Summary of Accomplishments – Bascom S. Deaver, Jr.

Introduction

A university professor is expected to conduct research to generate new knowledge, teach, and provide service to the university and the broader community. Bascom Deaver has done all of these, and they are so interwoven so that it is difficult to discern where one ends and another begins. He exemplifies what a university professor should be.

Research

Bascom's research is focused on superconductivity and its applications. His research began with his Ph.D. work at Stanford, where his thesis experiment was the discovery that the magnetic flux threading a superconducting ring is quantized. The flux is the product of magnetic field through the ring and the area of the ring, and the flux quantum is hc/2e, where h is Planck's constant and e is the charge of the electron. In macroscopic units, $hc/2e = 2 \times 10^{-7}$ G cm^2, which is the earth's field (~1/2 G) through a circle of diameter 7×10^{-4} cm. This experiment provided the first experimental evidence for the pairing of electrons in superconductors predicted by Bardeen, Cooper, and Schrieffer. The quantum of flux was quickly recognized as a fundamental property of superconductors, and as a result of this work Bascom is known all over the world.

After coming to the University of Virginia Bascom continued his basic research on superconductivity and went on to explore its applications. His thesis work showed that flux was quantized, but the data were too noisy to see the sharp steps in flux vs. magnetic field which quantization implies. Bascom and William Goodman repeated the experiment and obtained far better data which showed that with cylinders of finite length sharp steps are not observed, rather somewhat rounded steps. This observation by itself suggests that the flux is not quantized. However, they also demonstrated that along the length of the cylinder there were different discrete amounts of flux, that is, along the length of the cylinder there were regions containing, for example, four or five flux quanta. This elegant experiment clearly demonstrated flux quantization.

Bascom and many other physicists recognized that at each of the flux quantization steps of the trapped flux changes very quickly with magnetic field and that this sensitivity could be used to detect small changes in the magnetic fields. Bascom and his students made one of the first superconducting magnetometers based on this idea. In collaboration with Charles O'Conner of the University of Virginia Chemistry Department Bascom used the magnetometer to measure the magnetic susceptibility of chemically interesting compounds. The most important aspect of the magnetometer, though, is that it is general purpose instrument which can detect small changes in magnetic fields. For example, an airplane with a sensitive magnetometer can detect a submarine underwater.

Making the magnetometers usually requires superconducting rings with tunnel junctions and the use of radio frequency and microwave fields. Biased correctly the operation of these devices is very sensitive to the microwave field, and it was quickly realized that they could be used to make extraordinarily sensitive microwave diodes for receivers. At the time, in the 1970's, the world's best microwave diodes were fabricated of GaAs by Robert Mattauch in the University of Virginia Engineering School, and he and Bascom collaborated to develop superconducting tunnel junction diodes. These diodes have replaced GaAs diodes when the ultimate sensitivity is required, and this work has been carried on by Arthur Lichtenberger in the

University of Virginia Engineering School. University of Virginia diodes can now be found in radio telescopes around the world.

Bascom and Robert Mattauch extended their efforts from the diodes to the more general problem of generating and detecting high frequency microwave and millimeter wave radiation. They secured a contract from the U.S. Army Foreign Science and Technology Center for this activity in 1986 with the objective of building a scale model radar range. Radar operates at a frequency of ~ 10 GHz, which has a 3 cm wavelength. The reflection of a 3 cm wave from a 30 m long plane is identical to the reflection of a 0.03 cm (1000 GHz) wave from a 30 cm long plane. Thus if reliable 1000 GHz sources and detectors can be fabricated it is possible to test radar responses of planes with 1/100 scale models. This work has continued to the present, and Bascom, Robert Mattauch, Arthur Lichtenberger, and Tom Crowe have made enormous progress in the development of sources and receivers operating at frequencies up to 1 THz.

In sum, Bascom's research has spanned the entire range from the most basic physics to practical applications. His research provides a model for why society should invest in research.

Teaching

An important part of the teaching in a university occurs in the research laboratories where students undergo the transformation from assimilating knowledge to generating new knowledge. This transformation occurs under the guidance of the professor in whose laboratory to work is done. Bascom has supervised many students, to be precise 11 masters students, 26 Ph.D. students, countless undergraduates, and 29 engineering students jointly with Robert Mattauch, Robert Weikle, Thomas Crowe, and Arthur Lichtenberger. A measure of his success is that his students have founded companies and become faculty members at research universities including Stanford, Vanderbilt, and Harvard.

In the past twenty years much of Bascom's instructional effort has been concentrated on our undergraduate program, with spectacular results. His contributions have been both administrative and instructional. He is a superb classroom teacher, but it is as a laboratory instructor that he really excels. Over the past twelve years he has taught the introductory laboratory course for physics majors (Physics 221-2). While such courses can be like following a cookbook or filling out a tax return, Bascom's is not. He engages the students by making them think about the connection between the equations in the textbooks and the physical apparatus in front of them. He brings the equation to life and conveys to our students the excitement of experimental physics.

Service

Bascom has for twenty years directed our undergraduate program, and he has worked tirelessly to ensure that it is first rate. It is composed of two parts, the physics major program and the offerings for non-majors. In addition to developing the introductory laboratory course into something which attracts majors Bascom has done much to ensure the continued vitality of our physics major program. He has on several occasions secured external funding from the National Science Foundation for our instructional laboratories, and under his direction we have developed two undergraduate concentrations, in computational physics and optics. The new concentrations have been quite successful. When optics was first taught 12 years ago it attracted 12 students when offered every other year. It is now offered annually, and there are 45 students enrolled this fall. Under Bascom's direction we have inaugurated a new B.A. program which is designed for students who are not planning to pursue physics as a career but would like to experience the intellectual excitement of physics. The new B.A. track allows students to take courses such as Widely Applied Physics (311-2) in which physics is applied to a much broader range of phenomena than in the standard upper level undergraduate physics courses. In short the new B.A. program exposes students to the intellectual beauty of physics without sophisticated mathematics. It is the perfect major for a student who is interested in physics but wishes to attend, for example, law school.

Under Bascom's direction we have expanded our offerings for non-science majors. We have always had a "physics for poets" course, but in the last ten years several new courses with broad appeal have been introduced, "How Things Work", "From Galileo to Einstein", and "Energy on This World and Elsewhere". Bascom's service extends substantially beyond our department. He was instrumental in launching our present program to train high school physics teachers, an activity which addresses one of the chronic problems of all school systems finding physics teachers. These efforts began in the spring of 1987 when Bascom and James Trefil taught a joint three credit course for high school physics teachers. The course was televised and broadcasted throughout the state. In the summers of 1987 and 1988 Bascom and Bruce Martin ran a summer institute for high school physics teachers with funding from NSF. These activities were the start of our present Master of Physics Education program, designed to train high school teachers to teach introductory physics even if they have not had a college physics course.

In sum, Bascom Deaver has contributed substantially to the Commonwealth of Virginia through his interwoven scholarship, teaching, and service.

Personal Statement – Bascom S. Deaver, Jr.

In September 1965 I came to UVa having recently been extremely fortunate in having completed a very successful doctoral research project at Stanford University working with Prof. William Fairbank. My experimental data established a fundamental new quantity in superconductivity that is now a textbook topic. My graduate students and I set up a new research lab and for a number of years continued to study basic properties of superconductors. Subsequently we worked on new applications of superconducting devices primarily for magnetic measurements. Since 1986 I have been co-director of a project that is a collaboration between Physics and Electrical Engineering to develop new devices for measurements of far infrared radiation. My role is mostly as advisor and administrator, although I serve on the dissertation committees of numerous students and can sometimes offer insights into topics about which I have some expertise. However there is still the excitement of being involved with the creation of new technology, some of which leads to new discoveries in basic science.

Over the years I have taught graduate courses in superconductivity and in low temperature physics, topics closely related to my research, and I taught a number of intermediate-level undergraduate courses. However, for many years I have concentrated on introductory physics courses, including particularly ones for potential physics majors. In these courses I need to have students realize that it takes a lot of investment in learning some basic physics and mathematics (things that can be fun and interesting in themselves) in order to appreciate some of the greatest insights in physics, and that they will probably find that the more they learn, the more exciting the subject becomes. At the same time it is necessary to try to exhibit some of the beauty, importance, and excitement of physics early on so that there is motivation to put in the effort to know more.

For me there is very little of the often-discussed conflict between teaching and research, because I consider most of my activities whether in the research lab or classroom to be "teaching" or more often, cooperative learning. All of my research has been done together with students, 37 graduate students for whom I have supervised dissertations or theses, many others in collaborations, and a large number of undergraduates. My role has been to identify the bit of frontier in physics that we probe for new data, to teach some experimental techniques, to work with the students to make measurements that we hope will lead to new insights, and to try to winkle out of the data some basic new fact. This is an endeavor in which we all learn. We share in the struggle and frustrations of making experiments work, but more important, in the fun and excitement of new data.

As an experimenter, I find my greatest enjoyment in the lab, although lately I have had less and less time to work there. I believe the best way to learn to do experiments is to be immersed in an active lab and be confronted with the task of building or measuring something. You then find out what instruments, apparatus and techniques you need and you learn about them. The process is sometimes confusing and daunting but the effort is rewarded by having something you conceived, designed, assembled and operated, actually work and produce data. This is the mode in which both graduates and undergraduates have operated in my research lab.

For a number of years now I have been teaching our two-semester introductory physics laboratory sequence for physics majors. Teaching these courses has some of the same problems and satisfactions as those in the research lab. Most students require a lot of encouragement and guidance not to miss the significance of what they are doing and must be led to enjoy the lab rather than be put off by it. Some take naturally to the process and show the qualities of future experimenters; others find the labs less satisfying, but our objective and hope is that they will experience some examples of how theory and the real world of instruments and data are connected, and that they will develop some better understanding of concepts about which they are learning in the lecture courses.

As long-time chairman of our Undergraduate Program Committee, I have been proud of the continual evolution of our program that has been possible through the dedication of our faculty to undergraduate teaching while at the same time vigorously building excellence in the graduate program. For decades the undergraduate program served particularly well the students who were bound for graduate school in physics and related areas, but considerably less well the majority of undergraduates. Over the last decade or so, there have been major improvements. We now have seven courses designed for liberal arts students, special courses for pre-medical students, for engineers, for other science students and for physics majors. The BS and Distinguished Major programs include new concentrations in computational physics and in optical physics and photonics. These programs, along with the Astronomy/Physics program offered jointly with the Astronomy Department, provide very strong preparation for the more than 50% of our majors who go on to graduate and professional schools.

One of the most significant improvements is the initiation of a new BA program designed for students desiring a strong background in physics but with career objectives in medicine, law, business or K-12 education, and for liberal arts students who want to understand better the role of science in modern society. Largely due to this program, the average number of physics majors has grown from 20 per year for the two decades prior to 1994 to 32 for the years since then. This is in contrast to the experience of most physics programs in the U.S., which over this same period had substantial decreases in the number of majors.

In 2002 the National Task Force on Undergraduate Physics selected our program as one of 21 “thriving” programs among the 759 departments in the U.S. granting bachelor’s degrees in physics. We had a site visit and extensive program review by representatives of the task force. Their report, in which they identified characteristics of thriving programs, noted most of the things mentioned above and also praised our extensive K-12 teacher education program.

Our five Undergraduate Program Committee members also serve as advisors for students seeking information about physics courses and programs. Since during their second year I teach most of the students who become majors, they often come to me to declare their major in physics. Consequently for a number of years I have been the advisor of record for 50 or more majors. I have enjoyed being able to get to know many of them through discussions of their interests, plans, and career objectives. A practice I have adopted over the years is to try to be available to talk to students when <u>they</u> want to talk. Many questions can be answered or problems solved in only a few minutes, so instead of scheduling regular office hours, since I am usually in the building somewhere, usually in the office or the lab, my practice is to have students come by and I will stop what I am doing and talk to them immediately. If we need more time we agree on a time to meet.

I find that students need to realize that there is a broad spectrum of talents, that each has unique talents and one is more skilled in a given area than another, that while at an earlier stage in their lives there were pressures for conformity, now they should recognize the great values of diversity. It’s very rewarding to follow the diverse careers of our students, which include a professor and formerly chairman of the Stanford Physics Department, a chair professor of physics at Vanderbilt, a million-dollar McDonald award winner and now professor of physics at Harvard, a financial advisor with J.P. Morgan, an orthopedic surgeon, a music faculty member, a science writer for a New York newspaper, a professional basketball player, a patent lawyer, an astronaut and a number of high school physics teachers.

I feel very fortunate to be affiliated with an institution where I can have such a stimulating and satisfying variety of experiences in teaching and learning.

CURRICULUM VITAE

BASCOM S. DEAVER, JR.

EDUCATION

B.S.	Georgia Institute of Technology	1952
M.A.	Washington University, St. Louis, MO	1954
Ph.D.	Stanford University	1962

PROFESSIONAL EXPERIENCE

1954-57	Physicist, 1st Lt., USAF, Air Force Special Weapons Center, New Mexico
1957-62	Physicist, Stanford Research Institute, Menlo Park, California
1959-62	Research Assistant in Low Temperature Physics, Stanford University
1962-63	National Science Foundation Postdoctoral Fellow, Stanford University
1963-65	Research Associate, Stanford University
1962-65	Physicist, Stanford Research Institute
1965-73	Associate Professor of Physics, University of Virginia
1973-	Professor of Physics, University of Virginia
1981-	Associate Chairman, Physics Department, University of Virginia

CONFERENCE COMMITTEES AND STUDY GROUPS

Chairman, Organizing Committee, Symposium on the Physics of Superconducting Devices, Charlottesville, 1967

Organizing Committee, Conference on Fluctuations in Superconductors, Asilomar, California, 1969

Organizing Committee, Conference on the Science of Superconductivity, Stanford University, 1969 Executive Committee, Research Conference on Instrumentation Science, Geneva, New York, 1970

Program Committee, Applied Superconductivity Conference, Annapolis, Maryland, 1972

Chairman, Organizing Committee, Conference on Future Trends in Superconductive Electronics, Charlottesville, 1978

Organizing & Program Committee, Applied Superconductivity Conference, Santa Fe, New Mexico, 1980

Board of Directors, Applied Superconductivity Conference (1980-1986)

Organizing Committee, "Near Zero: A New Frontier of Physics", a conference to honor W.M. Fairbank, Stanford University, 1982

Co-director, NATO Advanced Study Institute on "Advances in Superconductivity", Ettore Majorana Center for Scientific Culture, Erice, Italy, July 3-15, 1982

Member of Panel on Advanced Navigation Technology, Naval Studies Board, National Academy of Sciences, Woods Hole, MA, June 20-30, 1983

Participant and Invited Speaker, Workshop on Problems in Superconductivity, Copper Mountain, CO, Aug. 21-23, 1983

Member of Task Group on Superconductive Electronics, Naval Studies Board, National Academy of Sciences, Dec. 1983-May 1984

Member, Consultants Committee for Physics Department, Virginia Military Institute, Lexington, VA, site visit Feb. 19-21, 1984

Chairman, Beams Award Committee, Southeastern Section, American Physical Society

Member, Executive Committee, Southeastern Section, American Physical Society, 1986-1989

Member, Institute for Defense Analyses Working Group on Superconducting Electronics

Fabrication Facility, Sept. 1988
Member, Scientific Advisory Board, Hypres, Inc., 1989-1991
Member, Program Committee, Applied Superconductivity Conference, Boston, MA, 1994

CONSULTING

Stanford Research Institute, Menlo Park, California.
U.S. Naval Radiological Defense Laboratory, San Francisco, California.
U.S. Naval Ship Research and Development Laboratory, Annapolis, Maryland.
Oak Ridge National Laboratory, Oak Ridge, Tennessee.
Georgia Tech Engineering Experiment Station, Atlanta, Georgia.
Develco, Inc., Mountain View, California.
U.S. Army Foreign Science and Technology Center, Charlottesville, Virginia.
Superconducting Technology, Division of United Scientific Corp., Mountain View, California.

MEMBERSHIPS AND HONORS

Alfred P. Sloan Fellow, 1966-1968
American Physical Society
Virginia Academy of Science
Sigma Xi
Tau Beta Pi
Sigma Pi Sigma
Omicron Delta Kappa
Raven Society
University of Virginia Sesquicentennial Associate, 1978
ACT-NUCEA Award for Innovations in Continuing Education, 1988
1993-94 All University Teaching Award
1998-99 Harrison Award for Undergraduate Advising
2000 George B. Pegram award of the Southeastern Section of the American Physical Society for excellence in teaching
2004 Alumni Association Distinguished Professor Award

DISSERTATIONS AND THESES SUPERVISED: 26 Ph.D. & 11 Masters in physics**;** member of thesis and dissertation committees for 29 electrical engineering students

PUBLICATIONS AND ABSTRACTS: 74 publications, 3 chapters in books, editor of 3 books, 50 published abstracts of talks

PATENTS

M. Bol, B.S. Deaver, Jr., and W.M. Fairbank, Superconductive Circuit and Method for Measuring Magnetic Fields and Magnetic Properties of Materials Employing Serially Connected Superconducting Loops, U.S. Patent #3454875 (1969).

Julia W. P. Hsu, Mark Lee, and Bascom S. Deaver, Jr., Nanometer Distance Regulation using Electromechanical Power Dissipation, U. S. Patent No. 5,886,532 (1999)