. B. McInerney, NASA Langley; and S. M. Bogdonoff, Princeton University

2:15 p.m.  “Experimental Study of Turbulent Structure in Compressible Shear Layers Using Fluctuating Pitot Pressure Measurements,” Y. R. Shau and G. D. Oncley, University of Texas at Austin

2:30 p.m.  “Compressible Free Shear Layers,” M. Samimi, G. S. Elliott, and M. F. Reeder, Ohio State University

2:45 p.m.  “Hot Wire Measurement Method for Temperature and Velocity Fluctuations from Transonic to Subsonic Range in Heated Flows at Low Reynolds Number,” P. Dupont and J. F. Debeve, Institut de Mecanique Statistique de la Turbulence, Marseille

3:00 p.m.  “Imaging Turbulent Structure in High-Speed Air by Filtered Rayleigh Scattering,” R. Miles, W. Lemper, and J. Forkey, Princeton University

B

Lagrangian Turbulence—Mark Twain Room

Chairman: D. E. Stock and G. B. Jones

2:00 p.m.  “On the Role of Accelerating Particles in the Generation of Reynolds Stress,” R. A. Handler and J. D. Swearingen, Naval Research Laboratory; P. S. Bernard, University of Maryland


3:00 p.m.  Break

3:20 p.m.  “On the Particle Motion in a Homogeneous Isotropic Turbulence,” U. Lei and F. G. Yen, National Taiwan University

3:35 p.m.  “Turbulent Deposition and Trapping of Aerosols at a Wall,” J. W. Brooke, K. Kontomaris, and T. J. Hanratty, University of Illinois; and J. B. McLaughlin, Clarkson University

4:00 p.m.  “Dispersion by Irregular Surface Waves in Stratified One-Dimensional Channel Flows,” B. Jong, University of Twente
Wednesday Morning, September 26, 1990

7:00 a.m. "Second-Order Closure Models for High-Speed Compressible Turbulent Flows," C. G. Sorensen and S. Sarkar, NASA Langley Research Center

6:15 p.m. Social Hour—Zano's Motor and Steak House

7-10 p.m. Banquet Dinner

Complex Turbulent Flows—Mark Twain Room
Chairmen: J. L. Zakin and M. McMichael

8:20 a.m. "Quantitative Determination of the Evolution of the Wake Bending and Impulse Start Circular Cylinder," C. Chu and Y. Liao, National Taiwan University

8:40 a.m. "Visual Study on Vortex Developments over Lifting Surfaces After Impulsive Start," F. Finan, University of Missouri-Rolla

10 a.m. "Turbulence Wavenumber Spectra in Fully-Developed Smooth Pipe Flow," J. C. S. Lai, University of New South Wales; K. J. Bullock and P. Hottis, University of Queensland

Energy and Scalar Variance for Turbulence: Velocity and Scalar Bispectra. J. R. Herndg, National Center for Atmospheric Research; and C. Metax, Institut de Mecanique de Grenoble

10 a.m. "Bispectral Behavior of Large Ensembles of Exact Solutions to Burgers' Equation for Random Initial Conditions—A Preliminary Report," W. Zheng and X B Reed, Jr., University of Missouri-Rolla

10:00 a.m. "Effect of Turbulence Measured by Low Inertia Gill Anemometer on Droplet Coagulation," R. Hopkins and J. Podzimek, University of Missouri-Rolla

Adjournment
equipment Exhibit

Locators of equipment for turbulence measurements and analysis plan to demonstrate their equipment during the Symposium. TIantec and Aerometrics will be present.

Registration

Attendees are urged to return the registration form to allow an accurate estimate of attendance. A registration fee of $225 is being charged. The special rate of $100 is available for graduate students if accompanied by a letter from their faculty advisor. It includes coffee breaks and does not cover the cost of the lunches or the banquet. Attendees who preregister will receive a local hotel room on the UMR campus and motel locations with telephone numbers in order to make their own lodging arrangements.

Transportation

Pickup will be provided at major motels in Rolla.

Proceedings for Former Symposia


Meeting Places

University Center-East, University of Missouri-Rolla, for lectures and luncheons; Land's Motel and Steak House for social hours and banquet.

For Further Information

Walter Ries, Coordinator
Continuing Education
119 Mechanical Engineering Annex
University of Missouri-Rolla
Rolla, MO 65401-0249
Phone (314) 341-4132 or 1-800-752-5057

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Continuing Education
University of Missouri-Rolla

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September 24-26, 1990

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Continuing Education
University of Missouri-Rolla

REGISTRATION CARD
September 24-26, 1990

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Social Security No. ___________________________

Register first for the Symposium. Make checks payable to the University of Missouri-Rolla, Cash, checks, purchase orders, VISA or MasterCard accepted.

SYMPOSIUM ON TURBULENCE

Registrants: (Please Check)
C Registration Fee $225
C Registration Fee less $100 deposit $125
C Graduate Student Registration Fee $100
C Monday Luncheon $8
C Tuesday Luncheon $8
C Banquet Dinner $19
C 1971 Proceedings $11
C 1973 Proceedings $12
C 1975 Proceedings $22
C 1981 Proceedings $34
C 1983 Proceedings $40
C 1984 Proceedings $40
C 1986 Proceedings $30
C 1988 Proceedings $30
C Overseas Mailing Charge $25

Total Enclosed
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