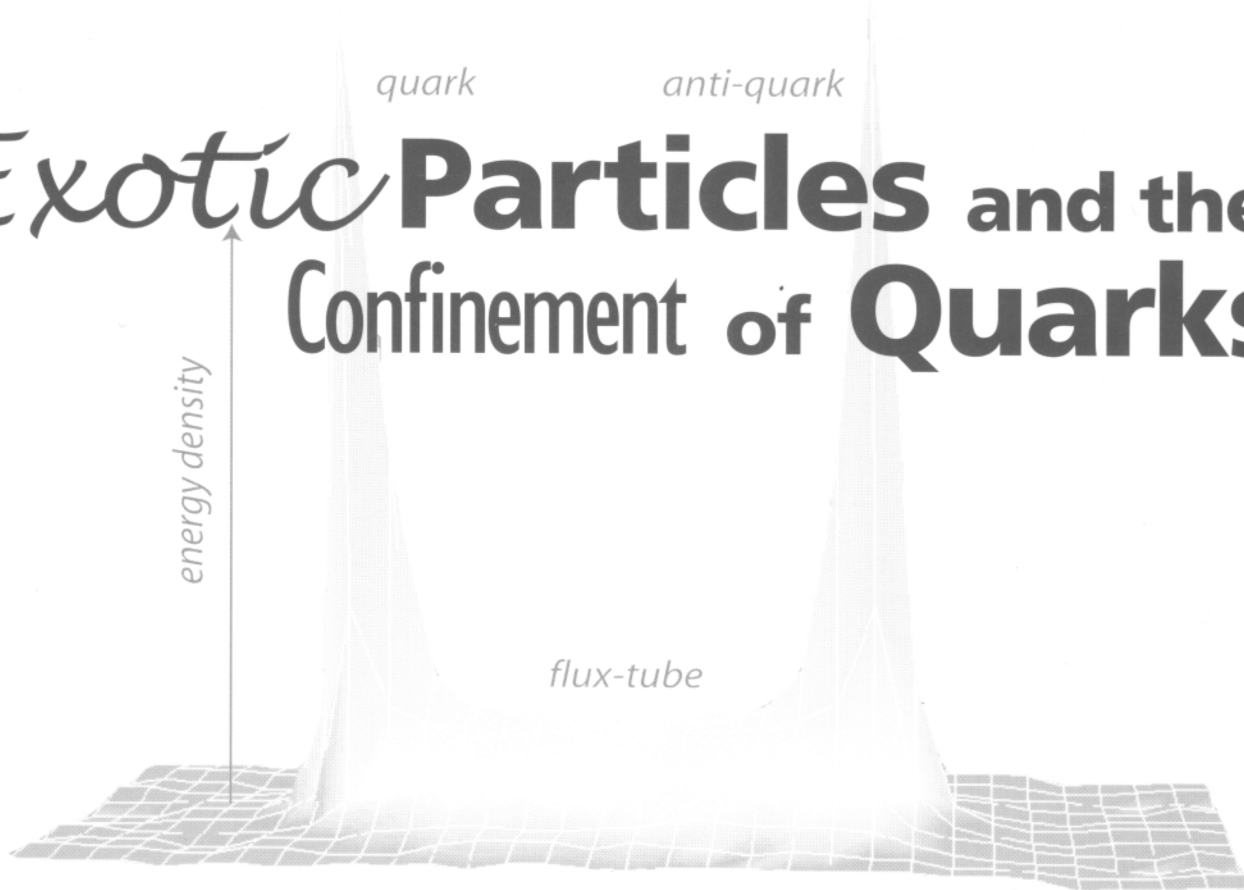
Office of the Bloomington Chancellor and Office of the Vice President for Research

Distinguished Faculty Research Lecture

ALEX DZIERBA

Professor of Physics
College of Arts and Sciences

Exotic Particles and the Confinement of Quarks



from G. Bali

Monday, April 12, 2004
3:00 p.m.
Whittenberger Auditorium

Reception immediately following the lecture in
the University Club President's Room
Indiana Memorial Union, Bloomington

This annual lecture provides an opportunity for research scholars to share their work with the university community and provides the university with an occasion to pay tribute to its most distinguished researchers. It is the privilege of Indiana University to honor one of its outstanding research scholars by designating Alex Dzierba, professor of physics in the College of Arts and Sciences, as the Distinguished Faculty Research Lecturer for 2004. Professor Dzierba is given this honor not only as an accomplished research scholar, but also as an outstanding representative of the academic community at IU Bloomington.

Exotic Particles and the Confinement of Quarks

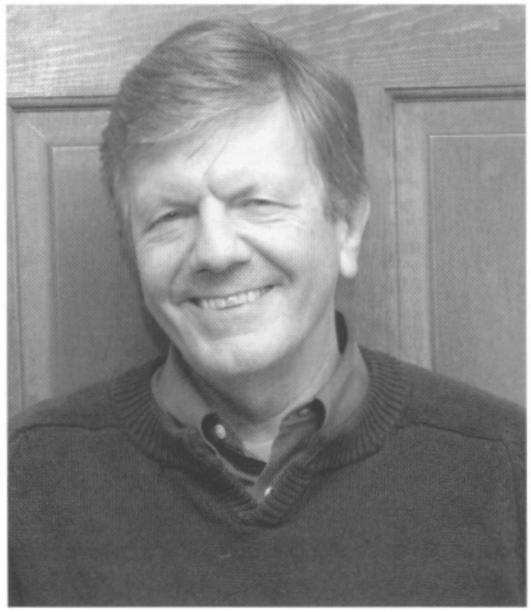
Understanding the confinement of quarks—fundamental constituents of matter—is recognized as one of the important and outstanding problems in physics. This lecture will describe one current search for an explanation of quarks' confinement in the vibrations of flux-tubes—a project the Secretary of Energy recently included as a short-term priority in the 20-year strategic plan of the Office of Science in the Department of Energy.

In the early part of the 20th century, experiments studying the hydrogen atom, which consists of a single proton and electron, provided the basis for the quantum theory of matter. As experiments became more refined, a new theory was born that brought together electromagnetism, quantum mechanics, and relativity. That theory—quantum electrodynamics, or QED—is one of the jewels of science, making possible predictions ranging from the properties of subatomic particles to the operation of lasers.

According to QED, the proton and electron in an atom are constantly exchanging photons, the quanta of the electromagnetic field. Starting in the 1950s, physicists built a new periodic table of elements based on subatomic particles detected in cosmic rays and later analyzed using accelerators. This new table of particles was explained by the quark model. Quarks carry electrical charge that can be either one-third or two-thirds of the charge of the proton or electron. Neutrons and protons are made up of three quarks and are members of a family of particles called *baryons*. *Mesons* form another family and consist of a quark and an antiquark.

Like the electron and proton of the hydrogen atom, quarks are bound together, but the force binding the quarks is dramatically different than the force that holds the atom together. The interquark force is many times stronger. Even more amazing, quarks are forever confined within the subatomic particles of which they are a part. The proton and electron of the hydrogen atom can be separated with relative ease, but no one has ever freed a quark from a baryon or a meson.

The last three decades of experimentation and theoretical progress have led us to the theory of quantum chromodynamics, or QCD. This theory, the development of which was guided by the structure of QED, postulates that quarks are bound by exchanging gluons, the quanta of the chromodynamic field. Gluons carry the analog of electrical charge, called color charge, meaning quarks carry color charge as well. Gluons can self-interact and form flux-tubes, which are the collapse of flux lines together to form a slender tube. These flux-tubes explain why quarks are confined—a meson is a quark and antiquark connected by a flux-tube. Furthermore, the vibrations (or excitations) of these flux-tubes should lead to a whole new family of mesons—called *exotic* mesons.



Alex Dzierba

Alex Dzierba completed his undergraduate studies in 1964 at Canisius College in Buffalo, N.Y. In 1969, he received his Ph.D. in experimental particle physics at the University of Notre Dame. Dzierba was appointed Research Fellow and then Senior Research Fellow at the California Institute of Technology. In 1973, he joined the faculty of the physics department at Indiana University Bloomington as an assistant professor. He was promoted to full professor in 1979.

Dzierba served as program officer for elementary particle physics at the National Science Foundation during the 1982-1983 academic year and was scientific associate at CERN in Geneva, Switzerland, during the 1985-1986 academic year. He was elected Fellow of the American Physical Society in 1992. He served as chair of the Users Executive Committee at Brookhaven National Laboratory from 1991 to 1993.

Dzierba has served as scientific leader of a number of international collaborations, including projects at the Fermi National Accelerator Laboratory and at the Brookhaven National Lab. He currently leads a collaboration of 100 physicists from 25 institutions in six countries who are carrying out the search for exotic mesons. This project includes the construction of a $45 million facility at the Jefferson Accelerator Laboratory in Newport News, Va. Dzierba serves as trustee for the Southeastern Universities Research Association, which runs the Jefferson Lab.

Dzierba is author or co-author of more than 100 scientific articles in refereed journals. He co-authored the cover story for the Sept./Oct. 2000 issue of *American Scientist* that describes the physics topic of this lecture. From 1999 to 2001, he was president of the Indiana University chapter of Sigma Xi, the international honor society of scientific and engineering research. He currently serves on the board of examiners for the physics GRE exam.

Dzierba was elected to the IU Honors College faculty in 2000. In 1994, he developed the honors introductory physics course and has taught the class eight times since it was introduced. He won teaching excellence awards in the physics department from 1995 through 1999. In 2000, Dzierba won IU's Trustees Teaching award. Undergraduates in his research group have included several Wells and STARS scholars. Graduates from his group, including one Rhodes Scholar, have gone on to graduate work at Berkeley, Caltech, Cambridge, Chicago, Cornell, and M.I.T.

Dzierba is the proud father of three sons and a daughter. He and his wife, Linda, live in Greene County with their son Christopher.

The Distinguished Faculty Research Lecture Award

A primary obligation of a university faculty is to do research—to work toward the discovery of new knowledge and the creation of artistic or technological means whereby that knowledge may sustain or bring progress and understanding to humanity. Since its early years, Indiana University has been dedicated to this mission of research. Its faculty members have been recognized for significant contributions to their disciplines by election to distinguished organizations such as the National Academy of Sciences and the American Academy of Arts and Sciences, and by awards from agencies such as the Guggenheim Foundation and the National Endowment for the Humanities. It is in recognition of this research activity that Indiana University Bloomington inaugurated the Distinguished Faculty Research Lecture Award.

Distinguished Faculty Research Lecturers

1980—J. Rufus Fears, "Roman Liberty: An Essay in Protean Political Metaphor"
1981—Anthony Mahowald, "The Precocious Germ Cell, A Haven from Developmental Change"
1982—David Pisoni, "Speech Technology: The Evolution of Computers that Speak . . . and Listen"
1983—Ciprian Foias, "Abstract Mathematics and Concrete Problems"
1984—Richard M. Shiffrin, "Automatic and Controlled Processes in Memory and Attention"
1984—Eliot Hearst, "Empty Intervals and Absent Events: Something About Nothing in the Psychology of Animals and People"
1985—Richard Westfall, "Galileo and the Jesuits"
1986—Elinor Ostrom, "How Inexorable is the 'Tragedy of the Commons?': Institutional Arrangements for Changing the Structure of Social Dilemmas"
1987—Howard Gest, "A Trail of Directed Serendipity in Research on Photosynthetic Bacteria"
1987—John R. Preer Jr., "Repairing Genetic Defects by the Introduction of Cloned Genes"
1988—Bruce Cole, "Love, Lust, and Loss in Venetian Painting of the Golden Age"
1989—Milos Novotny, "Chemical Communication in Mammals"
1990—H. Scott Gordon, "How Many Kinds of Things Are There in the World?"
1991—Robert E. Pollock, "Cold Traps"
1992—Joan Hoff, "Watergate Revisited"
1993—Esther Thelen, "The Origins of an Embodied Cognition and the Dynamics of Time Scales"
1994—Lewis Rowell, "Narrative Beginnings in Music"
1995—Ronald A. Hites, "The Movement of Toxic Pollutants through the Environment"
1996—Eugene D. Weinberg, "Iron Withholding: A Defense Against Disease"
1997—Kathy D. Schick and Nicholas P. Toth, "The Role of Rock: The Evolutionary Origins of Human Technology"
1998—Charles S. Parmenter, "Laser Studies of Energy Flow in Molecules"
1999—Larry N. Thibos, "Perfecting the Optical System of the Human Eye"
2000—Fedwa Malti-Douglas, "Clinton, Lewinsky, and the Great Books"
2001—Roger G. Newton, "Alien Science"
2002—Ellen D. Ketterson, "Is It Just Hormones? Testosterone, Mating Systems, and Parental Care in Birds"
2003—David C. Williams, "Civic Constitutionalism, the Second Amendment, and the Right of Revolution"

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