fusion technology

AUTHORS — JANUARY 1990

STELLARATORS

NEAR-TERM DIRECTIONS IN THE WORLD STELLARATOR PROGRAM

J. F. Lyon

J. F. Lyon (PhD, physics, University of Tennessee, 1970) is stellarator program coordinator in Oak Ridge National Laboratory's (ORNL's) Fusion Energy Division and an adjunct professor in nuclear engineering at the University of Tennessee. His current activities are in stellarator confinement and reactor studies. He has worked in the mirror, tokamak, and stellarator programs at ORNL and on tokamak and stellarator programs in the USSR, France, the United Kingdom, Japan, and the Federal Republic of Germany (FRG).

CONSTRUCTION AND INITIAL OPERATION OF THE ADVANCED TOROIDAL FACILITY

J. F. Lyon
G. L. Bell
J. D. Bell
R. D. Benson
T. S. Bigelow
K. K. Chipley
R. J. Colchin
M. J. Cole
E. C. Crume
J. L. Dunlap
A. C. England
J. C. Glowienka
R. H. Goulding
J. H. Harris
D. L. Hillis
S. Hiroe
L. D. Horton
H. C. Howe
R. C. Isler
T. C. Jernigan
R. L. Johnson
R. A. Langley
M. M. Menon
P. K. Mioduszewski
R. N. Morris
M. Murakami
G. H. Neilson

J. F. Lyon (top right) (PhD, physics, University of Tennessee, 1970) is stellarator program coordinator in Oak Ridge National Laboratory's (ORNL's) Fusion Energy Division and an adjunct professor in nuclear engineering at the University of Tennessee. His current activities are in stellarator confinement and reactor studies. He has worked in the mirror, tokamak, and stellarator programs at ORNL and on tokamak and stellarator programs in the USSR, France, United Kingdom, Japan, and Federal Republic of Germany (FRG). **G. L. Bell** (top left) (BS, Auburn University, 1983) is a PhD candidate at Auburn University. He has worked with vacuum spark discharges and is currently carrying out electron cyclotron emission experiments on the Advanced Toroidal Facility (ATF). **J. D. Bell** (center right) (MS, University of Tennessee, 1983) is a staff member in ORNL's Computing and Telecommunications Division. He has worked in automated data acquisition and fluctuation analysis for tokamaks and stellarators. **R. D. Benson** (bottom left) (BS, University of Tennessee) is an engineer at ORNL. His current activities are in project engineering for the Fusion Energy Division stellarator confinement projects. **T. S. Bigelow** (biography and photograph not available). **K. K. Chipley** (bottom right) (BSME, Memphis State University, 1973) is leader of the Engineering Section, Fusion Technology Engineering, Martin Marietta Energy Systems, responsible for design and analysis of mechanical systems for

fusion experiments. He was responsible for the vacuum vessel design for the ATF. **R. J. Colchin** (biography and photograph not available). **M. J. Cole** (top right) (BSME, Memphis State University, 1973) is a mechanical engineer in the Central Engineering Division of Martin Marietta Energy Systems. He is responsible for the design of the helical field coil system on the ATF, which includes all tooling fixtures for fabrication and installation. **E. C. Crume** (top left) (PhD, University of Tennessee, 1972) is a member of the ORNL Fusion Energy Division research staff. He is currently involved in spectroscopic measurements of impurity behavior in the ATF. He has also worked on numerical simulation of impurity transport in tokamaks and calculations of transport coefficients in tokamaks and stellarators. **J. L. Dunlap** (second from top right) (PhD, Vanderbilt University, 1959) is head of the Toroidal Confinement Physics Section in ORNL's Fusion Energy Division. He has worked in mirror, tokamak, and stellarator plasmas. **A. C. England** (second from top left) (PhD, University of Rochester, 1961) is a member of the ORNL Fusion Energy Division staff. He has worked on mirrors at ORNL and at Max-Planck-Institut für Plasmaphysik, tokamaks at ORNL and Princeton Plasma Physics Laboratory (PPPL), and on the ATF. **J. C. Glowienka** (biography and photograph not available). **R. H. Goulding** (third from top right) (PhD, University of Wisconsin, 1987) is a member of the ORNL research staff. He is presently involved in radio-frequency (rf) heating experiments on the ATF and the design, construction, and testing of rf launchers and associated matching systems for several tokamak experiments. **J. H. Harris** (third from top left) (PhD, University of Wisconsin, 1981) is a member of the research staff at ORNL. His research interests include the design of stellarator configurations and experimental studies of fluctuations and confinement. He has worked on stellarator experiments in the United States, the USSR, and Japan. **D. L. Hillis** (biography and photograph not available). **S. Hiroe** (biography and photograph not available). **L. D. Horton** (fourth from top right) (BASc, engineering science, University of Toronto, Canada, 1981; MS, 1982, and PhD, 1985, nuclear engineering, University of Michigan) is a member of the research staff at ORNL. He has worked on the charge-exchange spectroscopy diagnostic at the Joint European Torus experiment and is presently part of the ATF spectroscopy group. **H. C. Howe** (biography and photograph not available). **R. C. Isler** (fourth from top left) (PhD, physics, Johns Hopkins University, 1963) is a senior research staff member in ORNL's Fusion Energy Division. His primary field of research is spectroscopic analysis of high-temperature plasmas. **T. C. Jernigan** (fifth from top right) (PhD, University of Wisconsin, 1971) is project manager of ATF construction in ORNL's Fusion Energy Division. He was previously project manager for the ISX-A tokamak construction. He has worked on experimental physics in tokamaks and internal ring devices. **R. L. Johnson** (bottom left) (BS, Georgia Institute of Technology, 1958) is head of the confinement systems engineering department in the Central Engineering Division of Martin Marietta Energy Systems. He provides technical and management support to a wide variety of experimental fusion projects. He is also the design manager for the ATF. **R. A. Langley** (bottom right) (PhD, Georgia Institute of Technology, 1963) is a member of the ORNL staff. He has worked in the fields of atomic and molecular physics, material science, and plasma physics. He currently works on vacuum, wall conditioning, and plasma/wall interactions on the ATF. **M. M. Menon** (photograph not available) (PhD, electrical engineering, University of Waterloo, Canada) has worked at ORNL since 1974, joining the Fusion Energy Division in 1976. His interests are in neutral beam injection systems, ion sources, cryogenic power transmission, and high-voltage insulation in vacuums.

B. E. Nelson
D. A. Rasmussen
J. A. Rome
M. J. Saltmarsh
P. B. Thompson
M. R. Wade
J. A. White
T. L. White
J. C. Whitson
J. B. Wilgen
W. R. Wing

P. K. Mioduszewski (top right) (BS, physics, University of Bonn, FRG, 1965; MS, physics, University of Marburg, FRG, 1969; PhD, physics, Technical University of Aachen, FRG, 1971) researched plasma/wall interaction problems at Kernforschungsanlage Jülich from 1972 to 1980. He joined ORNL's Fusion Energy Division in 1980, where he is currently leader of the plasma edge physics group. He is involved in studies on the ATF, as well as in international collaborations on the Tore Supra and TEXTOR tokamak facilities. **R. N. Morris** (top left) (BS, electrical engineering, Wayne State University, 1978; MS, 1979, and PhD, 1984, Georgia Institute of Technology) is a computational physicist in ORNL's Computing and Telecommunications Division. He is currently involved in the alignment of the ATF coil sets, the beamline systems, and the position of plasma diagnostics. **M. Murakami** (second from top right) [PhD, Massachusetts Institute of Technology (MIT), 1970] is ATF experimental program coordinator in ORNL's Fusion Energy Division. His current activities are in experimental studies of confinement and transport in stellarators. He has worked in tokamak experiments at ORNL and PPPL and stellarator experiments in Japan. **G. H. Neilson** (second from top left) (PhD, University of Tennessee, 1979) is a section head in ORNL's Fusion Energy Division. His section is responsible for operation of and improvements to the ATF. He has worked on magnetic diagnostics and equilibrium control in stellarators and tokamaks. **B. E. Nelson** (third from top right) (MS, mechanical engineering, University of Missouri, 1976) is the head of the Confinement and Plasma Technology Section of the Engineering Division of Martin Marietta Energy Systems. He has worked on the design and analysis of magnets, magnet structures, and magnetic confinement systems for fusion research. **D. A. Rasmussen** (third from top left) (PhD, University of California, Davis, 1981) is a member of the ORNL research staff. His interests include the experimental study of confinement and transport in toroidal systems through the use of electron temperature and density diagnostic devices. **J. A. Rome** (fourth from top right) (BS, MS, and ScD, MIT) is a senior scientist in ORNL's Fusion Energy Division. **M. J. Saltmarsh** (fourth from top left) (PhD, nuclear physics, University of Oxford, United Kingdom, 1966) is associate director for operations of the ORNL Fusion Energy Division. He has worked in the field of magnetic fusion since 1977. **P. B. Thompson** (fifth from top right) is manager of fusion projects engineering for the Central Engineering Division of Martin Marietta Energy Systems. He is also engineering manager for the ATF and provides technical and management input to a variety of experimental fusion projects. **M. R. Wade** (fifth from top left) (MS, Georgia Institute of Technology, 1987) is currently working on his doctoral thesis in the ORNL Fusion Energy Division. His main area of study is neutral particle analysis on the ATF. **J. A. White** (sixth from top right) (MS, University of Tennessee, 1983) is a member of the ORNL Engineering Division staff. He has worked on electrical power and control systems for various experiments. He is currently the chief engineer for the ATF. **T. L. White** (biography and photograph not available). **J. C. Whitson** (sixth from top left) (PhD, Clemson University, 1967) is a member of the ORNL Computing and Telecommunications Division staff. He has worked on tokamak and stellarator research engineering and theory for the past 16 years. **J. B. Wilgen** (bottom right) (PhD, California Institute of Technology, 1975) is a member of the ORNL research staff. He is currently working on millimetre-wave diagnostics and pellet fueling on the ATF. **W. R. Wing** (bottom left) (PhD, University of Iowa, 1972) is a senior research staff member of the ORNL Fusion Energy Division. He has worked in the turbulent heating and tokamak programs. He is presently responsible for the magnetic diagnostics and data system for the ATF.

REALIZATION OF THE ADVANCED TOROIDAL FACILITY TORSATRON MAGNETIC FIELD

J. H. Harris
T. C. Jernigan
F. S. B. Anderson
R. D. Benson
R. J. Colchin
M. J. Cole
A. C. England
R. F. Gandy
M. A. Henderson
D. L. Hillis
R. L. Johnson
D. K. Lee
J. F. Lyon
G. H. Neilson
B. E. Nelson
J. A. Rome
M. J. Saltmarsh
C. W. Simpson
D. J. Taylor
P. B. Thompson
J. C. Whitson

J. H. Harris (top right) (PhD, University of Wisconsin, 1981) is a member of the research staff at Oak Ridge National Laboratory (ORNL). His research interests include the design of stellarator configurations and experimental studies of fluctuations and confinement. He has worked on stellarator experiments in the United States, the USSR, and Japan. **T. C. Jernigan** (top left) (PhD, University of Wisconsin, 1971) is project manager for construction of the Advanced Toroidal Facility (ATF) in ORNL's Fusion Energy Division. He was previously project manager for the ISX-A tokamak construction. He has worked on experimental physics in tokamaks and internal ring devices. **F. S. B. Anderson** (biography and photograph not available). **R. D. Benson** (second from top right) (BS, University of Tennessee) is an engineer at ORNL. His current activities are in project engineering for the Fusion Energy Division stellarator confinement projects. **R. J. Colchin** (biography and photograph not available). **M. J. Cole** (second from top left) (BSME, Memphis State University, 1973) is a mechanical engineer in the Central Engineering Division of Martin Marietta Energy Systems. He is responsible for the design of the helical field coil system on the ATF, which includes all tooling fixtures for fabrication and installation. **A. C. England** (third from top right) (PhD, University of Rochester, 1961) is a member of the ORNL Fusion Energy Division staff. He has worked on mirrors at ORNL and at Max-Planck-Institut für Plasmaphysik, tokamaks at ORNL and Princeton Plasma Physics Laboratory (PPPL), and on the ATF. **R. F. Gandy** (third from top left) (PhD, University of Texas) is a member of the physics department at Auburn University. His research interests lie in the areas of stellarator physics and electron cyclotron emission diagnostics. **M. A. Henderson** (fourth from top right) (MS, Auburn University, 1987) is currently working on his PhD at Auburn University. His dissertation involves the construction of the Compact Auburn Torsatron and investigation of its magnetic flux surfaces. **D. L. Hillis** (biography and photograph not available). **R. L. Johnson** (fourth from top left) (BS, Georgia Institute of Technology, 1958) is head of the confinement systems engineering department in the Central Engineering Division of Martin Marietta Energy Systems. He provides technical and management support to a wide variety of experimental fusion projects. He is also the design manager for the ATF. **D. K. Lee** (fifth from top right) (PhD, Washington University, 1966) is a member of the ORNL research staff. He has worked on field error studies and is currently working on theoretical calculations of magnetic islands in stellarators. **J. F. Lyon** (fifth from top left) (PhD, physics, University of Tennessee, 1970) is the stellarator program coordinator in ORNL's Fusion Energy Division and an adjunct professor in nuclear engineering at the University of Tennessee. His current activities are in stellarator confinement and reactor studies. He has worked in the mirror, tokamak, and stellarator programs at ORNL and on tokamak and stellarator programs in the USSR, France, United Kingdom, Japan, and Federal Republic of Germany. **G. H. Neilson** (bottom right) (PhD, University of Tennessee, 1979) is a section head in ORNL's Fusion Energy Division. His section is responsible for operation of and improvements to the ATF. He has worked on magnetic diagnostics and equilibrium control in stellarators and tokamaks. **B. E. Nelson** (bottom left) (MS, mechanical engineering, University of Missouri, 1976) is the head of the Confinement and Plasma Technology Section of the Engineering Division of Martin Marietta Energy Systems. He has worked on the design and analysis of magnets, magnet structures, and magnetic confinement systems for fusion research.

J. A. Rome (top right) (BS, MS, and ScD, Massachusetts Institute of Technology) is a senior scientist in ORNL's Fusion Energy Division. **M. J. Saltmarsh** (top left) (PhD, nuclear physics, University of Oxford, United Kingdom, 1966) is associate director for operations of the ORNL Fusion Energy Division. He has worked in the field of magnetic fusion since 1977. **C. W. Simpson** (biography and photograph not available). **D. J. Taylor** (biography and photograph not available). **P. B. Thompson** (bottom right) is manager of fusion projects engineering for the Central Engineering Division of Martin Marietta Energy Systems. He is also engineering manager for the ATF and provides technical and management input to a variety of experimental fusion projects. **J. C. Whitson** (bottom left) (PhD, Clemson University, 1967) is a member of the ORNL Computing and Telecommunications Division staff. He has worked on tokamak and stellarator research engineering and theory for the past 16 years.

STELLARATOR WENDELSTEIN VII-AS: PHYSICS AND ENGINEERING DESIGN

Jörg Sapper
Hermann Renner

Jörg Sapper (photograph not available) [Dipl. Ing., Universities of Berlin and Stuttgart, Federal Republic of Germany (FRG), 1964] was a design engineer for large rotating, electrical machines at AEG and BBC for 10 years. He has been with the stellarator department at the Max-Planck-Institut für Plasmaphysik (IPP) since 1975 where he was in charge of operation, design, and procurement of the basic confinement systems. He was head of the Wendelstein VII-AS (W VII-AS) project during its construction and currently is technical project manager for W VII-AS. **Hermann Renner** (photograph not available) (experimental physicist, Universities of Göttingen and Munich, FRG, 1970) has been a member of the stellarator department at IPP since 1970. He served as experimental leader for W IIb and as project leader of W VII-A. He is currently head of the W VII-AS project.

ELECTRON CYCLOTRON RESONANCE HEATING TRANSMISSION LINE AND LAUNCHING SYSTEM FOR THE WENDELSTEIN VII-AS STELLARATOR

V. Erckmann
The Wendelstein VII-AS Team
W. Kasparek
G. A. Müller
P. G. Schüller
M. Thumm

Photographs and biographies for **V. Erckmann** and the **Wendelstein VII-AS Team, W. Kasparek, G. A. Müller, P. G. Schüller,** and **M. Thumm** were not available at publication time.

COMPACT HELICAL SYSTEM PHYSICS AND ENGINEERING DESIGN

Kiyohiko Nishimura
Keisuke Matsuoka
Masami Fujiwara
Kozo Yamazaki
Jiro Todoroki
Tetsuo Kamimura
Tsuneo Amano
Heiji Sanuki
Shoichi Okamura
Minoru Hosokawa

Kiyohiko Nishimura (left) (PhD, engineering, Tohoku University, Japan, 1984) is a research scientist at the National Institute for Fusion Science (NIFS). He has worked on ion cyclotron radio-frequency (rf) plasma production and heating experiments with the Compact Helical System (CHS). **Keisuke Matsuoka** (right) (PhD, engineering, University of Tokyo, Japan, 1974) is an associate professor at the NIFS. He has worked on experiments

in the CHS. **Masami Fujiwara** (photograph not available) (PhD, physics, Nagoya University, Japan, 1970) is a director of the Large Helical Device Project at NIFS. **Kozo Yamazaki** (top right) (PhD, engineering, University of Tokyo, Japan, 1977) is an associate professor at the NIFS. He has worked on experiments and physics design studies of tokamak and helical systems. **Jiro Todoroki** (top left) (MS, physics, University of Tokyo, Japan, 1965) is an associate professor at the NIFS. He has worked on magnetohydrodynamic (MHD) theory and computations for helical systems. **Tetsuo Kamimura** (second from top right) (PhD, engineering, Osaka University, Japan, 1969) is a professor at the NIFS. His research interests include particle orbit, plasma waves, and anomalous transport in toroidal fusion devices. **Tsuneo Amano** (second from top left) (PhD, physics, Kyoto University, Japan, 1962) is a professor at the NIFS. He has worked on MHD stability and transport theory of tokamak, reversed-field pinch, and helical systems. **Heiji Sanuki** (third from top right) (PhD, plasma physics, Nihon University, Japan, 1973) is a research scientist at the NIFS. He has worked on stability, transport, and drift orbit in bumpy tori and helical systems. **Shoichi Okamura** (third from top left) (PhD, physics, University of Tokyo, Japan, 1977) is a research scientist at the NIFS. He has worked on experiments in the CHS. **Minoru Hosokawa** (biography and photograph not available). **Hiroshi Yamada** (fourth from top right) (PhD, engineering, University of Tokyo, Japan, 1987) is a research associate at the NIFS. He has studied MHD instability and transport in helical system and tokamak plasmas. **Shugo Tanahashi** (fourth from top left) (PhD, engineering, Nagoya University, Japan, 1979) is an associate professor at the NIFS. He has worked on electrical engineering for the CHS and T-IIU devices since 1976. **Shin Kubo** (fifth from top right) (PhD, physics, Kyoto University, Japan, 1981) is a research scientist at the NIFS. He has been involved in electron cyclotron heating (ECH) of the CHS since 1987. **Yasuyuki Takita** (fifth from top left) (BS, engineering, Nagoya Institute of Technology, Japan, 1976) is a member of the technical staff at the NIFS. He has worked on ECH experiments in the CHS. **Tatsuo Shoji** (sixth from top right) (PhD, physics, Nagoya University, Japan, 1977) is an associate scientist at the NIFS. He has been engaged in rf heating and plasma production experiments on the CHS since 1988. **Osamu Kaneko** (sixth from top left) (PhD, physics, University of Tokyo, Japan, 1979) is a research associate in the Plasma Heating Division of the NIFS. His interests lie in neutral beam injection heating physics and engineering. **Harukazu Iguchi** (bottom right) (PhD, physics, Nagoya University, Japan, 1979) is a research scientist at the NIFS. He has been engaged in experiments on plasma confinement in a bumpy torus and the CHS. **Chihiro Takahashi** (bottom left) (BS, mathematics, Meijo University, Japan, 1976) is a member of the technical staff at the NIFS. He has worked on experiments on the CHS.

Hiroshi Yamada
Shugo Tanahashi
Shin Kubo
Yasuyuki Takita
Tatsuo Shoji
Osamu Kaneko
Harukazu Iguchi
Chihiro Takahashi

RECENT HELIOTRON E PHYSICS STUDY ACTIVITIES AND ENGINEERING DEVELOPMENTS

Tokuhiro Obiki
Masahiro Wakatani
Motoyasu Sato
Shigeru Sudo
Fumimichi Sano
Takashi Mutoh
Kimitaka Itoh
Katsumi Kondo
Masahiko Nakasuga
Kiyoshi Hanatani
Hideki Zushi
Tohru Mizuuchi
Hiroshi Kaneko
Hiroyuki Okada
Yasuhiko Takeiri
Yuji Nakamura
Sakae Besshou
Yoshiyuki Ijiri
Masashi Iima
Tohru Senju
Keiji Yaguchi
Tomosumi Baba
Sakuji Kobayashi
Keiji Matsuo
Katsunori Muraoka
Takashige Tsukishima
Masamitsu Nakajima

Tokuhiro Obiki (top right) [Dr. Eng., Kyoto University (KU), Japan, 1973] is director of the KU Plasma Physics Laboratory (KUPPL). He is involved in the heliotron program and in neutral beam injection (NBI) heating, divertor physics, and design studies for the Large Helical Device. **Masahiro Wakatani** (top left) has worked in magnetohydrodynamic (MHD) theory, diamagnetic drift effects, and applications to stellarators and heliotrons. **Motoyasu Sato** (second from top right) (D. Eng., electrical engineering, KU, Japan, 1976) is a member of the KUPPL research staff. He has been responsible for electron cyclotron resonance heating (ECRH) experiments on Heliotron E since 1980 and also for research and development on high-power ECRH systems. **Shigeru Sudo** (second from top left) (DSc, plasma physics, Tokyo University, Japan, 1977) worked on laser-irradiated pellet plasma production at Max-Planck-Institut für Plasmaphysik and has been a KUPPL research staff member since 1980. He is in charge of a Thomson scattering diagnostic system, pellet injection experiments, and development of pellet injectors for Heliotron E. **Fumimichi Sano** (third from top right) (D. Eng., plasma physics, KU, Japan, 1980) is a member of the KUPPL research staff. He is in charge of NBI heating and ion source system development for Heliotron E. **Takashi Mutoh** (third from top left) (D. Eng., electrical engineering, KU, Japan, 1977) worked on ion cyclotron radio-frequency (ICRF) heating at KUPPL from 1977 until 1989, when he became a member of the research staff at the National Institute for Fusion Science. He is in charge of the radio-frequency heating system for the Large Helical Device. **Kimitaka Itoh** (fourth from top right) (BS, 1974; MS, 1976; and PhD, 1979, physics, University of Tokyo, Japan) is an associate professor at the National Institute for Fusion Science. He previously worked as a research physicist at Japan Atomic Energy Research Institute and as an associate professor at KU. His interest is in the theory of instability and transport in magnetic confinement plasmas. **Katsumi Kondo** (fourth from top left) (D. Eng., plasma spectroscopy, KU, Japan, 1988) is a member of the KUPPL research staff. He is in charge of spectroscopic diagnostics for Heliotron E. **Masahiko Nakasuga** (fifth from top right) (Kumamoto University, Japan, 1963) works on magnetic field calculation and device design for magnetic coil systems. **Kiyoshi Hanatani** (fifth from top left) (D. Eng., KU, Japan, 1988) is a member of the KUPPL research staff. He has worked on development and application of computational models on confinement and heating of stellarator and heliotron plasmas. **Hideki Zushi** (sixth from top right) is a member of the KUPPL research staff. He has done experimental work on MHD instabilities. **Tohru Mizuuchi** (sixth from top left) (D. Eng., electrical engineering, KU, Japan, 1983) is a member of the KUPPL research staff. He is currently working on edge plasma physics in helical systems. **Hiroshi Kaneko** (seventh from top right) (D. Eng., KU, Japan, 1989) has been a member of the research staff at the National Institute for Fusion Science since May 1989. His current activity is design study for the Large Helical Device. He worked on Heliotron E experiments in plasma heating and confinement, particularly soft X-ray measurements. **Hiroyuki Okada** (bottom left) (ME, nuclear engineering, KU, Japan, 1983) has been a member of the KUPPL research staff since 1983. He is working on heavy-ion beam probing for potential measurement and ICRF experiments in Heliotron E. **Yasuhiko Takeiri** (bottom right) (PhD, KU, Japan, 1988) was a KUPPL staff member until he moved to the National Institute for Fusion Science in 1989. His current activities are in the design study of the Large Helical Device, development of

a negative-based NBI system, and confinement studies of the Compact Helical System. **Yuji Nakamura** (top right) (D. Eng., nuclear engineering, KU, Japan, 1987) has been a member of the KUPPL research staff since 1987. He has done theoretical work on pellet ablation and transport. His current interests are MHD problems in nonaxisymmetric configurations. **Sakae Besshou** (top left) (DSc, plasma physics, Tokyo University, Japan, 1980) has been a member of the KUPPL research staff since 1980. He is in charge of magnetic measurements, bolometry, and neutron detection for Heliotron E. **Yoshiyuki Ijiri** (second from top right) is an engineer at KUPPL. He works on data processing and microwave interferometry for plasma density measurements. **Masashi Iima** (second from top left) (Dipl. Eng., Takamatsu Technical College, Japan, 1978) is a member of the KUPPL research staff. He is currently working on the development of a high-power ECRH system. **Tohru Senju** (third from top right) is a mechanical engineer at KUPPL. His interests are in high-vacuum technology and mechanical design. **Keiji Yaguchi** (third from top left) (Dipl. Eng., electrical engineering, Kyoto Institute of Technology, Japan, 1984) is an electrical engineer at KUPPL. He works on density measurements with a far-infrared laser and the Heliotron E power supply. **Tomosumi Baba** (fourth from top right) (Dipl. Eng., mechanical engineering, Takamatsu Technical College, Japan, 1980) is a KUPPL staff member. His current interests are in the areas of pellet injector development and cryogenic, high-vacuum, and high-pressure technologies. **Sakuji Kobayashi** (fourth from top left) (BS, science and engineering, Ritsumeikan University, Japan, 1984) is a KUPPL staff member. His interests are the ECRH system and high-vacuum and cryogenic technologies. **Keiji Matsuo** (fifth from top right) (D. Eng., Kyushu University, Japan, 1987) is a research associate at Kyushu University. He has done measurements and analyses of microturbulence in helical and mirror plasmas. **Katsunori Muraoka** (fifth from top left) (D. Eng., Kyushu University, Japan, 1970) is a professor in the energy conversion department at Kyushu University. He has been involved in development of laser-aided plasma diagnostic systems. **Takashige Tsukishima** (bottom right) (PhD, Nagoya University, Japan, 1963) is a professor in the Department of Electrical Engineering and the director of the Plasma Science Center at Nagoya University. His current interests are in high-temperature plasma diagnostics with lasers and in strongly nonlinear phenomena in plasma such as turbulence and self-organization. **Masamitsu Nakajima** (bottom left) (D. Eng., KU, Japan, 1960) has worked on microwave circuits involving active devices such as semiconductor amplifiers and oscillators. He is now engaged in research on optical communications.

H-1 DESIGN AND CONSTRUCTION

Sydney M. Hamberger
Boyd D. Blackwell
Leslie E. Sharp
D. B. Shenton

Sydney M. Hamberger (top right) (BSc, physics, 1950; PhD, 1966; DSc, 1978, London University) worked on microwave discharges at the Research Laboratories of the GEC, England, from 1952 to 1958. He then joined the Controlled Thermonuclear Division at Harwell, which later became part of the Culham Laboratory. He was head of the plasma physics and, later, stellarator groups, until 1977 when he went to Canberra to found the new Plasma Research Laboratory at the Australian National University (ANU). He has held visiting appointments at the University of Oklahoma and the University of California, Los Angeles, and has been a consultant at Oak Ridge National Laboratory. **Boyd D. Blackwell** (top left) (BSc, physics, 1973; PhD, physics, 1980, University of Sydney, Australia), after a period studying magnetoacoustic wave propagation at Texas Technical University, performed ion cyclotron range of frequencies (ICRF) heating experiments on the Alcator-C tokamak at the Massachusetts Institute of Technology. He joined the Plasma Research Laboratory in 1984. He is responsible for ICRF heating on the H-1 heliac and works on magnetic configurations and on the small heliac SHEILA. **Leslie E. Sharp** (bottom right) (BSc, physics, 1960; PhD, 1965, University of Sydney, Australia) joined the plasma physics group at Culham Laboratory in 1968, where he worked mainly on plasma diagnostics and on several stellarators. He joined the Plasma Research Laboratory in 1978, where he has continued his work on new stellarator designs and on advanced diagnostics for measuring plasma fluctuations. **D. B. Shenton** (bottom left) (BSc, engineering, London University, 1950) joined Harwell and Culham Laboratory from the ANU accelerator group to work on the engineering of major plasma experiments before moving to head the Astrophysics Research Division of the U.K. Science and Engineering Research Council. He returned to the Plasma Research Laboratory at the ANU in 1985 as consultant engineer for the H-1 project.

TJ-II PROJECT: A FLEXIBLE HELIAC STELLARATOR

Carlos Alejaldre
Jose Javier Alonso Gozalo
Jose Botija Perez
Francisco Castejón Magaña
Jose Ramon Cepero Diaz
Jose Guasp Perez
A. Lopez-Fraguas
Luis García
Vladimir I. Krivenski
R. Martín
A. P. Navarro
Angel Perea
Antonio Rodriguez-Yunta
Mario Sorolla Ayza
Antonio Varias

Carlos Alejaldre (top right) (PhD, Polytechnic Institute of New York) leads the Theory Plasma Section at CIEMAT and is a member of the Euratom fusion program committee. He has worked in the theory of shock propagation in inertial confinement fusion targets and is currently interested in the theory of electron cyclotron resonance heating (ECRH) and magnetohydrodynamic (MHD) behavior of helical axis devices. **Jose Javier Alonso Gozalo** (top left) (electrical engineering, 1980) has worked in the Fusion Division of CIEMAT since 1986. He has worked on electrical projects for power plants. **Jose Botija Perez** (center right) (mechanical engineering, ETSII, Spain) has been with the Fusion Division of CIEMAT since 1984. **Francisco Castejón Magaña** (center left) (University of Zaragoza, Spain, 1984) is a member of the Plasma Theory and Simulation Section of the Fusion Division of Asociacion Euratom/CIEMAT, where he works on plasma kinetic theory. **Jose Ramon Cepero Diaz** (bottom right) (engineer, ETSII, Spain, 1976) has been with the Fusion Division of CIEMAT since 1983, where he works on ECRH for the TJ-II experiment. **Jose Guasp Perez** (bottom left) (PhD, physics, University of Madrid, Spain, 1970) is a theoretician in the Fusion Division of CIEMAT. His main interests

are magnetics and transport in stellarators. **A. Lopez-Fraguas** (top right) (PhD, Madrid University, Spain, 1982) is a member of the Plasma Theory Section of CIEMAT. His research interests are stellarator equilibrium and stability and high-energy physics. **Luis García** (top left) (PhD, physics, Universidad Complutense, Spain, 1979) was a postdoctoral research fellow at Oak Ridge National Laboratory (ORNL) in 1981, and in 1982, he joined the staff of the ORNL Fusion Energy Division. In 1986, he became an associate professor at the Universidad Complutense. He has worked on physics optimization of magnetic confinement devices and nonlinear properties of MHD instabilities. **Vladimir I. Krivenski** (second from top right) (MS, physics, University of Milan, Italy, 1983; PhD, physics, University of Nancy I, France, 1988) is a member of the Plasma Theory Section of CIEMAT. His research interests include the interaction of radio-frequency (rf) waves and plasma and kinetic study of the electron distribution function duiring ohmic and rf heating. **R. Martín** (second from top left) leads the ECRH group at Asociacion Euratom/CIEMAT. His research interests are radiation/plasma interaction, microwave power generation and transmission, and nuclear physics. **A. P. Navarro** (third from top right) (MS, 1969, and PhD, 1973, Universidad Complutense, Spain) joined CIEMAT in 1969 as a physicist working in noise analysis in nuclear reactors. He is currently head of the Fusion Division of Asociacion Euratom/CIEMAT. **Angel Perea** (third from top left) (MS, chemical engineering) is currently head of the engineering group of Asociacion Euratom/CIEMAT. He is active in engineering of fusion devices. **Antonio Rodriguez-Yunta** (fourth from top right) (PhD, atomic physics, Universidad Complutense, Spain, 1988) is a member of the Theory Plasma Section of CIEMAT, where he works on theoretical calculations of transport in plasmas. **Mario Sorolla Ayza** (bottom left) (microwave engineering, Politechnic University of Barcelona, Spain, 1984) is a high-power microwave engineer in the ECRH group of CIEMAT. He has also designed high-power millimetre-wave components for the TJ-II ECRH transmission lines. **Antonio Varias** (bottom right) (PhD, theoretical physics, University of Santiago de Compostela, Spain, 1984) is a member of the Theory Plasma Section at CIEMAT, where he has been involved in MHD equilibrium and stability studies of fusion plasmas.

URAGAN-2M: A TORSATRON WITH AN ADDITIONAL TOROIDAL FIELD

V. E. Bykov
A. V. Georgievskij
V. V. Demchenko
Yu. K. Kuznetsov
Yu. A. Litvinenko
A. V. Longinov
O. S. Pavlichenko
V. A. Rudakov
K. N. Stepanov
V. T. Tolok

V. E. Bykov (top right) [Kharkov Politechnical Institute (KPI), USSR, 1959; Candidate of Science, Efremov Institute, USSR, 1972] is involved in computational studies of magnetic configurations in stellarators and torsatrons. **A. V. Georgievskij** (top left) (KPI, USSR, 1958; Candidate of Science, Efremov Institute, USSR, 1969) is a principal scientific officer responsible for studies of magnetic configuration and design of the Uragan family of stellarators. **V. V. Demchenko** (bottom right) [DSc, physics, Kharkov Institute of Physics and Technology (KIPT), USSR, 1987] is a staff member of the Division of Physical and Chemical Sciences, International Atomic Energy Agency, Vienna. He has worked in magnetohydrodynamic theory and applications to tokamaks and stellarators and heating of toroidal plasmas. **Yu. K. Kuznetsov** (bottom left) [Dnepropetrovsk State University,

USSR, 1963; Candidate of Science, Kharkov State University (KSU), USSR, 1970] is head of the Stellarator Technology Development Division of the KIPT, where he is responsible for the design and construction of the Uragan-2M torsatron. His interest is in magnetic diagnostics of plasma in toroidal magnetic systems. **Yu. A. Litvinenko** (top right) (KSU, USSR, 1960; Candidate of Science, Efremov Institute, USSR, 1980) is responsible for the study of forces and stresses in mechanical systems of stellarators. **A. V. Longinov** (top left) (KPI, USSR, 1964) is responsible for radio-frequency (rf) heating of plasma in Uragan-2M. His main interests are ion cyclotron resonance heating and current drive in toroidal magnetic systems. **O. S. Pavlichenko** (center right) (Moscow Physical Technical Institute, USSR, 1959; Candidate of Science, 1968, and DSc, 1979, KSU, USSR) is associate director for plasma physics and head of the Plasma Physics Division at KIPT. His interests lie in plasma diagnostics. **V. A. Rudakov** (center left) (Candidate of Science, KSU, USSR, 1967) is involved in stellarator fusion reactor studies. **K. N. Stepanov** (bottom right) (Candidate of Science, 1958, and DSc, 1965, KSU, USSR) is head of the rf Heating and Plasma Theory Division at KIPT. His main interests are in the theory of plasma stability and heating and plasma/wave interaction. **V. T. Tolok** (bottom left) (Candidate of Science, 1957, and DSc, 1966, KSU, USSR) is a professor at KSU. He was previously head of the Plasma Physics Division at KIPT. His interests lie in stellarator studies and rf plasma heating.

PHYSICS AND ENGINEERING DESIGN FOR WENDELSTEIN VII-X

Craig Beidler
Günter Grieger
Franz Herrnegger
Ewald Harmeyer
Johann Kisslinger
Wolf Lotz
Henning Maassberg
Peter Merkel
Jürgen Nührenberg
Fritz Rau
Jörg Sapper
Francesco Sardei
Ruben Scardovelli
Arnulf Schlüter
Horst Wobig

Craig Beidler (top right) (PhD, University of Wisconsin-Madison, 1987) is currently a member of the Wendelstein VII-X (W VII-X) group at the Max-Planck-Institut für Plasmaphysik (IPP), Garching. His research interest is neoclassical transport in stellarator-type devices. **Günter Grieger** (top left) [PhD, University of Munich, Federal Republic of Germany (FRG), 1959] is head of the Wendelstein Stellarator Division at IPP. **Franz Herrnegger** (second from top right) (PhD, University of Innsbruck, Austria, 1967) is a research staff member at IPP. He has worked in magnetohydrodynamic (MHD) equilibrium and stability theory with applications to stellarators as well as the optimization of stellarator configurations. **Ewald Harmeyer** (second from top left) (Dr. Ing., Technische Hochschule Darmstadt, FRG, 1988) has worked with AEG at Frankfurt am Main in the fields of electrical engineering of high-voltage equipment and power supplies. Since 1980 he has been a staff member at IPP and has mainly been concerned with the engineering problems of modular stellarator coil systems. **Johann Kisslinger** (third from top right) (Dipl. Ing., Fachhochschule München, FRG, 1972) is a research staff member at IPP. He is currently working as a member of the W VII-X design group in the area of magnetic field and coil optimization. Previous experience includes design work for the modular coils of the advanced stellarator, W VII-AS. **Wolf Lotz** (bottom left) (PhD, University of Freiburg, FRG, 1957) is a computational plasma physicist in the stellarator physics group at IPP. He has worked previously as an experimental physicist for various plasma experiments. His current activities are in theoretical stellarator confinement studies. **Henning Maassberg** (bottom right) (PhD, Technische Hochschule Darmstadt, FRG, 1981) is a computational physicist in the W VII-AS group. He has worked in the fields of neoclassical transport,

plasma heating, and plasma instabilities. His current activities include the evaluation and explanation of W VII-AS experimental data. **Peter Merkel** (top right) (PhD, University of Munich, FRG, 1965) is a computational plasma physicist in the stellarator physics group at IPP. He has worked in MHD theory and in the field of collective particle accelerators. His current activities are in stellarator optimization studies. **Jürgen Nührenberg** (top left) (PhD, University of Munich, FRG, 1969) has been head of the stellarator physics group at IPP since 1979. He has worked in MHD and neoclassical transport theory including their computational applications to both stellarators and tokamaks. His current activities concentrate on stellarator optimization. **Fritz Rau** (second from top right) (Dr. rer. nat., Technische Hochschule München, FRG, 1962) has worked with the Max-Planck-Gesellschaft since 1963, and in the field of stellarator research at IPP since 1965. He has been a member of the W VII-X group from the beginning of the project and is concerned with magnetic field studies of modular stellarator coil systems and with problems of the edge structure. **Jörg Sapper** (photograph not available) (Dipl. Ing., University of Stuttgart, FRG, 1964) was a design engineer for large rotating electrical machines in industry (AEG and BBC) for 10 years. He has been with the Stellarator Division at IPP since 1975, as engineer for the operation, design, and procurement of the plasma confinement systems. He served as head of the construction project for W VII-AS and is now technical project manager of W VII-X. **Francesco Sardei** (center left) (Dr. Ing., Technische Universität München, FRG, 1972) joined IPP after a 1-year postdoctoral fellowship at IBM Scientific Center, Palo Alto. At IPP he has mainly worked on the theory and numerical modeling of shock wave interaction with magnetic fields, trapped particle anomalous diffusion, and impurity and neutral gas transport. **Ruben Scardovelli** (third from top right) (Dottore, nuclear engineering, University of Bologna, Italy, 1981; PhD, nuclear engineering, University of Illinois, 1987) is presently at the Max-Planck-Institut für Plasmaphysik on a postdoctoral fellowship. **Arnulf Schlüter** (bottom left) (PhD, University of Bonn, FRG, 1947) was a professor of theoretical physics at the University of Munich in 1958, director of IPP in 1965, and president of the Bavarian Academy of Sciences in 1986. He developed the two-fluid model of a plasma in 1949 and applied it to many astrophysical problems. In 1955, he initiated theoretical fusion studies in FRG. Since 1974, he has been a member of the Committee on Science and Technology of the European Community under the Euratom treaty. **Horst Wobig** (bottom right) (PhD, University of Munich, FRG, 1967; postdoctoral work at Princeton University, 1968–69) has been a member of the Stellarator Division at IPP since 1971. His main activities have been related to the theoretical design and support of the stellarator experiments W VII-A, W VII-AS, and W VII-X.

DESIGN STUDY FOR THE LARGE HELICAL DEVICE

Atsuo Iiyoshi
Masami Fujiwara
Osamu Motojima
Nobuyoshi Ohyabu
Kozo Yamazaki

Atsuo Iiyoshi (top) (PhD, engineering, Keio University, Japan, 1965) is responsible for the Large Helical Device Project and is director-general of the National Institute for Fusion Science (NIFS). He was previously director of the Kyoto University Plasma Physics Laboratory, where he worked on the Heliotron Project. **Masami Fujiwara** (photograph not available) (PhD, physics, Nagoya University, Japan, 1970) is a director of the Large Helical Device Project at NIFS. **Osamu Motojima** (bottom) (PhD, engineering, Kyoto University, Japan, 1976) is a director of research operations and device engineering at NIFS.

He previously worked on the Heliotron E experimental study. **Nobuyoshi Ohyabu** (right) (PhD, physics, University of Tokyo, Japan, 1974) is an associate professor at NIFS. He was previously with General Atomics, where he developed tokamak boundary control schemes such as the expanded boundary divertor and ergodic magnetic limiter concepts. **Kozo Yamazaki** (left) (PhD, engineering, University of Tokyo, Japan, 1977) is an associate professor at the NIFS. He has worked on experiments and physics design studies of tokamak and helical systems.

ADVANCED TOROIDAL FACILITY II STUDIES

J. F. Lyon
B. A. Carreras
N. Dominguez
L. Dresner
C. L. Hedrick
S. P. Hirshman
M. S. Lubell
J. W. Lue
R. N. Morris
S. L. Painter
J. A. Rome
W. I. van Rij

J. F. Lyon (top right) (PhD, physics, University of Tennessee, 1970) is the stellarator program coordinator in Oak Ridge National Laboratory's (ORNL's) Fusion Energy Division and an adjunct professor in nuclear engineering at the University of Tennessee. His current activities are in stellarator confinement and reactor studies. He has worked in the mirror, tokamak, and stellarator programs at ORNL and on tokamak and stellarator programs in the USSR, France, United Kingdom, Japan, and Federal Republic of Germany (FRG). **B. A. Carreras** (top left) is a member of the ORNL research staff. He has worked in magnetohydrodynamic (MHD) theory and applications to tokamaks, stellarators, and reversed-field pinches. **N. Dominguez** (second from top right) (PhD, University of Texas at Austin, 1986) is a research staff member of the Theory Section of ORNL's Fusion Energy Division. He has worked on the equilibrium and MHD stability of plasmas in mirrors, tokamaks, and stellarators. **L. Dresner** (second from top left) (PhD, Princeton University, 1959) is a senior member of the research staff at ORNL, which he joined in 1954. His recent work has been on the stability and protection of superconducting magnets and on the solution of nonlinear partial differential equations. **C. L. Hedrick** (biography and photograph not available). **S. P. Hirshman** (third from top right) [PhD, plasma physics, Massachusetts Institute of Technology (MIT), 1976] is a member of the ORNL research staff. He has participated in theoretical and numerical calculations of transport processes in toroidal plasma, MHD equilibrium in stellarators, and anomalous transport in low-pressure tokamaks due to drift-wave fluctuations. **M. S. Lubell** (third from top left) (SB, physics, MIT, 1954; MA, physics, University of California, Berkeley, 1956) is head of the Magnetics and Superconductivity Section of ORNL's Fusion Energy Division. **J. W. Lue** (fourth from top right) (PhD, physics, University of Pittsburgh, 1972) is with the Fusion Energy Division of ORNL. His current research includes magnet system design for fusion reactors and investigation of superconducting magnet stability. **R. N. Morris** (fourth from top left) (BS, electrical engineering, Wayne State University, 1978; MS, 1979, and PhD, 1984, Georgia Institute of Technology) is a computational physicist in ORNL's Computing and Telecommunications Division. He is currently involved in the alignment of the ATF coil sets, the beamline systems, and the position of plasma diagnostics. **S. L. Painter** (fifth from top right) (MS, nuclear engineering, University of Tennessee) is on the staff of ORNL's Fusion Energy Division and a doctoral candidate in nuclear engineering at the University of Tennessee. His research interests include computational plasma engineering and stellarator reactor systems studies. **J. A. Rome** (bottom left) (BS, MS, and ScD, MIT) is a senior scientist in ORNL's Fusion Energy Division. **W. I. van Rij** (bottom right) (PhD, physics, Florida State University, 1970) is a member of the Computing and Telecommunications Division of Martin Marietta Energy

Systems. He is active in the development of three-dimensional MHD equilibrium and neoclassical transport codes and their application to toroidal confinement devices.

LASER-INDUCED "SEMICOLD" FUSION

Christoph Steinert

Christoph Steinert (Dipl., physics, 1955, and Dr. rer. nat., 1959, Technical University of Aachen, Federal Republic of Germany) began his career with Babcock & Wilcox in 1959, moving to Siemens AG in 1965. His main field of work has been nuclear fission reactors, especially the areas of neutron physics, core design, and advanced fuel cycles. He was project manager of a thermal breeder study and did basic research on plutonium recycling in light water reactors. His recent activities have been in nuclear fusion.