Fusion technology™

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SPECIAL ISSUE ON D-^{3}He FUSION

OPEN CONFINEMENT SYSTEMS AND THE D-^{3}He REACTION / *Richard F. Post, John F. Santarius*

Richard F. Post (top) (PhD, physics, Stanford University, 1951) is a professor emeritus of the University of California–Davis, Department of Applied Science, and a senior scientist in the magnetic fusion program at Lawrence Livermore National Laboratory. He has been active in magnetic fusion research, primarily the magnetic mirror approach, since 1952. **John F. Santarius** (BS, physics, California Institute of Technology, 1973; PhD, physics, University of Texas, 1979) is leader of the plasma engineering group at the Fusion Technology Institute of the University of Wisconsin–Madison. His current research centers on plasma physics and engineering for commercial fusion reactor and test facility design. His other research includes fusion reactors for space applications and plasmas for industrial processing and technological applications.

A DESCRIPTION OF A D-^{3}He FUSION REACTOR BASED ON A DIPOLE MAGNETIC FIELD / *Akira Hasegawa, Liu Chen, Michael E. Mauel, Harry H. Warren, Sadayoshi Murakami*

Akira Hasegawa (top) (BS and MS, Osaka University, Japan; PhD, University of California–Berkeley, 1964; DSc, Nagoya University, Japan, 1967) was a member of the technical staff at Bell Laboratories and an adjunct professor at Columbia University. He is now a professor of communication engineering at Osaka University. He has been active in the areas of plasma physics, space physics, nonlinear optics, and fluid dynamics. **Liu Chen** (bottom) (PhD, University of California–Berkeley, 1972) has been with Princeton Plasma Physics Laboratory since 1974. He is currently a principal research physicist and deputy head of the Theory Division and a lecturer with the rank of professor in the Department of Astrophysical Sciences. **Michael E. Mauel** (no photograph available) [BS, Massachusetts Institute of Technology (MIT), 1978; ScD, electrical engineering, MIT, 1983] is an associate professor of applied physics at Columbia University. He has conducted experiments investigating high-beta tokamak physics and codiscovered the high-beta poloidal operating mode on the Tokamak Fusion Test Reactor (TFTR). His current research includes advanced tokamak operation, tokamak disruption control, and reconstruction of axisymmetric plasma equilibria from experimental measurements.

Harry H. Warren (no photograph available) (BS, William and Mary College, 1988; MS, applied physics, Columbia University, 1990) is a PhD candidate working in the areas of Hamiltonian chaos and nonlinear wave-particle-driven transport. He was the first to demonstrate robust conservation of the first and second adiabatic invariants of charged-particle motion in a dipole magnetic field, even in the presence of strong wave-induced chaos and radial transport.

Sadayoshi Murakami (right) (BS, 1987, and MS, 1989, materials science, Hiroshima University, Japan) is a graduate student at the Theory and Computer Simulation Center of the National Institute for Fusion Science in Japan. His research interests include computational plasma physics and nonlinear dynamics.

ESTIMATES OF D-^{3}He DRACON TRAP-BASED REACTOR PARAMETERS / *Vladimir Mitrofanovich Glagolev*

Vladimir Mitrofanovich Glagolev (Leningrad Polytechnical Institute, USSR, 1941) has worked on fusion at the I.V. Kurchatov Institute of Atomic Energy since 1945. His interests include high-frequency heating, plasma stabilization, and magnetic configurations with a spatial magnetic axis. Since 1981, he has been developing a theory of equilibrium, stability, and thermal losses in the magnetic Dracon trap.

THE POLYWELL™: A SPHERICALLY CONVERGENT ION FOCUS CONCEPT / *Nicholas A. Krall*

Nicholas A. Krall (PhD, theoretical physics, Cornell University, 1959) was vice president and chief scientist at JAYCOR until 1987, when he left to form Krall Associates, a corporation that specializes in basic plasma science. He is also an adjunct professor at the University of California-San Diego.

ADVANCED FUSION FUEL FOR INERTIAL CONFINEMENT FUSION / *Rasol Khoda-Bakhsh, Heinrich Hora, George H. Miley, Robert J. Stening, Peter Pieruschka*

Rasol Khoda-Bakhsh (top right) (BS, physics, Teachers Training College, Iran, 1974; MSc, 1977, and PhD, 1981, University of Birmingham, United Kingdom) is the Vice-Chancellor of Education Affairs of Urmia University, Iran. From October 1990 through October 1991, he was on sabbatical at the University of New South Wales, Australia, Kensington-Sydney Campus, in the Department of Theoretical Physics. His research interests are in the fields of neutron scattering and laser/plasma interaction. **Heinrich Hora** (top left) [Diplom-Physiker, Martin Luther University, Federal Republic of Germany (FRG), 1956; Dr. Rer. Nat., Friedrich Schiller University, FRG; DSc, University of New South Wales, Australia, 1981] has been professor and head of the Department of Theoretical Physics at the University of New South Wales since 1975. He is currently holding a position at CERN in Geneva, Switzerland. His research interests include laser/plasma interaction theory (nonlinear forces, absorption, particle acceleration, first self-focusing theories), photodetectors, semiconductor lasers, free electron lasers, and extreme states. **George H. Miley** (bottom right) (PhD, University of Michigan, 1958) is a professor in the Department of Nuclear Engineering at the University of Illinois. In addition to research on fusion, he is well known for his research on energy conversion and nuclear-pumped lasers. **Robert J. Stening** (bottom left) (BSc, 1962, and MSc, 1963, University of Australia-Sydney; PhD, University of Queensland, Australia, 1969; Dip. Tert. Ed., University of New England, Australia, 1977) is an associate professor at the main University of New South Wales campus

at Kensington in Sydney. His research interests include ionspheric physics, tides in the upper atmosphere, and laser/plasma interactions. **Peter Pieruschka** (right) (BSc, physics, Technical University of Munich, FRG, 1987; MSc, nuclear theory, University of Christchurch, New Zealand, 1989) is currently working on his PhD at the Australian National University, Canberra, Australia. He previously worked on an Australian research grant project. His research interests include rotational states of nuclei, laser fusion, and statistical mechanics for molecular structures.

PRELIMINARY STUDIES OF DIRECT ENERGY CONVERSION IN A D-^{3}He INERTIAL CONFINEMENT FUSION REACTOR / *Kunioki Mima, Kiyoshi Yoshikawa, Osami Morimiya, Haruhiko Takase, Hideaki Takabe, Yoneyoshi Kitagawa, Toshiki Tajima, Yasuji Kosaki, Sadao Nakai*

Kunioki Mima (top right) (BS, 1968; MS, 1970; and PhD, 1973, physics, Kyoto University, Japan) has been a professor of the Institute of Laser Engineering (ILE) at Osaka University since 1983. His current interests are nonlinear plasma physics, free electron laser theory, and inertial confinement fusion (ICF) theory. **Kiyoshi Yoshikawa** (top left) (D. Eng., nuclear engineering, Kyoto University, Japan, 1974) is an associate professor at the Institute of Atomic Energy at Kyoto University. His main interests are direct energy conversion, reactor-relevant technology, and fusion reactor design. **Osami Morimiya** (second from top right) (BE, mechanical engineering, 1960; BE, electrical engineering, 1962; and PhD, 1991, Tokyo Institute of Technology, Japan) is now a chief research scientist at the Toshiba Corporation Research and Development Center. He worked on the vacuum arc phenomena and is now involved in CVL development for the atomic vapor laser isotopic separation program. **Haruhiko Takase** (second from top left) (BE, 1981, and ME, 1983, Tokyo Institute of Technology, Japan) is a research scientist at the Toshiba Corporation Research and Development Center. He has worked on magnetic confinement fusion, ICF, accelerators, and solid-state physics. **Hideaki Takabe** (third from top right) (BS, 1975; MS, 1977; and D. Eng., 1980, electrical engineering, Osaka University, Japan) is an associate professor at the ILE at Osaka University. His interests are theoretical and computational research of plasma and atomic physics, particularly as related to ICF research. **Yoneyoshi Kitagawa** (third from top left) (BS, 1968, and MS, 1970, physics; DS, experimental physics, 1975, Kyoto University, Japan) is an associate professor at the ILE at Osaka University. He is currently in charge of the Lekko VIII CO_2 laser system. His interests include laser/plasma interaction, laser particle acceleration, and laser fusion. **Toshiki Tajima** (bottom right) (PhD, University of California–Irvine, 1975) is a professor of physics and senior staff member at the Institute for Fusion Studies at the University of Texas–Austin. He was co-inventor of the muon-catalyzed fusion-fission reactor and is primarily interested in nonlinear plasma physics and computational physics. A biography and photograph of **Yasuji Kosaki** were not available. **Sadao Nakai** (bottom left) (BS, 1961; MS, 1963; and D. Eng., 1966, electrical engineering, Osaka University, Japan) is director of the ILE at Osaka University and a professor on the faculty of engineering at Osaka University. His interests are the development of high-power lasers and particle beams and ICF research.

BURN CHARACTERISTICS OF COMPRESSED FUEL PELLETS FOR D-^{3}He INERTIAL FUSION / *Yasuyuki Nakao, Takuro Honda, Hideki Nakashima, Yoshinori Honda, Kazuhiko Kudo*

Yasuyuki Nakao (right) (Dr., nuclear engineering, Kyushu University, Japan, 1981) is an associate professor of nuclear engineering at Kyushu University. His current research interests include nuclear processes in high-density plasmas, transport of neutrons and charged particles, and kinetics of burning plasmas. **Takuro Honda** (left) (M. Eng., nuclear engineering, Kyushu University, Japan, 1989) is a doctoral student of nuclear engineering at Kyushu

University. His current interest is fusion-born particle transport in inertial confinement fusion (ICF) plasmas. **Hideki Nakashima** (top) (Dr., nuclear engineering, Kyushu University, Japan, 1978) is an associate professor of energy conversion engineering at Kyushu University. He has been engaged in the nuclear design study of fusion reactors, fusion fuel cycles, and target design for ICF. His current interests include advanced-fuel reactors and fusion applications in space. **Yoshinori Honda** (center) (M. Eng., nuclear engineering, Kyushu University, 1991) is now a researcher at Hitachi Ltd., Systems Development Laboratory, where he is currently analyzing the features of nuclear energy systems. **Kazuhiko Kudo** (bottom) (Dr., mechanical engineering, Kyushu University, Japan, 1974) is a professor of nuclear engineering at Kyushu University. His areas of interest include nuclear safety and reactor control systems.

INSTABILITY ANALYSIS OF A MAGNETICALLY PROTECTED CAVITY IN A D-^{3}He INERTIAL CONFINEMENT FUSION REACTOR / *Hideki Nakashima, Yasuhiko Inoue, Yukinori Kanda, Yasuyuki Nakao, Masami Ohnishi*

Hideki Nakashima (top right) (Dr. Eng., nuclear engineering, Kyushu University, Japan, 1978) is an associate professor of energy conversion engineering at Kyushu University. He has been engaged in the nuclear design study of fusion reactors, fusion fuel cycles, and target design for inertial confinement fusion (ICF). His current interests include advanced-fuel reactors and fusion applications in space. **Yasuhiko Inoue** (top left) (MS, energy conversion engineering, Kyushu University, Japan, 1991) is an engineer at Kyushu Electric Power Company's Genkai nuclear power station. **Yukinori Kanda** (no photograph available) (physics, Tohoku University, Japan) is a professor of nuclear energy conversion engineering at Kyushu University. His main interest is nuclear data for fusion and fission reactors. **Yasuyuki Nakao** (bottom right) (Dr., nuclear engineering, Kyushu University, Japan, 1981) is an associate professor of nuclear engineering at Kyushu University. His current research interests include nuclear processes ion high-density plasmas, transport of neutrons and charged particles, and kinetics of burning plasmas. **Masami Ohnishi** (bottom left) (Dr. Eng., electrical engineering, Kyoto University, Japan, 1979) is a research associate at the Institute of Atomic Energy at Kyoto University. His current interests include alpha-particle transport in magnetic fusion, dynamics and control of fusion reactors, and reactor design studies of open-ended systems.

SPACE PROPULSION BY FUSION IN A MAGNETIC DIPOLE / *Edward Teller, Alexander J. Glass, T. Kenneth Fowler, Akira Hasegawa, John F. Santarius*

Edward Teller (right) (PhD, physics, University of Leipzig, Germany, 1930) studied under Werner Heisenberg and was engaged as a theoretical physicist in the areas of quantum, molecular, and nuclear physics until 1939, when the announcement of the discovery of fission led him to work on the Manhattan Project. After World War II, he became a professor of physics at the University of Chicago, then returned to Los Alamos Scientific Laboratory as assistant director. In 1952, he joined the newly established Lawrence Livermore National Laboratory (LLNL), where he was director from 1958 to 1960. In

1960, he became a professor of physics at the University of California while retaining the position of associate director at LLNL. He retired from these positions in 1975 and is now director emeritus of LLNL and a senior research fellow at the Hoover Institution. **Alexander J. Glass** (top right) (BS, physics, Rensselaer Polytechnic Institute, 1954; MS, 1955, and PhD, 1963, physics, Yale University) joined the staff of the Institute for Defense Analysis in 1964, specializing in high-power laser technology. In 1966, he moved to the U.S. Naval Research Laboratory, where he founded and led the Laser Physics Branch. From 1969 to 1972, he served a professor and chairman of electrical engineering at Wayne State University. He joined the Laser Program at LLNL in 1973 as head of the Theory and Design Analysis Group. He also served as a lecturer in the Department of Applied Physics at the University of California–Davis. In 1983, Dr. Glass was named president and chief operating officer of KMS Fusion, a private company active in laser fusion research. He returned to LLNL as laboratory associate director for programs in 1988. **T. Kenneth Fowler** (top left) (BS, engineering, Vanderbilt University, 1953; MS, physics, Vanderbilt University, 1955; PhD, physics, University of Wisconsin, 1957) joined Oak Ridge National Laboratory in 1957, where he was leader of the Plasma Theory Group until 1965. He then moved to General Atomics, where he was head of the Plasma Physics Division until 1967. At LLNL, he was associate director for magnetic fusion energy from 1970 to 1988. He was named professor and chair of the Department of Nuclear Engineering at the University of California–Berkeley in 1988. **Akira Hasegawa** (bottom right) (BS and MS, Osaka University, Japan; PhD, University of California–Berkeley, 1964; DSc, Nagoya University, Japan, 1967) was a member of the technical staff at Bell Laboratories and an adjunct professor at Columbia University. He is now a professor of communication engineering at Osaka University. He has been active in the areas of plasma physics, space physics, nonlinear optics, and fluid dynamics. **John F. Santarius** (bottom left) (BS, physics, California Institute of Technology, 1973; PhD, physics, University of Texas–Austin, 1979) is leader of the Plasma Engineering Group at the University of Wisconsin Fusion Technology Institute and a senior scientist in the Department of Nuclear Engineering and Engineering Physics. His research centers on the design of magnetic fusion reactors for terrestrial electric power and for space applications. Other research areas include advanced energy conversion, plasma processing, and the physics of fusion plasmas.

NONENERGY APPLICATIONS FOR FUSION / *John M. Dawson*

John M. Dawson (BS, 1952; MS, 1954; and PhD, 1957, physics, University of Maryland) worked at the Princeton Plasma Physics Laboratory from 1956 to 1973, becoming head of the Theoretical Group. He then joined the faculty of the University of California–Los Angeles (UCLA) as a professor of plasma physics and was director of the Center of Plasma Physics and Fusion Engineering from 1976 to 1987 and associate director of the Institute of Plasma and Fusion Research from 1988 to 1991. He is currently leading a numerical tokamak group at UCLA.

LOWERING RADIATION HAZARDS BY USING D-^{3}He REACTORS / *I. N. Golovin*

I. N. Golovin (Moscow University, 1936; candidate's degree, 1939; doctoral degree, 1961; professor, 1970) is a scientist at the Kurchatov Institute of Atomic Energy. He was involved in the building of the first tokamak and has studied plasmas in tokamaks and mirror confinement.

PROTONS AS A POTENTIAL SOURCE OF RADIOACTIVITY IN D-^{3}He REACTORS / *Hesham Y. Khater, William F. Vogelsang*

Hesham Y. Khater (top) (PhD, nuclear engineering, University of Wisconsin–Madison, 1990) is a postdoctoral research associate in the Fusion Technology Institute at the University of Wisconsin–Madison. He has been involved with several magnetic and inertial confinement fusion reactor design studies. He has a special interest in charged-particle activation. His research interests are in neutronics, radioactivity, and safety analysis of fusion reactors. **William F. Vogelsang** (PhD, physics, University of Pittsburgh) is a professor of nuclear engineering and engineering physics at the University of Wisconsin–Madison. His interests have included critical assemblies and nondestructive fuel assay. His research interests are in the radioactivity and safety problems of fusion reactors and the design and neutronics analysis of fusion and fission systems. He also serves as the editor of the journal *Nuclear Technology*.

WASTE DISPOSAL OF CANDIDATE STRUCTURAL MATERIALS IN FUSION REACTORS UTILIZING DIFFERENT FUEL CYCLES / *Hosny M. Attaya, Mohamed E. Sawan, Gerald L. Kulcinski*

Hosny M. Attaya (top) [BS, 1967, and MS, 1974, nuclear engineering, University of Alexandria, Egypt; MS, 1977, and PhD, 1981, nuclear engineering, University of Wisconsin–Madison (UWM)] is a member of the fusion power program in the Engineering Physics Division at Argonne National Laboratory. He was responsible for activation analyses for the International Thermonuclear Experimental Reactor (ITER). His current interests are primarily in the areas of radioactivity and neutronics. **Mohamed E. Sawan** (center) (BS, nuclear engineering, University of Alexandria, Egypt, 1967; MS, 1971, and PhD, 1973, nuclear engineering, UWM) is a senior scientist and leader of the neutronics group at the Fusion Technology Institute at UWM. He was previously an associate professor of nuclear engineering at the University of Alexandria. His current interests include neutronics, shielding, activation, and safety analyses for both inertial confinement and magnetic fusion reactors. **Gerald L. Kulcinski** (bottom) (PhD, nuclear engineering, UMW, 1965) is the Grainger Professor of Nuclear Engineering and the director of the Fusion Technology Institute at UWM. His current research interests include radiation damage to materials, surface modification of metals, fusion reactor design, and unique applications of nuclear energy.

SHIELDING ASPECTS OF D-^{3}He FUSION POWER REACTORS / *Laila A. El-Guebaly*

Laila A. El-Guebaly (PhD, nuclear engineering, University of Alexandria, Egypt, 1979) is an associate scientist at the Fusion Technology Institute of the University of Wisconsin–Madison. She specializes in the area of neutronics and shielding of fusion reactors. For the last several years, she has been involved in the shield optimization analysis of D-T and D-^{3}He reactors for both terrestrial and space applications. Her interests include the evaluation of the effect on the superconducting magnets and personnel of radiation streaming through large penetrations and assembly gaps in fusion reactor designs. She is currently in charge of the U.S. shielding design analysis for the International Thermonuclear Experimental Reactor (ITER).

TRITIUM IN THE FUEL CYCLE OF A D-^{3}He FUSION REACTOR / *Masabumi Nishikawa*

Masabumi Nishikawa (BE, chemical engineering, Kyoto University, Japan, 1966; MASc, University of British Columbia, Canada, 1968; PhD, Kyoto University, Japan, 1971) is a professor in the Department of Nuclear Engineering at Kyushu University. His current interests include mass (tritium) and heat balance in fusion reactors and also in chemical reactors.

COLD FUSION

COLD FUSION STUDIES IN THE USSR / *V. A. Tsarev, D. H. Worledge*

A photograph and biography for **V. A. Tsarev** were unavailable. **D. H. Worledge** (BS, physics, 1967, and PhD, experimental reactor physics, 1970, University of Birmingham, United Kingdom) is a program manager in the Nuclear Power Division at the Electric Power Research Institute (EPRI) and technical director of EPRI's work on cold fusion.

CLOSED-SYSTEM ANALYSIS OF TRITIUM IN PALLADIUM / *Krystyna Cedzynska, Fritz G. Will*

Krystyna Cedzynska (no photograph available) (M. Eng., chemistry, 1969, and PhD, 1976, Technical University of Lodz, Poland) is a lecturer in the Institute of General Food Chemistry at the Technical University of Lodz. She was a visiting scientist at the National Cold Fusion Institute (NCFI) during 1990–1991. Her research interest is in analytical and electrochemical studies of inorganic elements and biologically active compounds and in studies of batteries. **Fritz G. Will** (no photograph available) (PhD, physical chemistry, Technical University of Munich, Federal Republic of Germany, 1959) was employed by the General Electrical Research and Development Center from 1960 to 1990. He then joined the University of Utah as a research professor of chemical engineering and served as director of the NCFI. He has done research on electrode mechanisms, batteries, fuel cells, and high-temperature ceramics and glasses for space power systems.

ION IMPLANTATION AS A DEFINITIVE MEANS OF INVESTIGATING ANY POSSIBILITY OF INTRACRYSTALLINE NUCLEAR FUSION / *Moishe Garfinkle*

Moishe Garfinkle (PhD, Pennsylvania State University, 1962) is currently involved in theoretical studies in irreversible thermodynamics at Drexel University. Previously, at Lewis Research Center, he conducted W-UO_2 coupon fabrication and stability studies and investigated the viability of W-Re structural components toward determining the feasibility of hydrogen-fueled nuclear rocket engines for deep-space probes.

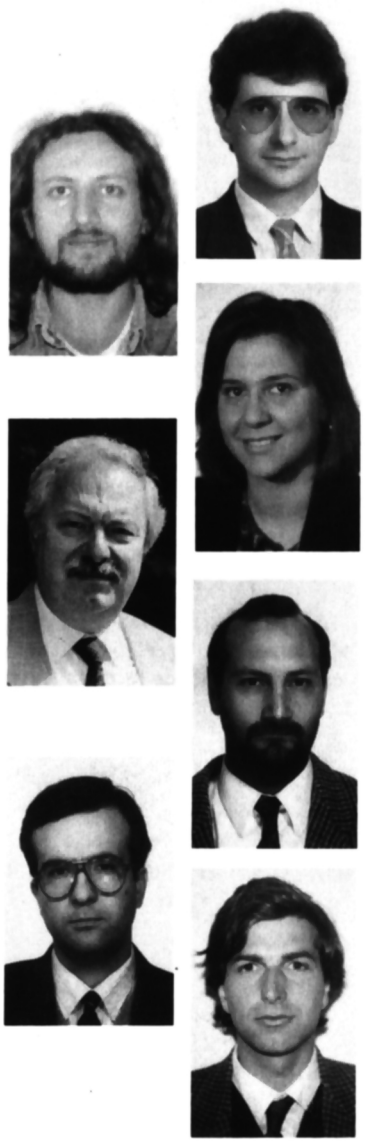
OBSERVATION OF GRAVITY DECAYS OF MULTIPLE-NEUTRON NUCLEI DURING COLD FUSION / *Takaaki Matsumoto*

Takaaki Matsumoto (MS, nuclear engineering, Kyoto University, Japan, 1966) studied neutron and nuclear reactor physics at the Kyoto University Research Reactor Institute from 1966 to 1973. Since 1973, he has been with Hokkaido University as an associate professor of nuclear engineering. His interests include nuclear transmutation of radioactive wastes and nuclear alchemy.

COHERENT AND SEMICOHERENT NEUTRON TRANSFER REACTIONS I: THE INTERACTION HAMILTONIAN / *Peter L. Hagelstein*

Peter L. Hagelstein (no photograph available) has been on the faculty at Massachusetts Institute of Technology (MIT) for $5\frac{1}{2}$ years. He has worked in the area of X-ray lasers since 1975, and he and his group are currently developing a small-scale X-ray laser at MIT. During the past several years, he has worked on a theory for anomalous effects in deuterated metals.

SEARCH FOR ENHANCEMENT OF NEUTRON EMISSION FROM NEUTRON-IRRADIATED, DEUTERIDED, HIGH-TEMPERATURE SUPERCONDUCTORS IN A VERY LOW BACKGROUND ENVIRONMENT / *Francesco Celani, Antonio Spallone, Lorella Liberatori, Fausto Croce, Lucio Storelli, Stefano Fortunati, Mario Tului, Nicola Sparvieri*



Francesco Celani (top right) (MS, physics, University of Rome, Italy, 1975) has been a researcher at Frascati National Laboratory (INFN-LNF) since 1976. He is an expert in digital and analog electronics for nuclear particle detectors. His interests include cold fusion research and high-temperature superconductivity. **Antonio Spallone** (top left) (MS, University of Rome, Italy, 1986) has been a researcher at INFN-LNF since 1984. His interests include cold fusion research and high-temperature superconductivity. **Lorella Liberatori** (second from top right) (MS, physics, University of Rome, Italy, 1986) is a fellow at INFN-LNF working on magnetic effects in high-temperature superconductors. **Fausto Croce** (no photograph available) (MS, chemistry, 1971) in the chemistry department at Universita "La Sapienza," where he studies the lithium battery. **Lucio Storelli** (center left) (MS, physics, University of Rome, Italy, 1966) is interested in the inherent problems in both slow and fast neutron detection and gamma-ray spectroscopy. **Stefano Fortunati** (third from top right) (MS, chemistry, University of Rome, Italy, 1984) has worked on the coupling of a polymeric matrix with biological metabolites to constitute electrochemical sensors. He is interested in the production and development of high-temperature superconductors. **Mario Tului** (bottom left) (MS, physics, University of Rome, Italy, 1988) is a researcher in the new material department at CSM-ILVA (IRI). He has worked in the field of high-energy physics and is involved in magnetic materials and ceramic superconductors. **Nicola Sparvieri** (bottom right) (MS, University of Rome, Italy, 1983) is a researcher at the Alenia Corporation. He has worked on the optical properties of silicon, experimental studies of microwave ferrites, and high-temperature superconductors.