Preface

This short historical summary of the U. of O. Department of Physics was motivated by a conversation between Professor Russell J. Donnelly and myself in the spring of 2015. Recalling the rapid evolution of the Department during the post-Sputnik era, we noted that certain important events could not be clearly remembered, because our colleagues who witnessed them were no longer with us. We felt that it would be helpful to compile a short history, primarily recording names, dates, and research activities for each area of study within the Department. We hoped to enlist as collaborators members of the Physics faculty, who played a major role in the development of their field, and had first hand knowledge of the events described. Recognizing that the window of opportunity for this undertaking was rapidly closing, we started work on the project right away. As if to underline that urgency, sadly Russell Donnelly passed away in the early summer of 2015. That turn of events left me alone to coordinate the planned collaborative effort.

The Department was fortunate because in each research area, except one, the first person approached with the request to join this collaboration, accepted immediately. The one exception was "Materials Science", where most faculty members were hired relatively recently, and the others were unable to undertake the required work at this time. That part of the department history remains unwritten for now.

The goal was to compile a history that is as objective as can reasonably be accomplished, and as complete as space limitations permit. We intended to concentrate on facts, and aimed to minimize editorializing, in order to avoid involuntary distortions and other pitfalls associated with that type of writing. As a check, all faculty members were given the opportunity to read and comment on the text dealing with their research area. Collaborators were requested to note for each faulty member the date of their Ph.D., the granting institution, the year when they joined the Department, and the organization from where they came. Apart from the above general features, all collaborators chose what, how and how much they wished to discuss.

The sequence in which research areas are listed does not imply ordering according to any criterion of merit. To achieve some semblance of a logical structure, they are arranged approximately in decreasing order of the typical energies that characterize them.

Paul L. Csonka, March 20

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1. Early History of the Department of Physics (*)

Russell J. Donnelly

Physics first appeared in the curriculum in the Catalog of 1878 -1879. A Department of Physics was established when the Board of Regents adopted a report of its Special Committee to reorganize the faculty and course of study, July 23, 1895.

When the College of Literature, Science and the Arts was approved by the Board of Regents February 6, 1900, a Department of Physics was included in the College.

Following the report of its Curricula Committee March 7, 1932, the Board of Higher Education placed Physics in the lower division of the University curriculum. Oregon State College had the higher division. When the Lower Division and Service Departments was established by the Board of Higher Education April 16, 1934, the Department of Physics was placed in this Department.

By action of the Board of Higher Education, October 28, 1941, Physics was returned to major status at the University, and after the establishment of the College of Liberal Arts January 27, 1942, the Department of Physics became part of the College.

On January 17, 1977 the College of Liberal Arts was renamed the College of Arts and Sciences. The Department of Physics remained in the College.

Originally the University of Oregon offered Natural Philosophy. This was taught by Professor Mark Bailey and later by Professor George H. Collier. The other physics related courses were Astronomy, Mechanics and Acoustics and Optics. In 1879 two more were added, Magnetism and Hydrostatics.

From 1880 to 1893 Mechanics, Physics and Optics were taught for three successive terms of the junior year.

In 1895 Professor Collier was voted into emeritus status and was replaced by Charles Friedel. Curriculum revision was made under the direction of Charles H. Chapman, President of the University and a Ph.D. from Johns Hopkins University (Mathematics). The courses now were four (astronomy was still offered): Elementary Physics, Advanced Physics, Advanced Mechanics and Electricity and Magnetism. These courses continued up to 1900.

A continuing demand for improved lab equipment was eased somewhat with the addition of a course called Practical Mechanics. In this class students were able to construct new apparatus to be used in teaching physics. The first lab was established in 1879 at the University of Oregon. This was eight years after Harvard commenced a laboratory with physics. Some $2000 was expended for the lab equipment. This is a surprisingly large and generous sum, considering the size and poverty of the University. However, this equipment was not for student use but was intended for lecture demonstrations. The purchase of the apparatus was a mistake because the infant university and Board of Regents did not have any knowledge of what was modern. Queen Grey and Co., of Philadelphia unloaded some surplus, outdated, lab equipment at an excessive price. At least the spirit of the Regents was correct. In 1897 more equipment was purchased – modern equipment -upon the urging of Chapman and a small sum given over by the regents for the purchase. (Collier had been fired because he refused to have anything to do with labs. He felt the lecture and textbook approach was all that was necessary. His education, of course, dated from the period prior to any labs in American higher education.) A workshop was established to repair equipment. Students in Physics did the repair work under the direction of Friedel. This proved to be a valuable aid to the continuation of physics labs and it expanded the basic knowledge of students on how to make their own equipment.

Under Friedel the curriculum expanded. The following courses were offered making twenty-two hours of credit in total: *Elementary Physics, Advanced Experimental Physics, Introductory Mathematical Physics, Advanced Mathematical Physics, Theory of Sound, Elementary Laboratory Physics, Electrical Standards, Geometrical Optics, Mathematical Theory of Electricity, Fourier's Theory of Heat, Advanced Laboratory Physics and Photometry*.

In 1903 William P. Boynton came to the University to replace Freidel who took a leave of absence. Upon Friedel's return Boynton remained as Assistant Professor of Physics, becoming Department head and full professor when Friedel resigned in 1906. It was a one-person department again until 1914 when Albert E. Caswell was appointed to the University and the Department of Physics. Up to 1920, Caswell, Boynton and one student assistant comprised the faculty.

From 1905 to 1920 the curriculum was *Elementary Physics, General Physics, Physical Measurements, Analytical Mechanics, Mathematical Theory of Electricity and Magnetism, Electrical Measurements, Thermodynamics, Molecular Physics, Theory of Light, Harmonic Motion, Advanced Undergraduate Laboratory Work, Advanced Mathematical Physics, Advanced Laboratory and Research Seminar*. Some additions were made to this basic list of courses through this period of 15 years. They were *Heat, Meteorology, Physical Technics (probably techniques), Sound, History of Physics, Teaching of Physics, Light, Selected Topics.*
A brief description of these courses follows:

- *General Physics* was "open to those who have completed elementary physics and trigonometry. This course and the following are required in the Sophomore year in the Engineering Course, and are recommended to those intending to be teachers of science."
- *Mathematical Theory*: "The course introduces the student to the development and representation of the more important principles of Physics by the aid of the powerful analytical methods of mathematics."
- *Physical measurements* was a laboratory course to accompany General Physics.
- *Thermodynamics* was "a course on the theory of heat as applied to ideal gases, saturated vapors, and other simple types of substances, introductory to the study of the steam engine."
- *Mechanics* was "a nonmathematical experimental presentation of the principal facts of the mechanics of solids, liquids, and gases."
- *Heat* was "a study of thermometry and calorimetry, with introduction to the theory of solutions and to the kinetic theory in its application to gases and liquids, and thermodynamics."
- *Light*: "a study of the more important phenomena of reflection, refraction, interference, diffraction, polarization of light, based upon a preliminary general discussion of wave motion."
- *Electricity and Magnetism*: "The fundamental facts and the theories, and their relation to modern applications such as the transmission of power, and intelligence, methods of measurements, recent theories of matter, etc."
- *Selected Topics* consisted of "a series of experimental lectures on topics of interest such as Sound and its application to the study of music, the gyroscope, wireless telegraphy, radio-activity, etc.
- *Sound*: "more extended treatment than that given in the general courses, intended especially for students of music… Considerable attention is given to the scientific basis of harmony and music, and to the

Physics of musical instruments."

- *Meteorology*: "a study of the physics of the atmosphere, including the use of meteorological instruments, the study of air and ocean currents, the distribution of temperature and moisture, the study of weather reports and maps, and some practice in forecasting."
- *Physical Technics* concerned "the construction, adjustment, repair and manipulation of physical apparatus, including a study of home made apparatus for high school laboratories, the elements of glass working, etc."
- *Light and Color* which was added in 1918 dealt with "a study of some of the problems of illumination and color; of particular interest to the architect."
- The course called *Applications of Electricity and Magnetism* was "a study of electric circuits as used for signaling, or transmission and control of power, and of the fundamentals of direct current machinery. There will also be a brief statement of alternating currents, and of electric waves and their application to wireless telegraphy."
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In 1901-02 the catalog records that gas, water and electricity were furnished for both lecture tables and laboratory. There were three rooms devoted to the physical sciences. In 1907 additions were made to the equipment – including new cases for apparatus and an apparatus for the determination of the Mechanical Equivalent of Heat.

By 1911 the physical laboratories occupied both the basement and first floor of Deady Hall. The equipment for all types of experiments was made available. In 1915 small research rooms were acquired for students doing research projects. In addition there was a battery and switchboard room as a center of circuits to all parts of the building. (Later this was moved to the basement of Pacific Hall, but there is no record of it ever being used.) By 1920 the Department of Physics labs were very well equipped. James A. Pruett joined the faculty in 1920.

In 1920 the University of Oregon Graduate School was really started. Various Departments were, through the decade of the 20's given authority to offer graduate degrees through the Ph. D.

From 1920 on the curriculum begins to get larger and more complex. By 1920 the curriculum was fairly standard throughout the institutions of higher education in the U. S. During the period of consolidation (the invention of the State System 1929 –) the courses in Physics are reduced to a very few lower division courses. The faculty was likewise reduced. McAlister was transferred to Oregon State College, while Boynton left. This couple, Norris and Caswell, then made up the department until the State Board allowed the return of Science as a major to the U of 0 (with great thanks to Donald Erb, President of the University) and by 1943 the department expanded faculty and offerings. The quality of the faculty was not high because of the war. But the intent was there and the growth of post WWI was anticipated albeit not to the extent that it did occur.

The first Ph. D. given by the Department of Physics was in 1932. Hilbert J. Unger, B. A. Reed, 1928 was the individual awarded the Ph. D.

(*) This material has appeared on the home page of the U. of O. Department of Physics as the first part of an article "Notes on the History of the Department of Physics 1878-1971", by Russell J. Donnelly. (The remaining part of that article has been incorporated into Table 3.)

2. Pine Mountain Observatory (PMO)

James Imamura (*)

Edwin (Ed) Ebbighausen arrived in Oregon in 1946. With his arrival, the number of faculty members in the Physics Department increased to three. Earlier in his career Professor Ebbighausen taught in one of the elite colleges for women, where, in those days it was inadmissible for a male teacher to be physically close to his female students. Therefore, he had to enter the lecture room walking along an underground tunnel, and then up through a trapdoor onto the raised platform on which he lectured. Once class was concluded, he had to retreat through the same trapdoor.

After his arrival to Eugene (no trapdoors here), he refurbished an old 15 inch cast iron and brass telescope he found abandoned on the top floor of the building that housed the Physics Department. He then set out to explore the Mountainous regions of Eastern Oregon, seeking a suitable location to build an astronomical observatory. He sometimes travelled on foot, at other times he rode an aged Harley-Davidson tricycle borrowed form the U. of O. Physical Plant, or asked a rancher friend to fly him over remote areas of interest. After years of searching, starting in 1963 he began serious site testing at three different locations in the eastern Cascades. In 1966 he settled on the easternmost one: Pine Mountain, elevation of 6300 feet, near Bend, OR.

While working to realize his plan, Professor Ebighausen overcame multiple obstacles, thanks to the ingenuity that characterized much of what he did: To obtain data on sky conditions around the various potential sites, he recruited volunteers to make daily observations, and provided them with detailed instructions, such as "note the state of the sky around sundown and also when you retire for the night. … if you forget or…are unable to record, be sure to cross out the space … ." He persuaded the US Forest Service to make available a site for an observatory, inside the Deschutes National Forest, he made arrangements to have a road built, erected a small structure, at reduced cost had power brought to the top of the mountain by a 7,200 Volt underground power line from Redmond, and the National Science Foundation (NSF) eventually provided $184,000, after $64,000 had been pledged in matching funds. Local popular support was an important factor during these negotiations. In addition to all this, Professor Ebbighausen persuaded the inhabitants of the surrounding area to contribute funds to the observatory not just once, but on a continued basis. As a result of these myriad efforts and support from the NSF, the state, and the local community, the observatory was constructed in the spring and summer of 1967.

After completion of the observatory, Professor Ebbighausen proceeded to make the first astronomical observations at the newly christened Pine Mountain Observatory (PMO) in 1967, and published the first scientific papers generated by the observatory. As time went on "Ed" became something of a cult figure in the region. Many recognized this tall thin man, and admired his unassuming simple ways, such as camping out while making observations. A plaque placed by the Physics Department on one of the buildings of Pine Mountain Observatory, now serves to preserve the memory of Professor Ed Ebbighausen.

The 15” telescope, brought there in 1966 by Ebbighausen, was the first astronomical research instrument at PMO. In August 1967, a 24’’ reflector telescope had first light under the direction of Professor Ebbighausen. Also present was Professor Russell Donnelly then Chairman of the U. of O. Physics Department. Professor Donnelly had played a crucial role gaining support from the NSF and the state. As Chairman, he also worked extensively to arrange funding for infrastructure and instrumentation, and he supported the hiring of personnel and faculty working at PMO. The telescope was housed in a two-story concrete block building with an 18-foot dome. Radio telephone connection was established through Bend to the IBM-360 computer on the University of Oregon campus A third dome was erected to hold a 32’’ telescope , dedicated in June of 1978,”the largest in the Northwest” according to Professor Donnelly.

Professor James Kemp joined the Physics Department as a condensed matter physicist in 1961, but switched research interests to astronomical polarimetry, a field in which he became a pioneer performing important work at PMO on magnetic white dwarfs. He discovered the first strongly magnetic white dwarf, Grw +70◦ 8247 in 1970. With field strength of 15,000-32,000 Tesla(!), it still ranks among the most magnetic of all known white dwarfs. Capitalizing on results obtained at PMO, Oregon added several astronomers in the 1970s. Dr. Ira Nolt, and James Radostitz brought instrument building skills and strong observational programs in infrared and sub-millimeter astronomy. They developed sensitive infrared bolometers for the study of planets and other cool celestial objects, instruments used at observatories around the world.

Professor Gregory Bothun joined the astrophysics group in 1990. An expert in physical cosmology, he was interested in the structure of galaxies, and the universe itself. He used PMO for research on low surface brightness galaxies and faint stars outside normal galaxies. Due to his leadership, the Physics Department and within it PMO, started utilizing the World Wide Web in research as early as 1994, and maintains an interest in developing high performance computing as a research tool. Since then, PMO has continued to evolve and grow. Currently, PMO houses the 32” telescope, the 24” telescope, and a new 14” robotic telescope installed in 2014, remotely controlled from the U.of O campus, and used for educational and research purposes. The venerable15” will be housed in the planned visitor’s center. Digital cameras are mounted on both the 24” and 32” telescopes. Today PMO under the guidance of its current Associate Director, Professor Scott Fischer, is used for both scientific research and public outreach programs.

(*) Some details about the early history of PMO were contributed by P. Csonka.

3. Experimental High Energy Physics

James Brau

In the late 1980's the UO physics department initiated research in experimental high energy physics (HEP). James Brau was recruited to lead this effort in 1988. Brau succeeded the first year with a Department of Energy (DOE) funding proposal; DOE support has continued and grown uninterrupted as the experimental HEP program matured, contributing to the vibrancy of the physics department

Raymond Frey was recruited in 1989 as the second experimentalist. Brau and Frey worked at the SLAC Linear Collider (SLC) program to study the Z boson produced with polarized electrons annihilating positrons. Frey completed his collaboration with Mark II at SLC and joined Brau on the SLD experiment to replace Mark II.

The Oregon group had a significant impact on SLD. First they built the silicon-tungsten luminosity monitor at Oregon before transporting it to SLAC for installation in SLD. Other significant hardware roles included Brau's managing the construction of an upgraded CCD vertex detector with more than 300 million pixels, Frey's service as commissioner during installation of the upgraded vertex detector, and Frey's construction of a complementary detector for the measurement of the electron beam polarization. The main result of the SLD experiment was the precise measurement of the left-right asymmetry in polarized electron-positron production at the Z-pole. This continues to yield the most precise value of the electroweak mixing angle ($\sin^2 \theta_W$) from a single measurement.

David Strom was the third faculty hired in experimental HEP in 1991. He continued his prior collaboration on the OPAL experiment at the CERN LEP ring to study Z boson production and W pairs at higher energy, and to search for new physics. Building on the UO experience in developing the SLD silicon-tungsten luminosity monitor, Strom joined the OPAL effort to build a similar but improved device, employing the UO shops for tungsten machining, based on their SLD experience. OPAL measured many properties of the Z boson and went on to explore higher energy, measuring the threshold W pair production cross section and searching for evidence of Higgs boson production.

During the first years the UO group worked on detectors for the Superconducting Super Collider (SSC), initially EMPACT and then GEM, until the SSC was terminated in 1993. One outcome of the SSC effort was a relationship Brau developed with Moscow State University; it brought Nikolai Sinev to Oregon. Sinev became a valued member of the UO team and continues to contribute critical technical expertise.

During this period, Brau and Frey also participated in a Fermilab neutrino experiment, NuTeV, investigating electroweak interactions from a complementary approach to the electron-positron colliders of

SLC (SLD) and LEP (OPAL). Eric Torrence was hired in 2000. At the time he was involved at CERN in OPAL, and continued that effort with Strom at UO.

With cancellation of the SSC, Brau initiated a role with the Laser Interferometer Gravitational-Wave Observatory (LIGO) through discussions with LIGO leaders at MIT and Caltech. DOE's understanding of parallel Oregon HEP and LIGO physics programs was established and National Science Foundation funding for a LIGO research program began in 1998. In 1999 Robert Schofield joined the effort and became the prominent environmental monitoring figure. To achieve a sensitivity of less than 10^{-18} meters ameliorating environmental factors (seismic, thermal, etc.) is essential. UO's scientific interest focused on gamma ray bursts and supernovae. Frey replaced Brau as the principal investigator for the UO LIGO NSF grant in 2012.

The UO group joined the BaBar Collaboration in 1999 and worked for several years on the BaBar heavy fermion physics program, including the measurement of CP violation in the b quark system. Detector areas of work included tracking trigger improvements and upgrades of the muon detector system. As BaBar concluded, the group applied for membership in LHC's ATLAS in 2005. ATLAS soon became the principal research effort. UO assumed roles on the ATLAS trigger, leading to Strom's election as trigger coordinator and to the trigger/data acquisition management team. Torrence became an ATLAS leader in data preparation. Several physics topics were investigated by UO, including exotic Higgs, supersymmetry, top cross sections and flavor-changing neutral current decays, quantum black hole production and tau-related topics. In 2012 Stephanie Majewski joined the UO ATLAS effort as a new faculty member, concentrating on supersymmetric top searches and upgrade of the liquid argon calorimeter. In 2012 the UO group contributed to the Higgs boson discovery by the ATLAS Collaboration.

Since the formation of the UO experimental HEP group, the future linear collider has been a strong interest. For many years, the DOE and NSF funded a multi-institutional detector R&D program through UO sub-contracts, with more than 30 universities and laboratories receiving funding through UO. UO led the formation of the American Linear Collider Physics Group and the World-wide Study for Future Electron-positron Linear Colliders. The UO group played a leading role in the development of the SiD (Silicon Detector) concept for the linear collider, with detector R&D on silicon-tungsten electromagnetic calorimetry, CMOS vertex detector sensors, and beamline instrumentation. Today, the effort to realize the International Linear Collider (ILC) continues with the Linear Collider Collaboration; the Japanese government is preparing for a decision on hosting the ILC.

UO experimental HEP group has established an excellent world-wide reputation. It has functioned within the Center for High Energy Physics since December 2005. More than thirty (30) million dollars of external funding has been secured since 1988. It has produced many Ph.D.'s and postdocs who are active world-wide. Today the group has a strong and promising physics program with the LHC ATLAS experiment, plays a prominent role in the preparation of the next large particle physics project, the ILC, and is part of the LIGO collaboration that for the first time in history succeeded in directly observing gravitational waves.

4. Elementary Particle Theory

Nilendra Deshpande

The study of particle theory at Oregon began with the appointment of Robert (Bob) Zimmerman (Ph.D. University of Washington, 1963) in 1966. He came here from Lawrence Livermore Lab and his interest at that time was in quantum field theory and the question of compositeness. The very next year, the Physics Department was able to hire Michael (Mike) Moravcsik (Ph.D. Cornell, 1956) from Lawrence Livermore Lab. Mike's research interest was in high energy scattering and polarization phenomena. Apart from being prolific in his research, he was interested in attracting third world students to study physics and he made many trips to interview students and rate their suitability for graduate study in US. Mike in turn attracted Paul Csonka (Ph.D. Johns Hopkins University, 1963), who was at CERN. Paul too was interested in scattering phenomena at high energies, but with a view of understanding the role of symmetries. He also had a strong interest in particle accelerators.

With Mike and Paul engaged in active research, they were able to get Department of Energy funding for research. The particle theory group has retained this funding for the past 45 years continuously. In 1971 the department hired Rudolph (Rudy) Hwa (Ph.D., Physics, Brown University, 1962; Ph.D., Electrical Engineering, University of Illinois, 1958). Rudy came from the State University of New York at Stony Brook. He worked on the S-matrix theory of the strong interactions and related topological problems. Later his interests evolved to multiparticle dynamics and the quark-gluon plasma, with excursions to other areas that include critical phenomena, chaos, human electroencephalograms, and problems in other complex systems. At about this time Bob Zimmerman changed his interest to astrophysics and gravity. Rudy Hwa was picked up on the Department of Energy grant, which also provided student and postdoc support.

In 1975 Nilendra (Desh) Deshpande (Ph.D. University of Pennsylvania, 1965) came to Oregon from the University of Texas at Austin, at first as Visiting Professor and later as a permanent faculty member. Desh's interest was in weak interaction phenomenology, especially models beyond the Standard Model and the Higgs boson. Later he worked on CP violation and phenomenology of the B Meson. In 1977 the group added Davison (Dave) Soper (Ph.D. Stanford University, 1971) who came here from Princeton. Dave's interest was in strong interactions, but from a more formal viewpoint of understanding it on the basis of quantum chromodynamics. He made path breaking contributions towards putting the parton model on firm theoretical basis.

In the period from 1981 to 1989, the theory group was well funded and could support two postdocs a year. Professor Deshpande won an Outstanding Junior Investigator grant from 1981 to 1986. Paul Csonka developed several novel approaches to the design of significantly smaller in size accelerators, x-ray lasers, and telecommunications. The Department of Energy partly supported his research in the first two of these areas through additional grants, while further funding came from other sources. A number of postdocs from this and earlier periods went on to become physics professors at major universities. This was also the period when the strength of the theoretical group was at its peak of five faculty.

In the 1980s the state of Oregon put in a bid to host the planned Superconducting Supercollider (SSC) accelerator. To support this endeavor, in 1985 the UO particle physicists, urged on by UO President Olum, organized a five months workshop titled the Oregon Workshop on Super High Energy Physics. Over fifty distinguished phisycists participated in this successful meeting at various times. The same year the particle physics group also hosted the Annual meeting of the APS Division of Particles and Fields, with 361 participants. Eventually the state of Oregon did not get the SSC, and later Congress canceled the project. However, partly in response to the excitement about the SSC, the high energy theory group argued for starting a high energy experimental group at UO. This resulted in the hiring of James (Jim) Brau, under whose able leadership the experimental group steadily grew in stature, reaching its present strength of five faculty members.

In 1989 the group lost Mike Moravcsik, who passed away in Italy on one of his frequent travels. From 1998 to 2014 the senior theory faculty mentioned gradually retired and were, over time, succeeded by outstanding young hires. In 1999 Steve Hsu (Ph.D. UC Berkeley, 1991) arrived from Yale. His interest was in phase transitions in strong interactions and entropy of black holes. In 2004 Graham Kribs (Ph.D. University of Michigan, 1998) came here from the Institute for Advanced Study in Princeton. He works in particle phenomenology and is an expert in theories beyond the standard model and early cosmology. In 2010, Spencer Chang (Ph.D. Harvard University, 2004) joined us from UC Davis. Hi also works in particle phenomenology, with expertise in theories beyond the Standard Model and dark matter. In 2012 Steve Hsu left for Michigan State University to become Vice President for Research. In 2014 Tim Cohen (Ph.D. University of Michigan, 2011) came here from SLAC at Stanford. Tim's interest is also in particle phenomenology and dark matter, especially in detecting signals for particles beyond the standard model at the LHC.

The particle theory group's achievements have included a Sloan Fellowship, Nordita Professorship, and Fulbright Scholarship (twice) to Csonka, Ben Lee Fellowship to Kribs, Fellowships of the American Physical Society to Deshpande, Hwa, Kribs and Soper, and the J. J. Sakurai Prize to Soper. In addition Deshpande and Soper served as Physics Department Heads, Csonka served as Director of the Honors College, and Deshpande also served as the Associate Dean for the Sciences.

5. Nuclear Physics

Harlan Lefevre

I first visited the Oregon Physics Department in January of 1951 to learn about a use of scintillation counting. The department was then located in the basement of Deady Hall. A new science building (Pacific) was then under construction. Raymond T. Ellickson (later Physics Department Head) was then Dean of the Graduate School. He escorted my Reed College physics advisor and me through Physics, the new theatre, and the new Student Union.

I returned ten years later in May 1961 to give a colloquium in the basement of Pacific. I began teaching in the fall of 1961 (E and M). John Powell was Department Head. The physics faculty included Profs Bernd Crasemann, Francis Dart. Raymond Ellickson, Shang-Yi Ch'en, Edwin G. Ebbighausen, and Kenneth Zankle. That fall new hires included (besides me) Gregory Wannier, James Kemp, Donald Wells, Joel McClure, and H. J. Hrostkowski, a significant expansion of the department. Physics and Chemistry then shared a department office. Chemistry and physics faculty offices were intermingled on the first and second floors of Pacific.

Three years later a proposal for an accelerator for nuclear physics research was funded by the Atomic Energy Commission for about $500,000. The accelerator was purchased along with a custom high voltage terminal that included a duo-plasmatron ion source and a klystron buncher for neutron-time-of-flight spectroscopy. The accelerator was installed in the basement of Volcanology (then the university Health Center). The construction of a vault for the accelerator at the back of volcanology and a target room, control room, and shop area in the basement were completed in 1965.

In 1965 a University proposal for a "Center of Excellence" was funded by the National Science Foundation. That grant included funds for and IBM 360-50 computer for the computer center and for a DEC PDP-7 computer with a link to the 360-50 for dedicated use with the accelerator. Prof David McDaniels (Ph.D. Univ. of Washington, 1960) was hired to join Bernd Craseman (Ph.D. Berkeley, California, 1953), Harlan Lefevre (Ph.D.Wisconsin, Madison, 1961), and Donald Wells (Ph.D. Stanford, 1962) for research with the accelerator. Two nuclear theorists, Ian McCarthy (Ph.D. Univ. of Adelaide, 1955) and Amit Goswami (Ph.D. Calcutta University, 1964) complemented the effort.

Research with the accelerator proceeded until 1972 when Wells left after tenure failure. He was replaced with Jack Overley (Ph.D. Cal Tech, 1960). McDaniels opted out of the group and began research at Los Alamos. McCarthy left for a chair in Australia, Craseman worked on beta decay rather than use the accelerator. Goswami quickly abandoned nuclear theory in favor of (sic) Quantum Conscioness.

The AEC then terminated our support. Research was then funded by the NSF until about 1984.

From 1970 Professor McDaniels worked for about five years at Los Alamos on fast neutron radiative capture with the goal of establishing the validity of the semi-direct theory for these processes. Later on he worked to study the role of giant octupole Resonances utilizing the 800-MeV proton beam at the HRS facility of LAMPF. This work was done in concert with the same type of effort at the TRIUMF facility of the University of British Columbia.

In the mid 1970's we began using neutron time-of-flight spectroscopy to investigate near-threshold resonances in thick targets produced in (p,n)reactions. In mid-weight targets these resonances are spaced a few KeV apart and are excited by protons that have slowed down in the thick target through the resonance energy. We eventually found and studied a resonance three electron volts above it's 3 Mev threshold. It's width was measured to be three electron volts. With our MeV-ion microprobe we developed ion-energy loss spectroscopy for imaging biological specimens with energy-loss contrast. We participated in Ion-Microprobe conferences at Oxford and at the University of Melbourn. Prof. Overley and I continued to use the accelerator with support by NSF and FAA until 1996 for neutron physics, imaging, and explosives detection in airline luggage using neutron-transmission-spectroscopy.

Both Overley and I retired in 1998. One of my graduate students (Robert Schofield) has continued to use the laboratory for research in bio-materials. The PDP-7 computer has been moved to the Living Computer Museum in Seattle where as the oldest computer in their collection it is front-and-center on the museum floor. The museum and it's collection of running old computers was assembled by Paul Allen of Microsoft fame.

6. Astronomy

James Imamura

The Physics department has been home to astronomy at the University of Oregon for seventy years. Currently seven faculty have research programs that center on astrophysical phenomena, including studies of the large scale structure of the Universe, the formation and evolution of galaxies, origins and evolution of planetary and stellar systems, and the sources and detection of gravitational waves. Oregon astronomers utilize national and international ground-based and space-based observatories, supercomputing facilities, and the Interferometer Gravitational Wave Observatory (LIGO) in their efforts. Also at their disposal is the Pine Mountain Observatory (PMO) located in central Oregon near Bend. PMO is owned and operated by the University of Oregon.

Historically, astronomy has played a large role in the Physics Department at Oregon. In the 1930s, physics lost major status at Oregon, banished to providing lower division service courses. Realizing the mistake, physics was reinstated to major status in 1941 and incorporated in the College of Arts and Sciences in 1942. Astronomy played an integral part in the rebuilding process of the department. The first astronomer hired, Professor Edwin Ebbighausen, arrived in 1946.He was a perfect fit for the University at the time, an outstanding teacher and lecturer, author of a well-respected textbook with a strong bent for research, and a researcher studying the properties of binary star systems. The astronomy faculty remained stuck at one, until Sputnik's launch in 1957, that started the space race, and a thirst for all things space swept the country including Oregon. In this climate Professor Ebbighausen and later physics department chair Proessor Russell Donnelly, saw an observatory as a means to put Oregon on the astronomical map. As a result, Pine Mountain Observatory (PMO) was founded, with first light in 1967.

The Oregon astronomy group doubled in size in the early 1960s, when Professor James Kemp was hired. He came to Oregon in 1961 after a postdoctoral stint at the University of California at Berkeley where he had received his Ph.D. in electrical engineering in 1960. At Oregon, Professor Kemp switched his research interests to astronomy and became a pioneer in astrophysical polarimetry, performing seminal work on magnetic white dwarfs at PMO.

In 1966 theorist Professor Robert Zimmerman was hired. He had received his Ph.D. in theoretical physics from the University of Washington in 1963, he worked at the Lawrence National Laboratory before coming to the University of Oregon. Here, he investigated the properties of materials at nuclear densities for application to exotic compact stellar remnants such as neutron stars, and to the most energetic of stellar events known at the time, Type II Supernovae. Later Professor Zimmerman switched his interests to general relativity and gravitation, working on the gravitational waves produced by cosmic strings and fluctuations in the early Universe.

In 1966 James Radostitz , and in 1970 Dr. Ira Nolt, who received his Ph.D. from Cornel University, joined the Department. Professor Gregory Boeshaar arrived in 1977 bringing expertise in planetary nebulae, and in 1979 Professor Patricia Boeshaar was hired adding her expertise in cool and low mass stars and stellar statistics and galactic structure to the group. Both received their Ph.D.s in astrophysics from the Ohio State University, in 1976 and 1972 respectively.

In the 1980s, the state of Oregon invested in creating centers of excellence to improve research quality at the University of Oregon. The astrophysics group enjoyed strong growth as an indirect beneficiary of that investment. The group sought to take advantage of space-based observatories and high-performance computing. Researchers in high-energy astrophysics and cosmology were sought, especially those who would utilize both space-based and ground-based observatories. Professor James Imamura joined the astronomy group at this time. He came to Oregon in 1985 following postdoctoral positions at the Los Alamos National Laboratory and the University of Virginia after receipt of his Ph.D. in astronomy from Indiana University in 1981. His research interests centered on observational and theoretical studies of the properties of compact stars and the numerical modeling of the formation mechanisms of stars and planetary systems. Professor Gregory Bothun was hired in 1990, filling a void with his expertise in physical cosmology. He received his Ph.D. in astronomy from the University of Washington in 1981, and studied the large scale structure of the Universe and the properties of galaxies. Later Professor Bothun branched out into science education, and high performance computing in physics and astronomy. He recognized the power of the World Wide Web (WWW) early in 1994, guiding the department into the utilization of the WWW. Oregon is now a leader in using the WWW as an integral part of physics education. Professor James Schombert was hired in 1996. He received his Ph.D. in Astronomy from Yale University in 1984. Before coming to Oregon, he was staff scientist in the Astrophysics Division at NASA headquarters. Professor Schombert worked on observational studies of the origins and evolution of galaxies, public outreach in astrophysics, and science education.

An unexpected expansion of the Oregon astronomy effort occurred in early 2000s when the group moved in to the field of gravitational wave astrophysics, led by experimental high energy physicists, Professor James Brau and Professor Raymond Frey. They joined the development effort of LIGO to detect and study gravitational waves. With LIGO they worked on environmental noise and in searches for gravitational wave emission from pulsars and gamma-ray burst sources, and participated in the discovery of gravitational waves from the black hole binary pair GW150914. Professor Scott Fisher was hired in 2012. He received his Ph.D. in Astronomy from the University of Florida in 2001 coming to Oregon after serving as Program Director for Astrophysics at NASA. Professor Fisher studied the polarization and spectral properties of disks in young stellar systems and active galactic nuclei. Currently, he is the director of the Oregon astronomy outreach program and the Pine Mountain Observatory.

7. Optical Sciences

Michael Raymer

Atomic, Molecular, and Optical (AMO) sciences at UO has a lineage going back at least to 1950, when Shang-Yi Ch'en joined the faculty. He studied the pressure broadening of atomic absorption lines by atomic collisions—a topic of great interest in astrophysics and important in the development of lighting technology, for example the now-ubiquitous atomic sodium street lights.

Bernd Crasemann (Ph.D. Univ. California, Berkeley, 1953) joined the faculty in 1953. He studied inner-shell electronic transitions, and the effects of special relativity therein, using synchrotron radiation. He co-authored a classic textbook on quantum mechanics, with faculty member John L. Powell. Crasemann served as Senior Editor of Physical Review A from 1992 to 2006.

Marvin Girardeau (Ph.D. Syracuse Univ., 1958), who joined the faculty in 1963, studied the quantum theory of many-particle systems. In a now classic 1960 paper Marvin solved the quantum mechanical problem of a gas of impenetrable bosons moving in one dimension. This novel state of matter was not observed in the laboratory until forty years later, with the advent of laser cooling and Bose-Einstein condensation of dilute atomic gases.

During the 1970s through the early 1990s John Moseley (Ph.D. Georgia Institute of Technology, 1966) developed techniques for using lasers to look at the properties of small molecular ions. Most productive was the photo-fragment spectrometer, which merged an ion beam with an intra-cavity single-mode tunable laser beam, allowing high-resolution spectroscopy of the states of molecular ions near the dissociation limit.

In the early 1980s, atomic and molecular physics at UO received a boost from the M. J. Murdock Trust (funded by Melvin J. Murdock, the co-founder of Oregon-based Tektronix, Inc., which marketed the world's first triggered oscilloscope). The Trust, which provided $400,000 to start a Chemical Physics Institute. Its founding members were drawn from the physics (including Marvin Girardeau, John Moseley, and Bernd Crasemann) and chemistry departments (including Thomas Dyke, David Herrick, Paul Engelking, Warner Peticolas, and Bruce Hudson).

In the mid-1980s the same group of faculty working with then Vice Provost for Research, Richard Hersh, submitted a request to the Oregon State Legislature to expand atomic and molecular sciences by funding a Center of Excellence in Optical Sciences. This was around the same time that the American Physical Society's Division of Electron and Atomic Physics (of which Crasemann was President for 1981) in 1986 renamed itself to become the Division of Atomic, Molecular and Optical Physics. The "optics" name was clearly becoming more in vogue.

The new Center of Excellence in Optical Sciences, which was a part of the Chemical Physics Institute, was provided funding for three optics-related faculty lines in physics. Thomas Mossberg (Ph.D. Columbia Univ., 1978) in 1987 established a group to study experimental quantum optics. His group was first to demonstrate narrowing below the natural line width of an atomic emission line by the modification of the density of optical states within an optical cavity. In 1999 Mossberg went on to found successful optical technology companies in the Eugene area.

Michael Raymer (Ph.D. Univ. Colorado, 1979) established a group studying the quantum statistics of nonlinear-optical processes. His group was the first to measure a quantum state of light, using a technique they called quantum-state tomography. This technique is used widely in the field of quantum information research.

Howard Carmichael (Ph.D. Univ. Waikato, New Zealand, 1976) in 1989 began a group in theoretical quantum optics. He developed the theory of quantum-state trajectory evolution for efficient numerical simulation of quantum optical processes. In 2002 he moved "home" to New Zealand, and the University of Auckland.

In 1992 Stephen Gregory (Ph.D. University Waterloo, Ontario, 1975**)** joined the UO Physics Department, and carries out research in tunneling microscopy and spectroscopy, and molecular electronics.

Peter Sercel (Ph.D. Caltech, Ontario, 1992) also joined the physics faculty in 1992, and started a group studying the physics of semiconductor quantum structures using epitaxial growth technology. He departed in 1999 to join an optical technology company in Pasadena, California.

In 1995 Hailin Wang (Ph.D. University Michigan, Ann Arbor, 1990) joined the physics faculty. He started an experimental group studying coherent excitonic and spin processes in semiconductor heterostructures. His group also uses radiation pressure to manipulate vibrations of nanomechanical oscillators and couples electron spins in diamond to nanomechanical oscillators for potential applications in quantum information.

Optical sciences at UO took an important step in 1997, with the founding of the Oregon Center for Optics, with original physics members Mossberg, Raymer, Carmichael, Gregory, Wang, and Sercel, and chemistry members Jeffrey Cina and David Alavi. In 2002 a third chemistry faculty member Andrew Marcus joined the OCO. In 2015 the OCO changed its name to the Oregon Center for Optical, Molecular, and Quantum Science, and has a 14 faculty as full members.

Miriam Deutsch (Ph.D. Hebrew University, Jerusalem, 1997) joined the UO physics faculty in 2000, and began research in optical materials, plasmonics and innovative optical sensing methods.

Jens Nöckel (Ph.D. Yale, 1997), who joined the faculty in 2001, studies theoretical aspects of optical microcavities.

Daniel Steck (Ph.D. Univ. of Texas, Austin, 2001) joined the faculty in 2004, and studies cold-atom physics, including measurement and control of quantum systems, as well as quantum nonlinear dynamical systems.

Steven van Enk (Ph.D. Univ. Leyden, Netherlands, 1992) joined the faculty in 2006, and works in the theory of quantum information and quantum optics, including quantum communication, cryptography, and computing, as well as quantum-state tomography.

Benjamin McMorran (Ph.D. Univ. Arizona, Tucson, 2009) joined the faculty in 2011, and carries out experimental studies of magnetic materials, electron microscopy, and matter-wave optics, including quantum-vortex states of coherent electron beams.

Brian Smith (Ph.D. Univ. Oregon, 2007) joined the faculty in 2015, and studies optical quantum information, specifically the encoding of qubits in the spectral and temporal degrees of freedom of single photons.

8. Physics Solar Center

David McDaniels

The initial work of the Solar Center started in 1976 with an analysis of the novel solar collector of Henry Mathew of Coos Bay Oregon. This collector had been extensively monitored by John Reynolds of the Department of Architecture. The innovative design feature of Mathew's collector was that it was oriented vertically and a reflected metal surface was placed in front of the collector to enhance the solar energy collected. David McDaniels, Physics Department, made a one-dimensional analysis of this system to show why it performed better than a conventional system. This analysis was then extended to three dimensions and a report was published, describing the calculation process in detail.

Working with John Reynolds and Steve Baker of Architecture, McDaniels started a collaboration with several engineers at Oregon State University. The goal of this effort was to obtain a large solar center between the two schools. This initiative failed but during the course of the effort a large regional solar conference was held at OSU. Afterwards McDaniels collaborated with a meteorologist at OSU for one year on solar radiation problems.

This led the Oregon group to initiate a solar radiation monitoring network in Oregon and Idaho. At this time Dan Kaehn, who obtained his PhD in materials science from Oregon, had joined the group to handle the instrumentation effort. This all started in 1978 but unfortunately Dan Kaehn died in 1979. Another UofO graduate, Frank Vignola, immediately joined the group and helped establish the initial radiation monitoring stations. Funding for the monitoring effort was obtained from EWEB, Pacific Power, and the Bonneville Power Administration.

Using the solar radiation data collected from the network, Vignola and McDaniels published a large number of papers delineating the comparison of the diffuse and direct solar radiation components. The advantage of the effort was due to the large amount of quality data obtained by the network. In 1996 McDaniels retired and Vignola continued the effort successfully until this day.

9. Biophysics

Brian Matthews

The establishment of a biophysics program within the department followed the creation of the Institute of Molecular Biology and was initially motivated in large part by the Institute's desire to bring newly-established physical techniques to bear on questions of macromolecular structure and function.

In 1969 Brian Matthews was recruited to the University to establish a new protein crystallographic laboratory. He had received his doctorate from the University of Adelaide in1964, Australia, and in 1963 moved to the Medical Research Council Laboratory of Molecular Biology, Cambridge, England. There he was a member of the group led by David Blow that determined the three-dimensional structure of chymotrypsin, one of the first successful protein structure determinations.

Appointed as Associate Professor of Physics and Member of the Institute of Molecular Biology, Matthews was promoted to Full Professor in 1973 and designated Distinguished Professor in 1996. From 1989 until his retirement in 2008, he was an Investigator in the Howard Hughes Medical Institute, a private foundation that supports selected research groups across the country. He served as Director of the Institute of Molecular Biology (1980-1983; 1990-1992), Chairman of Physics (1985-1986), President of the Protein Society (1995-1997), Member of Council, U.S. National Academy of Sciences (2009-2012) and has been Editor of Protein Science since 2007.

His research interests focused on the structure, function and folding of proteins. His group determined the structures of a number of different proteins including the so-called Cro repressor. This study illustrated, for the first time, how a protein can bind to a specific site in DNA and regulate the expression of genetic information. His group also pioneered the combination of genetic-engineering and crystallographic techniques to understand the basis of protein stability and was the first to show that proteins of enhanced stability could be designed rationally.

George Rayfield took his Ph.D. with F. Reif at Berkeley in 1964 , working on quantized vortex rings in superfluid helium. He had been appointed to the department as Assistant Professor in 1967 and promoted to Associate Professor in 1968. Starting in 1976 he established a biophysics program focused on the light-driven proton pump bacteriorhodopsin.

Stephen James "Jim" Remington studied biophysics at the University of Oregon and was awarded Ph.D. in 1977. From 1978-1982 postdoctoral research in the laboratory of Prof. Huber at the Max Planck Institute for Biochemistry elucidated the structure and some details of the enzymatic mechanism of citrate synthase, a key metabolic enzyme found in all organisms. In 1985 he joined the faculty of the Physics Department and also became a member of the Institute of Molecular Biology. He was promoted to Professor in 1998 and in 2005 served as Codirector of the Institute of Molecular Biology.

A wide range of topics were investigated under the general heading of "Protein Structure-Function Relationships" and his research was supported on a continuing basis for over 25 years by both the National Science Foundation and the National Institutes of Health). From 1985-1995, studies on the mechanism of citrate synthase were continued and new, detailed structures were defined for the important metabolic enzymes serine carboxypeptidase from yeast and wheat and glycerol kinase and malate synthase from bacteria.

In 1995 the laboratory began a major new project to investigate the folding, maturation and photophysics of Green Fluorescent Protein (GFP), a molecule that has revolutionized cell biological studies. GFP serves as a noninvasive, visible tag for molecules and processes that are normal invisible in the cell. The laboratory published the first crystal structure of the molecule in collaboration with Roger Tsien at UCSD, and with Prof. Tsien pioneered genetic engineering techniques to create and characterize a wide range of biosensors and color variants, ranging from blue to red. GFP variants were developed that could be used as indicators of changes in pH and redox status within living cells.

Raghuveer Parthasarathy received his Ph.D. from the University of Chicago in 2002, and joined the Physics department in 2006 as an Assistant Professor, and was promoted to Associate Professor in 2011. His research initially examined membrane biophysics, especially involving measurements of mechanical properties of lipid membranes, and membrane-functionalized colloidal particles. His activities later expanded to studies of gut microbial communities, and he and approximately ten other UO faculty successfully launched a center focused on host-microbe interactions, launched in 2012 with a $10 million grant from the National Institutes of Health. In all its studies, the Parthasarathy Lab relies heavily on microscopy and image analysis, and developed new optical and computational tools for biophysical ends.

Tristan Ursell joined the Physics department in 2014, after obtaining his Ph.D. from Stanford University that same year. He is launching a research program that seeks to explain the mechanical properties of microbes, and also the collective dynamics that ensue when bacteria interact in swarms and other cooperative structures. His experiments make use of microscopy, microfabrication, and numerical simulation.

Richard Taylor received his Ph.D. from the University of Nottingham, UK in 2004. His group, which has largely been concerned with nanoelectronics and fractal pattern formation, has recently been devoting efforts to research on interfaces between electronics and neurons.

The UO Physics department has also been home to several faculty focused on non-biological "soft" materials. These include Heiner Linke (Ph.D. Univ. of Lund, 1997) at UO from 2001-2009, whose research explored Brownian ratchets, biologically-inspired nanomachines, and other topics.

Eric Corwin (Ph.D. Univ. of Chicago, 2007), who joined the UO faculty in 2010, explores a variety of disordered, non-equilibrium systems, included glasses and "jammed" materials, granular flows, emulsions, chaotically driven liquids, and more. His work involves laboratory model systems as well as state-of-the-art simulation methods.

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