

AUTHORS — JANUARY 1986

COMPACT TOROIDS

REVIEW OF THE LOS ALAMOS FRX-C EXPERIMENT

Richard E. Siemon (top right) (PhD, physics, University of California, San Diego, 1969) is the group leader of the field-reversed configuration (FRC) group at Los Alamos National Laboratory (LANL). **W. Thomas Armstrong** (top left) (PhD, physics, University of Colorado, 1978) is a staff member in the FRC group at LANL. His recent research interests include experimental studies of FRC formation constraints and the study of high-density FRC behavior. **Daniel C. Barnes** (second from top right) (PhD, applied mathematics, Purdue University, 1975) is a senior research scientist with Science Applications International Corp. His work is in computational plasma physics, and his current interests are formation and stability of FRCs. **R. Richard Bartsch** (second from top left) [PhD, electrical engineering, Massachusetts Institute of Technology (MIT), 1968] is a staff member in the Physics Division at LANL. He is presently engaged in the development of intense microwave sources, utilizing relativistic electron beams. **Robert E. Chrien** (third from top right) (PhD, astrophysical sciences, Princeton University, 1981) is a staff member in the FRC group at LANL. His main interests have been spectroscopy, magnetic probing of FRCs, and fusion product measurements. **James C. Cochrane** (third from top left) (MS, nuclear engineering, North Carolina State University, 1970) is a staff member in the Physics Division at LANL. He is presently working on plasma opening switch development. **Waheed N. Hugrass** (fourth from top right) (PhD, Flinders University of South Australia, 1980) is a staff member of the FRC group at LANL. He is currently engaged in FRC formation studies. **Ralph W. Kewish, Jr.** (fourth from top left) (BS, physics, Louisiana State University, 1964) is a staff member of the engineering group at LANL. He is presently working on the ZT-40M reversed-field-pinch experiment. **Phillip L. Klingner** (bottom right) (BS, social science, Michigan State University, 1973) is a senior programmer at LANL. He specializes in experiment control and data acquisition and analysis. **H. Ralph Lewis** (bottom left) (PhD, physics, University of Illinois, 1958) is a theorist and laboratory fellow at LANL in the Controlled Thermonuclear Reactor Division. His current interests are plasma stability theory and nonlinear

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Rulon K. Linford
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Ross L. Spencer
Michel Tuszewski



dynamics. **Rulon K. Linford** (top right) (PhD, electrical engineering, MIT, 1973) is the project leader for compact toroid research (spheromaks and FRCs) at LANL. **Kenneth F. McKenna** (top left) (PhD, aerospace engineering, The Pennsylvania State University, 1973) is deputy group leader of the FRC group at LANL. He has carried out holographic interferometry and bolometric measurements on FRCs and analytically developed FRC slow formation concepts. **Richard D. Milroy** (second from top right) (PhD, electrical engineering, University of Alberta, Canada, 1978) is a principal research scientist at Spectra Technologies. His current research interests include numerical code development and modeling of FRC formation. **Donald J. Rej** (second from top left) (PhD, applied physics, Cornell University, 1981) is a staff member in the FRC group at LANL. He has carried out Thomson scattering electron temperature measurements, plasma energy balance analyses, and translation and multipole stabilization experiments on FRCs. **James L. Schwarzmeier** (third from top right) (PhD, physics, University of Wisconsin, 1977) is a staff member in the plasma theory group at LANL. He is working on kinetic models of equilibrium, stability, and transport for FRCs. **Charles E. Seyler** (third from top left) (PhD, physics, University of Iowa, 1975) is an associate professor of electrical engineering at Cornell University. He is a theorist working on kinetic stability of global models in FRCs, nonlinear waves in relativistic electron beams, and nonlinear processes in ionospheric plasmas. **Eugene G. Sherwood** (fourth from top right) (BS/BA, University of Albuquerque, 1968) is a staff member in the Physics Division at LANL. He is presently engaged in the development of intense microwave sources, utilizing relativistic electron beams. **Ross L. Spencer** (bottom left) (PhD, physics, University of Wisconsin, 1979) is an assistant professor in physics and astronomy at Brigham Young University. He is a theorist interested in equilibrium and kinetic stability of FRCs. **Michel Tuszewski** (bottom right) (PhD, plasma physics, University of California, Berkeley, 1976) is a staff member in the FRC group at LANL. His interests are experimental and theoretical work on FRCs.



REVIEW OF EXPERIMENTAL SPHEROMAK RESEARCH AND FUTURE PROSPECTS

Masaaki Yamada

Masaaki Yamada (BS, 1966 and MS, 1968, nuclear engineering, University of Tokyo, Japan; PhD, physics, University of Illinois, 1973) is head of the Spheromak Research Branch at Princeton Plasma Physics Laboratory. He has performed research in spheromak and other fusion concepts, and micro and macro plasma instabilities. His special area of interest is experimental plasma physics.



FORMATION OF FIELD-REVERSED CONFIGURATIONS USING SCALABLE, LOW-VOLTAGE TECHNOLOGY

*Alan L. Hoffman
Richard D. Milroy
John T. Slough
Loren C. Steinhauer*

Alan L. Hoffman (top) (PhD, aeronautics and applied mathematics, California Institute of Technology, 1967) is director of the plasma physics and fusion group at Spectra Technology, Inc. (STI). He is project manager for the compact toroid research on field-reversed configurations (FRCs). **Richard D. Milroy** (bottom) (PhD, electrical engineering, University of Alberta, Canada, 1978) is a principal research scientist at STI. He is the developer



of a two-dimensional magnetohydrodynamics code for FRC formation modeling, and also is in charge of computer data acquisition for TRX. **John T. Slough** (left) (PhD, astrophysics, Columbia University, 1981) is a senior scientist at STI. He is in charge of the triggered reconnection experiment (TRX) program on FRCs. **Loren C. Steinhauer** (right) (PhD, aeronautics and astronautics, University of Washington, 1970) is a principal research scientist at STI. He directs an FRC theory program and also supplies analytical support for the TRX experiments.



INDUCTIVE SUSTAINMENT OF SPHEROMAKS

Alan C. Janos (top) [BS, applied and engineering physics, Cornell University, 1973; ScM, physics, Brown University, 1976; PhD, physics, Massachusetts Institute of Technology (MIT), 1980] has been a research physicist at the Princeton Plasma Physics Laboratory (PPPL) since 1980. At PPPL, his research has been focused on the experimental study of the physics of spheromak plasmas. His present research interests include magnetohydrodynamic equilibrium, stability, and sustainment (current drive) of spheromak configurations. From 1981 to 1983, he was the deputy project manager of the S-1 Spheromak Device Fabrication Project. At MIT, he was the principal investigator for experimental research on the Rector tokamak device from 1976 to 1980 during which time he investigated the effects of a stellarator field on the positional stability of tokamak plasmas. **Masaaki Yamada** (BS, 1966 and MS, 1968, nuclear engineering, University of Tokyo, Japan; PhD, physics, University of Illinois, 1973) is head of the Spheromak Research Branch at PPPL. He has performed research in spheromak and other fusion concepts, and micro and macro plasma instabilities. His special area of interest is experimental plasma physics.

*Alan C. Janos
Masaaki Yamada*



HELICAL QUADRUPOLE FIELD STABILIZATION OF FIELD-REVERSED CONFIGURATION PLASMA

Yasuyuki Nogi (right) (BS, 1963; MS, 1965; and PhD, 1973, Nihon University, Japan) is an associate professor at Nihon University. A photograph and biography were not available for **S. Shimamura**.

*S. Shimamura
Yasuyuki Nogi*



NUMERICAL CALCULATION OF EQUILIBRIA FOR THE FIELD-REVERSED CONFIGURATION

D. E. Shumaker (BS, nuclear engineering, University of Florida, 1970; PhD, applied science, University of California, Davis, 1977) is a computational physicist at the National Magnetic Fusion Energy Computer Center at Lawrence Livermore National Laboratory. His work has been in the area of numerical calculation of axisymmetric equilibria of compact torus plasmas. He has also developed transport codes for compact torus plasmas.

D. E. Shumaker



HYDRODYNAMIC CONFINEMENT OF THERMONUCLEAR PLASMA TRISOPS VIII (PLASMA LINER CONFINEMENT)

Daniel R. Wells (top) (BME, Cornell University, 1942; MSc, New York University, 1952; PhD, Stevens Institute of Technology, 1963) is professor of physics at the University of Miami (UM). His fields of interest are theoretical and experimental hydrodynamics and magnetohydrodynamics, partially and fully ionized gases, plasma physics, controlled thermonuclear reactions, high-altitude physics, high-altitude nuclear burst phenomena, electromagnetic theory, quantum mechanics, machine design, product design, accident reconstruction, and computer technology. **Paul Edward Ziajka** (center) (BS, biology and physics, UM, 1976; MS, physics, UM, 1978; PhD, physics, UM, 1981; MD, UM, 1984) is a housestaff physician in the Department of Internal Medicine, Orlando, Florida, Regional Medical Center. He is also a consultant to the UM Department of Neurology and the TRISOPS Corporation. His scientific experience includes nuclear physics, neutron measurements and data interpretation, tritium technology, and fusion energy. **Jack L. Tunstall** (bottom) (Birmingham-Southern College, 1947; MS, UM, 1958) is a research physicist at UM.

*Daniel R. Wells
Paul Edward Ziajka
Jack L. Tunstall*



A DEUTERIUM-TRITIUM IGNITION RAMP FOR AN ADVANCED FUEL FIELD-REVERSED CONFIGURATION REACTOR

Robert M. Zubrin (BA, mathematics, University of Rochester, 1974; MS, nuclear engineering, University of Washington, 1984) is a predoctoral graduate student at the University of Washington. His interests include reactor design studies and plasma simulations.

Robert M. Zubrin



CONCEPTUAL DESIGN OF A CASSETTE COMPACT TOROID REACTOR (THE ZERO-PHASE STUDY)—QUICK REPLACEMENT OF THE REACTOR CORE

Masahiro Nishikawa (top right) [PhD, nuclear engineering, Osaka University (OU), Japan, 1972] is an associate professor, Faculty of Engineering, OU. His primary research interests include fusion reactor physics and technology, and application of functional materials to various apparatus in the energy field. **Takefumi Narikawa** (top left) (MS, nuclear engineering, OU, Japan, 1968) is manager of Section A, Department of Nuclear Fusion Development, Mitsubishi Electric Corp. Since 1975, he has been engaged in the preliminary design of fusion machines. **Masatami Iwamoto** (bottom right) (PhD, electrical engineering, University of Tokyo, Japan, 1969) is manager of the Department of Electrotechnology Research, Central Research Laboratory, Mitsubishi Electric Corp. **Kenji Watanabe** (bottom left) (PhD, physics, OU, Japan, 1961) is a professor, Faculty of Engineering, OU. He is one of the organizers of a special research project on nuclear fusion supported by MOE, and is currently the group leader of Group VI (Fundamentals of Fusion Reactor Design and Assessment). His interests include theoretical and experimental analyses related to spheromak plasma and fusion reactor technology.

*Masahiro Nishikawa
Takefumi Narikawa
Masatami Iwamoto
Kenji Watanabe*



DESIGN OF A TRANSLATING FIELD-REVERSED CONFIGURATION REACTOR

George C. Vlases (top) (PhD, California Institute of Technology, 1963) taught at the University of Colorado from 1963 to 1969. He is presently affiliated with the University of Washington, where he is professor of nuclear engineering. In 1981 and 1985 he worked at the Max Planck Institute for Plasmaphysics in Garching, Federal Republic of Germany. His research interests include both plasma physics and fusion technology. **D. S. Rowe** (PhD, mechanical engineering, Oregon State University, 1973) is principal of the engineering consulting firm Rowe & Associates. He has been involved with the thermal and hydraulic performance of nuclear energy systems since 1963. Since 1978 he has worked with the University of Washington and Lawrence Livermore National Laboratory on fusion blanket design and application studies.

*George C. Vlases
D. S. Rowe
Firebird Design Team*



CONCEPTUAL DESIGN OF A MOVING-RING REACTOR

Adrian C. Smith, Jr. (top right) [BS, physics, electrical engineering, California Institute of Technology, 1970; PhD, applied physics, Cornell University (CU), 1977] is assistant program leader for planning and analysis in the Beam Research Program at the Lawrence Livermore National Laboratory (LLNL). In 1976, he joined the Pacific Gas and Electric Company (PG&E) to evaluate advanced power-generating technologies of potential use to electric utilities, with primary focus on conceptual designs of compact fusion reactors. In 1984, he joined LLNL, where his work centers on national defense applications of intense, high-energy electron beams. **Gustav A. Carlson** (top left) (BS, 1963; MS, 1964; and PhD, 1967, mechanical engineering, Carnegie-Mellon University) is presently a group leader in the Weapons Engineering Division at LLNL. He worked in magnetic fusion energy at LLNL from 1969 until May 1985, and is past chairman of the Fusion Energy Division of the American Nuclear Society. **William S. Neef, Jr.** (center right) (BME and MS, mechanical engineering, CU, 1954) is the project engineer for reactor technology and conceptual design at LLNL. From 1958 to 1967, he designed plasma physics experimental apparatus leading to the first "baseball" magnet geometry. After experience in LLNL's weapon test program and designing both gas and solid-state laser beamline components, he returned to magnetic fusion. He has worked on designs for tandem mirror and field-reversed mirror reactors and has contributed to several tandem hybrid designs. **Clinton P. Ashworth** (bottom left) (BS, electrical engineering, University of Utah, 1950) is supervising mechanical engineer for PG&E. He has been involved in several large power plant projects and participated in advanced power generation concepts work involving nuclear, fossil, advanced cycles, fuel cells, and PG&E's large wind turbine. His interests include fusion, renewables, reactor assessment, magneto-hydrodynamics (MHD), and fuel cells. A photograph and biography for **Kenneth E. Abreu** were not available. **Hans H. Fleischmann** (bottom right) [Dipl.-Phys. and Dr. rer. nat., Technical University of Munich, Federal Republic of Germany (FRG)] is professor of applied and engineering physics at CU (since 1967) where his research interests center mainly on the generation and physics of field-reverse large orbit and novel accelerator schemes. He has worked on plasma diagnostic and atomic collisions at GA Technologies

*Adrian C. Smith, Jr.
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Kenneth E. Abreu
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Clement P. C. Wong
Dilip K. Bhadra
R. Lewis Creedon
Edward T. Cheng
George R. Hopkins
William Grossmann, Jr.
David M. Woodall
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(GA) and on nuclear resonance fluorescence and multiple scattering at the Technical University of Munich. He has worked on nonlinear circuitry for Rohde & Schwarz, Mess geraetebau, Munich, and has served as a consultant to many industrial and government institutions. **Kenneth R. Schultz** (top right) (PhD, nuclear engineering sciences, University of Florida, 1971) is a manager of fusion development and technology at GA. He is responsible for the fusion nuclear technology aspects of several reactor design study projects for tokamak, mirror, and inertial confinement reactor applications, with emphasis on blanket engineering. He also is involved with several small blanket technology experiments. **Clement P. C. Wong** (top left) [BS and MS, nuclear engineering, University of Wisconsin (UW); PhD, nuclear engineering, University of Texas] has been involved in the design of blankets on several different fusion reactor studies since joining GA in 1977. His research interests are in the areas of fusion reactor blanket thermal-hydraulics and MHD effects and the assessment of tritium breeding materials. He has coordinated the blanket designs on the small reactor, tandem mirror hybrid reactor, and moving ring reactor studies. He led the material and design selection for the Lithium Blanket Module Study. Currently, he is the principal investigator, representing GA for the Fusion Breeder Program Reactor Study, and the Blanket Comparison and Selection Study. **Dilip K. Bhadra** (second from top right) (BSc, University of Calcutta, India; PhD, physics, University of California, 1969) is a staff scientist at GA. His specialty is the design and implementation of studies in plasma physics, both theoretical and applied. He has had extensive experience in working with aspects of the design of different conceptual reactor-type fusion devices. **R. Lewis Creedon** (center left) (Higher National Certificate, mechanical/aeronautical engineering, Southampton University, England, 1951) has been involved in the design of many fusion-related structures. He has worked on diagnostics, superconducting magnets, and, in particular, blanket design. His interests in neutron-economical and swelling-tolerant characteristics of blanket structures have been applied to a series of reactor studies and test module designs in which unique fusion-related structures have been required, including the lithium blanket module for the tokamak fusion test reactor. **Edward T. Cheng** (third from top right) (PhD, nuclear engineering, UW, 1976) has been a member of the Development and Technology Group in the Fusion Division of GA since 1978. He has been involved with various fusion blanket and reactor design studies including fusion breeder and chemical production applications. His interests are primarily in the areas of neutronics, radioactivity, and blanket engineering. **George R. Hopkins** (bottom left) (PhD, physics, Iowa State University, 1954) is a senior staff engineer at GA. His research interests over the past 14 years have been centered about fusion power technology and development, in which he has pioneered in the development of a low activation fusion reactor concept. Materials research and development, reactor design studies, plasma engineering, atomic physics, safety, blanket design, and limiter development are also areas to which he has contributed. **William Grossmann, Jr.** (bottom right) (PhD, aerospace engineering, Virginia Polytechnic Institute and State University) was an aerospace research engineer at the National Aeronautics and Space Administration Langley Research Center from 1958 to 1964 where he worked in magnetoplasmadynamic propulsion. He joined the Courant Institute of Mathematical Sciences (CIMS) as an assistant research scientist and later became an assistant professor of applied mathematics at the City University of New York. From 1967 to 1974 he was senior scientist at the Max-Planck-Institut of Plasmaphysik, Garching, FRG, where he was involved in high- β plasma stability. Since 1974 he has been at the CIMS where he is presently



research professor of plasma sciences, associate director of the Magneto-Fluid Dynamics Division, and adjunct professor of applied science. He is a fellow of the American Physical Society and holds the position of director of the Summer College on Plasma Physics at the International Centre for Theoretical Physics in Trieste, Italy. His current research interests are plasma stability theory, wave propagation, and radio-frequency heating of plasmas. **David M. Woodall** (top) (BA, physics, Hendrix College; MS, nuclear engineering, Columbia University; PhD, engineering physics, CU) is a professor and former chairman of the Department of Nuclear Engineering at the University of New Mexico (UNM). He is a member of the technical staff and the associate director of the Institute for Accelerator and Plasma Beam Technology at UNM. His current interests include research on a high current betatron, accelerator and plasma physics, pulsed power, and nuclear reactor safety. **Terry Kammash** (bottom) (BS, aeronautical engineering, Pennsylvania State University, 1952; PhD, nuclear engineering, University of Michigan, 1958) served as a consultant on controlled fusion research at LLNL, Argonne National Laboratory, Oak Ridge National Laboratory, and Battelle Pacific Northwest Laboratories.



SIMPLE LIQUID-METAL BLANKETS FOR LINEAR MAGNETIC FUSION REACTORS

W. K. Terry (top) (PhD, nuclear engineering, University of Washington, 1980) is a staff engineer in Rockwell International's Basalt Waste Isolation Project. Formerly, he was an assistant professor in the School of Nuclear Engineering at Purdue University. He collaborated with the Fusion Power Program at Argonne National Laboratory from 1982 to 1985. He has worked in the areas of plasma engineering and fusion reactor design, especially involving tokamaks and field-reversed configurations. **E. B. Paperman** (BS, physics, Miami University, 1980; MS, nuclear engineering, Purdue University, 1984) is a nuclear engineer, working for General Electric at the Knolls Atomic Power Laboratory.

*W. K. Terry
E. B. Paperman*

