Agendum
Oakland University
Board of Trustees Formal Session
February 7, 2019

DOCTOR OF PHILOSOPHY IN APPLIED AND COMPUTATIONAL PHYSICS DEGREE

A Recommendation

1. **Division and Department:** Academic Affairs, College of Arts and Sciences, Department of Physics.

2. **Introduction:** Oakland University proposes a new program in physics at the doctoral level. The Doctor of Philosophy in Applied and Computational Physics program will be offered in the College of Arts and Sciences (CAS).

The physical sciences are extremely important for the economic development of the Unites States. The Department of Physics at Oakland University proposes an attractive PhD program in Applied and Computational Physics. Over the last several decades, members of the physics department have consistently obtained federal funding to support their research. PhD students will further strengthen faculty research.

An examination of the department's strengths and an assessment of growth opportunities guided the choice of the areas emphasized in the new program. First, the department has developed important strengths in computational physics: i) a diversity of programs spanning many fields in physics; ii) a powerful computer cluster; iii) experience in teaching computational physics courses; and iv) a number of national and international collaborations capable of supplying qualified students.

Second, in the area of applied physics, the department has strong connections to local industries and federal agencies. Graduates interested in applied physics will have job opportunities in R&D Laboratories in the Detroit Metro area and in neighboring Ohio and Illinois. Potential fields of employment include the semiconductor sector, alternative energy (solar, wind), automotive-related research, and similar high-tech industries.

The Critical need for a Doctoral Program in Applied and Computational Physics at Oakland University

As Oakland University moves up in the Carnegie classification, it must continue to build on areas of strength. The Department of Physics has been a leader in research for several decades. This new doctoral program will build on that strength, providing graduate students training in applied and computational physics, thereby strengthening research and expanding educational opportunities for our students. Developing Science, Technology, Engineering, and Mathematics (STEM) fields is increasingly important for our society and our economic competitiveness. This PhD program will strengthen STEM graduate education and research in Michigan and the United States.

We seek approval by the Board of Trustees for this Doctor of Philosophy in Applied and Computational Physics Program, so that the program can welcome its first students in the Fall 2019 semester.

3. Previous Board Action: None.

4. Budget Implications: We estimate that there will be four students enrolled during the first year, building up to a total of 15 students by year five. The budget indicates that the PhD program will be generate a net positive income by year four. A pro forma budget is included as Attachment B.

5. Educational Implications: The Applied and Computational Physics PhD will extend the opportunities for graduate students to prepare for a research-intensive job in physics. Many Oakland University undergraduates and masters students in physics will have a chance to continue their education on campus. It will also attract top graduate students from around the world.

6. Personnel Implications: Given the growth in the Department of Physics over the last five years, the department currently has sufficient faculty to offer this PhD program. No new faculty lines are requested.

7. University Reviews/Approvals: The proposal for a Doctor of Philosophy in Applied and Computational Physics program was reviewed and approved by the CAS Assembly, the Oakland University Graduate Council, the Oakland University Senate, and the Senior Vice President for Academic Affairs and Provost.

8. Recommendation:

WHEREAS, the Doctor of Philosophy in Applied and Computational Physics program is consistent with objectives contained in Oakland University's Institutional Priorities; and

WHEREAS, the Doctor of Philosophy in Applied and Computational Physics program will build on the research strength in the Department of Physics and provide new educational opportunities in the STEM fields so important for our society and our economic competitiveness; now, therefore, be it

RESOLVED, that the Board of Trustees authorizes the College of Arts and Sciences to offer a Doctor of Philosophy in Applied and Computational Physics degree; and, be it further

RESOLVED, that the Senior Vice President for Academic Affairs and Provost will complete annual reviews of the Doctor of Philosophy in Applied and Computational Physics program to evaluate academic quality and fiscal viability to determine whether the program should be continued.

9. Attachments:

A. Proposal for the Doctor of Philosophy in Applied and Computational Physics program.
B. Pro Forma budget for the Doctor of Philosophy in Applied and Computational Physics Program.

Submitted to the President
on Feb. 1, 2019 by

James P. Lentini CAH

James P. Lentini, D.M.A.
Senior Vice President for
Academic Affairs and Provost

Recommended on 2/1, 2019
to the Board for approval by

Ora Pescovitz

Ora Hirsch Pescovitz, M.D.
President

ATTACHMENT A

PROPOSAL FOR A
Ph.D. in APPLIED AND COMPUTATIONAL PHYSICS

Department of Physics
College of Arts and Sciences

Requested Program Implementation Term: Fall 2019

College of Arts and Sciences Governance

CAS Graduate Committee on Instruction

Date Submitted: March 1, 2010 Date Approved: January 13, 2011

CAS Assembly

Date Submitted: February 1, 2011 Date Approved: March 15, 2011
Date Approved for Updated Proposal: October 30, 2018

University Governance

Graduate Council

Date Submitted: March 30, 2011 Date Approved: December 5, 2011
Date Approved for Updated Proposal: November 30, 2018

Senate

Date Submitted: January 2012 Date Approved: May 10, 2012
Date Approved for Updated Proposal: January 17, 2019

Board of Trustees

Date Submitted Date Approved

Presidents Council

Date Submitted Date Approved

PROPOSAL FOR A
Ph.D. in APPLIED AND COMPUTATIONAL PHYSICS

Submitted by
The Department of Physics
January 29, 2010
Revised October 24, 2018

SUMMARY

This catalog presents a proposal to create a Ph.D. degree, in the **Department of Physics at Oakland University**, in **Applied and Computational Physics**. The desired start date is the 2019 Fall Semester.

In recent years, the Physical Sciences were recognized as extremely important for the economic development of the Unites States. The Department of Physics at Oakland University is amply prepared to take advantage of new opportunities and proposes an attractive PhD program in Applied and Computational Physics. Along the years, the consistent federal funding obtained by the non-medical physics members of the Department points to the high level of their research. New talented PhD students will further strengthen the faculty research; therefore, the new program promises to be highly beneficial for Oakland University. In addition, the possibility of training Ph.D. students in specialized areas of research is a fundamental part in the development of any natural sciences department.

A careful examination of the Department's strengths and a realistic assessment of growth opportunities have guided the choice of the areas to be emphasized in the new program. First, the Department has developed a combination of important strengths in Computational Physics: i) a diversity of programs spanning many fields in physics ii) a powerful computer cluster (with over 300 nodes) iii) a wealth of experience in teaching computational physics courses iv) a number of national and international collaborations capable of supplying qualified students.

Second, in the area of Applied Physics, the Department has developed, under the guidance of Prof. Srinivasan, comprehensive facilities and strong connections to local area industries and federal agencies. The Applied Physics PhD graduates will have job opportunities in R&D Laboratories in the Detroit Metro area and in neighboring Ohio and Illinois. Potential fields of employment include the semiconductor sector, alternative energy (solar, wind), automotive-related research, and similar high-tech industries. The students graduating with a Ph.D. in Applied Physics will be strongly encouraged (and helped) to seek summer internship in R&D facilities to gain experience and increase the prospects for future employment.

The program is in accord with all university polices. It has been developed in compliance with all departmental, college, and university procedures governing the development of new courses, programs and degree offerings. In preparation for this program the department has consulted with all other units that may be affected by the development of this PhD program. Letters of support are attached from the Mathematics, Chemistry and Biology Departments.

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1. Program Rationale

Given the success of the Department of Physics faculty who are not related to the Medical Physics program in attracting external funding, and the current federal emphasis in supporting the development of Physics as a strategic asset for the economic development of the nation, it seems clear that the potentialities of the faculty in the Department of Physics will be better leveraged by the creation of a new program. This program will be centered in currently important areas of development in the fields of numerical simulations of materials properties and experimental development and characterization of new materials with technological applications. Furthermore, both experimental skills acquired on the Applied Physics track and computational skills acquired on the Computational Physics track can be used in a wide array of careers and endeavors. Given the very specialized characteristics of these two areas, the Physics Department is the natural place at Oakland to provide a doctoral degree and a first class research experience. Based on these considerations, this proposal describes a plan to create a Ph.D. program in Applied and Computational Physics.

An informal survey of Physics majors indicates that many of them would apply for a PhD program degree in Physics at OU (other than Medical Physics) if one was offered. In the last few years, some of our majors have been accepted in PhD programs in prestigious universities (examples include UC Riverside, Wayne State, and others).

2. Program Description

DEPARTMENT OF PHYSICS
PhD in Applied and Computational Physics:

Faculty research productivity, including publication of scientific papers and external grants, is presented in **Appendix III.**

PROGRAM DESCRIPTION AND REQUIREMENTS

Catalog copy

Description: The College of Arts and Sciences offers a physical sciences doctoral program in Applied and Computational Physics, at the Department of Physics. With a concentration in materials experimental research and computer modeling, this program will prepare graduates for industry and academic careers in areas related to various experimental and theoretical aspects of one of the largest fields in physics: Materials science. More generally, the curriculum prepares the students to engage in research in condensed matter physics, with materials research currently being the most technologically important area. This program emphasizes both practical, engineering applications (applied physics track) and theoretical and fundamental physical concepts (computational physics track). Ph.D. candidates may elect to do their dissertation with one of a number of Oakland University faculty currently involved in applied and computational physics research. In addition to available Oakland University graduate assistantships, many of the faculty in the Department may provide individual support for qualified students. Interested students should consult the program coordinator for details.

Course requirements: To be able to graduate a minimum of 8 core courses, equivalent to 30 credits, have to be obtained by the student. These are: PHY 5220 Statistical Thermodynamics, PHY 5520 Theoretical Physics, PHY 5620 Mechanics II, PHY 5740 Introduction to Solid State Physics, PHY 5830 Classical Electrodynamics, PHY 6730 Quantum Mechanics, SCI 5110 Ethics and Practice of Science (this last one counts for 2 credits, with the previous ones being 4 credits each). In addition, students can choose one of the two courses: PHY 5420 Advanced Electronics (for the Applied Physics track - 4 credits), or PHY 5530 Numerical Methods in Theoretical Physics (for the Computational Physics track - 4 credits). In addition, students will take PHY 6940 Research Seminar (typically in year three of their studies; 1 credit per semester for two semesters).

The required proficiency is measured in two ways: by completion with a grade of 3.0 or higher in the appropriate courses listed above, and by taking special examinations in preselected disciplines. These are commonly referred to as "qualifying exams." This comprehensive examination will consist of a written examination followed by an oral examination. The written examination will consist of two parts: Mathematics, and Applied and Computational Physics. An integral and major component of the program is the successful completion of original research either utilizing state-of-the-art experimental methods or taking a theoretical and/or computational approach to study a problem of current interest. This will be achieved by the student through careful and constant guidance provided by a faculty of his/her choosing, who is involved in research of the student's interest. Finally, the student will then prepare a doctoral dissertation, which will be submitted to a specially formed dissertation committee and shall defend the dissertation in a public oral examination.

Program Description

The purpose of this doctoral program is to provide students with training in physical science that includes a variety of forefront skills to enable them to meet the challenge of tomorrow's rapidly evolving technology. The program will focus on broad interdisciplinary areas of materials, instrumentation and numerical modeling where Oakland University already has a base of distinguished faculty researchers in the departments of Physics, Chemistry, Mathematical Sciences and Electrical and Mechanical Engineering. Formal course work will allow the students to learn the physics of materials, principles of devices, computational methods, and experimental techniques.

Industrial collaboration will be sought at all stages of the program. Examples of such collaboration include shared equipment in research projects, adjunct faculty from industry acting as dissertation supervisors and teaching advanced courses, encouragement of research projects that solve industrial problems and student internships in industrial laboratories. Although additional resources need to be provided by Oakland University in order to begin this program, most of these resources are already available. Of primary importance is adequate laboratory equipment (see above). Most of the required courses are already present in our catalog (see Appendix II). However, faculty members will be required to offer these courses more frequently.

The program will be designed to provide both interdisciplinary training to students and a forum to foster interdisciplinary collaboration among the research programs of the faculty participants, including industrial adjunct faculty. The curriculum will be designed for full-time students (8-12 credit hours per semester) but will allow the flexibility necessary for part-time students. Advising will be an important aspect of the program since we expect incoming students with majors in Physics, Chemistry, Mathematics, or Engineering. Each incoming student will be assigned an initial advising committee (representing at least two participating departments) who will direct the student to appropriate course work.

The curriculum is designed to provide a background that is sufficiently broad to give the student familiarity with a variety of concepts and techniques in technological science yet sufficiently deep to allow the student to acquire the insight necessary to complete a creative research project. The main goals of the curriculum are the understanding of physics of materials, principles of devices, computational methods, and experimental techniques. These goals can be met, in large part, by current course offerings at Oakland University.

Physics of materials will include theory of solids, statistical mechanics, and the necessary prerequisites. Principles of devices will include electronics, lasers, and similar subjects. Computational methods will include both theoretical modeling and the interface with experiment, with real problems based on the research of the faculty participants. Experimental techniques will be taught from among a variety of disciplines using actual research equipment, whenever possible.

All students will be encouraged to attend a weekly research seminar representing all the program participants. The seminars can range from student reports on journal articles to formal colloquiums by outside speakers. One goal of this seminar is to keep all participants informed of each other's activities.

The normal time scale to the degree will assume that the students are prepared to take graduate-level courses from the first year of their studies and that the qualifying examination will be taken at the end of the second year. Such students should complete the program in about four to five years. It is expected that, starting from the third year in the program, all students will be supported by research grants. It will be necessary, however, (and beneficial to the students) to have teaching assistantship support during the first two years.

Areas of Concentration

Students must choose one of the following concentration areas:

Computational Physics

Computational Physics has been growing as a major area of concentration in Physics. At OU, students will receive training in the major areas of Computational Physics, through specific courses, ranging from basic to advanced, and will greatly benefit from the expertise and cutting edge research being performed by faculty in many different fields (see Cholis, Elder and Garfinkle in Faculty Qualifications in Appendix I). At OU, students will also benefit from the state-of-the-art computational facilities maintained by the Physics Department since 2004, which was improved in 2010 through an NSF grant in excess of $ 140,000, and with additional improvements since then.

Applied Physics

In the area of Applied Physics, the Department has developed, under the guidance of Prof. Srinivasan, comprehensive facilities and strong connections to local area industries and federal agencies. The Applied Physics PhD graduates will have job opportunities in R&D Laboratories in the Detroit Metro area and in neighboring Ohio and Illinois. Potential fields of employment include the semiconductor sector, alternative energy (solar, wind), automotive-related research, and similar high-tech industries. The students graduating with a Ph.D. in Applied Physics will be strongly encouraged (and helped) to seek summer internship in R&D facilities to gain experience and increase the prospects for future employment.

Admission requirements

The students admitted into the Ph.D. program in Applied and Computational Physics must have a bachelor's degree with a major in either Physics, Engineering, Computer Science, or one of the mathematical sciences. Admission is highly selective: the prospective student should submit a graduate application, official transcripts from all colleges and universities previously attended, letters of recommendation from three faculty members capable of evaluating scholarly achievements and potential for independent research, and results of the Graduate Record Examination, including the subject test appropriate to the specialization in Applied and Computational Physics. There are no specific course prerequisites for this program.

Requirements for the Ph.D. degree

Course requirements:

General Core Requirements (minimum of 8 core courses + research seminar – 32 credits)

- PHY 5220 Statistical Thermodynamics
- PHY 5520 Theoretical Physics
- PHY 5620 Mechanics II
- PHY 5740 Introduction to Solid State Physics
- PHY 5830 Classical Electrodynamics
- PHY 6730 Quantum Mechanics
- SCI 5110 Ethics and Practice of Science (2 Credits)

And one of the two courses
  - PHY 5420 Advanced Electronics (for the Applied Physics track)
  - PHY 5530 Numerical Methods in Theoretical Physics (for the Computational Physics track)

The students will be encouraged to attend the research seminar (the Department of Physics colloquium). Students will take two semesters of PHY 6940 (1 credit per semester). The students will also take 16 credits of elective courses: 8 credits from the listed recommended courses and 8 credits of free electives.

Electives (8 credits from lists below)
Applied Physics track:

- PHY 5450 Nuclear Magnetic Resonance
- CHM 4700 Industrial Chemistry

- CHM 5410 Advanced Physical Chemistry
- CHM 5420 Topics in Physical Chemistry
- EE 5140 Instrumentation and Measurements
- EE 5300 Electromagnetic Engineering

Computational Physics track:

- PHY 5350 Modeling Complex Systems
- PHY 5300 Bioelectric Phenomena
- PHY 5040 Advanced Astrophysics
- PHY 5650 Physics of Continuous Media
- PHY 6740 Advanced Quantum Mechanics
- APM 5333 Numerical Methods
- APM 5334 Applied Numerical Methods: Matrix Methods
- APM 6334 Numerical Methods for Partial Differential Equations
- APM 6558 Mathematical Modeling in Industry: Continuous Models
- STA 5225 Stochastic Processes I
- ME 5510 Fluid Transport
- ME 7510 Gas Dynamics

Exit Options

Approval of research oriented dissertation, submitted to internal and external review.

Program Total Credits

A minimum of 80 credits beyond the bachelor's degree is required for the Ph.D. degree in Applied and Computational Physics, including at least 30 credits of dissertation research. The total course requirement is 12 courses (46 credits) and a research seminar (2 credits), with a minimum of 8 core courses and 2 courses not directly related to the dissertation topic. There are 2 free electives.

Additional Program Information

Minimum Requirements:

The Ph.D. degree in the proposed program will be a research degree and not be conferred solely as a result of study. The degree will be granted on evidence of general proficiency in the program area, and particularly on the candidate's ability for independent investigation as demonstrated in a final dissertation based upon his or her original research. This research will be at a level of sophistication equivalent to work published in refereed science journals. The basic requirements for the Ph.D. in Applied and Computational Physics are completion of a program of formal course work and independent research approved by the candidate's dissertation committee and the Joint Committee on Applied and Computational Physics.

Students with a Previous Masters Degree:
Students with a previous MS degree can obtain up to 32 credits reduction for their graduate studies with approval from the program committee. On entering the program, each MS student will be given a preliminary examination consisting of three parts: thermodynamics, quantum mechanics, and electricity and magnetism (the course content of PHY 4210, 4720, and 4820, respectively). Failure in any of the three parts of the exam will obligate the student to take the corresponding course.

Dissertation Committee

A dissertation committee consisting of at least three members (one of whom will serve as dissertation adviser) will be formed. The majority of the committee will consist of faculty members of the Department of Physics. The student's dissertation adviser will be chairperson of the committee. The committee is charged with the guidance of the student in course selection, review of dissertation proposals before initiation of a project, and approval of the completed dissertation.

Qualifying Examination

Typically, within two years after admission into the program, the student must pass a comprehensive qualifying examination. The comprehensive examination will consist of a written examination followed by an oral examination. The written examination will consist of two parts: Mathematics and Theoretical Physics. The oral exam will include the student's presentation of his/her research. The examination is intended to determine the extent of the student's knowledge and readiness for the doctoral degree and will be designed and evaluated by the dissertation committee. If the student does not pass the examination, the committee may allow the student to retake the examination within one year. Failure to pass the examination within two attempts shall constitute failure in the Ph.D. program.

Dissertation: Proposal and Defense Procedures

An integral and major component of the program is the successful completion of original research either utilizing state-of-the-art experimental methods or taking theoretical and/or computational approach to study a problem of current interest. Each student shall, in consultation with his or her adviser, prepare: a dissertation proposal outlining the problem to be studied and the relation of this problem to practical applications, a survey of the appropriate literature, a description of the appropriate techniques, and an outline of the experiments to be performed. The student shall, at the request of the dissertation committee, orally defend the proposal and elaborate on the methods for data collection and analysis.

The project shall be deemed ready for preparation of the dissertation at such time as the student's dissertation committee agrees that the student has completed the project and that the student is an expert in the use of the specific theoretical and/or experimental methods required by the project. The student shall then prepare a doctoral dissertation for submission to the committee and shall defend the dissertation in a public oral examination conducted by the dissertation committee and attended by the specialization committee.

Courses in the Program (Required and Elective)

The student is assumed to be prepared to take courses at the 5000 level upon admission. If this is not the case, additional course time will be required. At most 12 credits of 4000-level coursework can count toward the Ph.D. For example, it is assumed that the entering student has successfully completed the equivalent of

PHY 4210	Thermodynamics
PHY 4720	Quantum Mechanics I
PHY 4820	Electricity and Magnetism II

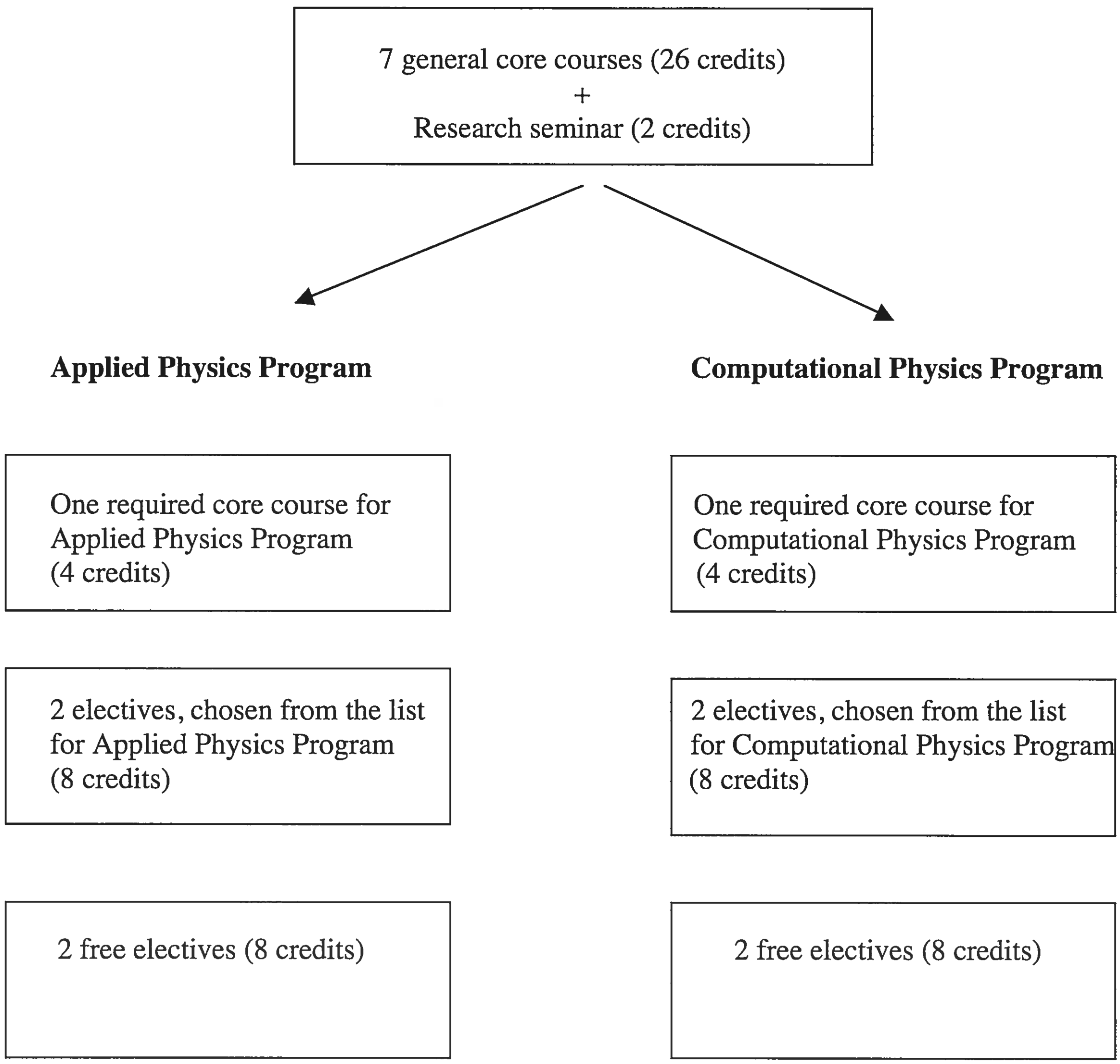
The students will be required to take 7 core courses (one of them being required for the chosen specialization - either computational physics or applied physics). The students would also take 16-20 credits of elective courses: 8 credits from the listed recommended courses and 8-12 credits of free electives. Once a student has chosen a specialization, certain elective courses will be essential to his/her education. Note that, in addition to physics courses, there are courses in chemistry, mathematical sciences and engineering. It is expected that once a student has the basic knowledge and training in physics, through the required courses, he or she will specialize in an area related to his/her dissertation research, and take elective courses appropriate to that specialization.

Additional Requirements:

The students will be encouraged to attend the research seminar each semester for the first three years. In the third year of their graduate studies, the students will be required to take the course PHY 6940 (1 credit per semester).

Note that all core and required courses (except for SCI 5110) for each specialization are Department of Physics courses. (Where an equivalent course exists in another department, the student could take that course instead). The list of required credits is summarized below.

Courses (48 credits)



Course Offerings

PHT 5150 Physics Teaching: Experiments and Equipment (2)
Secondary physics and physical science teachers will design, perform and critique laboratory and demonstration experiments selected to match individual teaching situations and available equipment. Related physical principles, potential open-ended questions and sources of experimental difficulties will be viewed.

PHY 5040 Advanced Astrophysics I (4)
Observational properties of stars, galactic structure, stellar dynamics.

PHY 5050 Advanced Astrophysics II (4)
Stellar structure and evolution, interstellar medium, galaxies, cosmology. Recommended Prerequisite: PHY 5040.

PHY 5220 Statistical Thermodynamics (4)
Review of classical thermodynamics. Kinetic theory of gases, transport phenomena, classical and quantum statistics, partition functions and thermodynamic properties, ensembles and fluctuations.

PHY 5250 Radiation Biophysics (4)
The study of molecular and cellular radiation biology, theories of biological effects of radiation, repair of radiation damage, effects of irradiation on human tissue and organs and radio-sensitivity of human tumors.
Prerequisite: Permission of instructor.

PHY 5300 Bioelectric Phenomena (4)
The physics of bioelectric phenomena: the electrical behavior of nerves, skeletal muscle and the heart; the electrocardiogram and the electroencephalogram; and biomedical devices such as the pacemaker.

PHY 5350 Modeling complex systems (4)
Methods of mathematical physics and nonlinear dynamics will be applied to investigate problems in physical, chemical, and biological systems. Examples studied will include population dynamics, epidemiology, instabilities and formation of patterns, diffusion phenomena (cell migration), and growth of brain tumors.

PHY 5420 Advanced Electronics (4)
Selected topics in the analysis and design of electronic circuits.

PHY 5450 Nuclear Magnetic Resonance (4)
Basic principles, imaging techniques, in vivo spectroscopy.
Student must have permission of instructor.

PHY 5480 Advanced Electronics Laboratory (2)
To accompany PHY 5420.

PHY 5520 Theoretical Physics (4)
Topics and techniques common to graduate physics courses: partial differential equations, eigenvalue problems, special functions, spherical harmonics, Green's functions, variational methods, linear vector spaces, tensors.

PHY 5530 Numerical Methods in Theoretical Physics (4)
Numerical differentiation and integration. Numerical solution of linear, transcendental and differential equations. Numerical modeling and data analysis. Accuracy and stability of algorithms. Knowledge of a scientific programming language (FORTRAN preferred). Recommended prerequisite: PHY 5520.

PHY 5620 Mechanics II (4)
Lagrange's and Hamilton's equations of motion, rotation of rigid bodies, coupled oscillations, nonlinear dynamics.

PHY 5650 Physics of Continuous Media (4)
Introduction to elasticity and fluid mechanics, including tensors, stress, strain, flow, conservation principles, constitutive equations, elasticity and fluid mechanics.

PHY 5730 Nuclear Physics (4)
Nuclear properties, forces, models, decays and reactions; nuclear energy, elementary particles.

PHY 5740 Introduction to Solid-State Physics (4)
Introduction to the thermal, electrical and magnetic properties of solids, including periodic structure, lattice dynamics, electron interactions and behavior, transport properties, Fermi surface, optical behavior and superconductivity. Emphasizes current experimental techniques.

PHY 5830 Classical Electrodynamics (4)
Review of electrostatics, magnetostatics, Maxwell's equations and electromagnetic waves. Relativistic description of particles, fields and interactions. Radiation by moving charges, bremsstrahlung, radiation damping, self fields.
Recommended prerequisites: PHY 5520.

PHY 6310 Biomechanics (4)
This course will include topics in statics, kinematics and dynamics, elastic and viscoelastic theory as applied to the physical properties of biological materials and body motion, as well as fluid properties in the mechanics of the circulatory system.
Prerequisite: permission of instructor.

PHY 6320 Introduction to Lasers and Masers (4)
Theory and principles of quantum electronics as applied to lasers and masers, properties of laser light, selected applications.

PHY 6650 Physics of Fluids in the Body (4)
Newtonian fluid flow; respiration, micturition and non- Newtonian fluid, mucous and blood, circulation; fluid flow in elastic tubes, blood, CSF, lymph.
Prerequisite: Permission of instructor.

PHY 6730 Quantum Mechanics (4)
Development of formal approach to quantum mechanics, selected illustrations and applications.
Recommended prerequisites: PHY 5520 and PHY 5620.

PHY 6740 Advanced Quantum Mechanics (4)
Continuation of PHY 6730. Additional illustrations and applications of formal quantum mechanics.
Prerequisite: PHY 6730.

PHY 6900 Current Topics in Medical Physics (4)
Lectures on current areas of research in medical physics. Student must be admitted to Ph.D. program or have permission of instructor.

PHY 6940 Seminar (1)
Student must have permission of instructor.

PHY 6996 Master of Science Research (2 – 12)
Graded Satisfactory/Unsatisfactory. May be repeated for additional credit.

PHY 7210 Interaction of Non-Ionizing Radiation with Tissue (4)
Review of electromagnetic theory, dielectric properties of tissue, piezoelectric effects, streaming potentials, dielectrophoresis, passive and active transport, cell-field interactions; observed effects in development, behavior and tissue repair; geomagnetic coupling. Interactions of ultrasound and lasers with cells.
Student must be admitted to Ph.D. program or have permission of instructor.

PHY 7260 Advanced Radiation Biophysics (4)
In depth study of selected topics in Radiation Biophysics. Areas such as target theory, cell cycle distribution influences, molecular and cellular repair theories and concepts of micro dosimetry will be covered.
Recommended prerequisites: PHY 5250. Permission of instructor.

PHY 8999 Doctoral Research (2 – 12)
Graded Satisfactory/Unsatisfactory. May be repeated for additional credit.

3. Assessment Plan Narrative

a. Citation of appropriate goals from Oakland University's Mission Statement.

(1) "A strong core of liberal arts and sciences [will] ... develop the skills, knowledge and attitudes essential for successful living and active, concerned citizenship [and] an enriched life."

(2) "...research and scholarship reinforce the instructional mission of the university. Whenever possible students are involved in research projects ...."

(3) "Each program ... ensure[s] .. superior career preparation or enhancement."

b. Specification of academic unit goals that flow from each of the cited university goals.

(1) "The nature of today's technology is derived from a very few academic disciplines. Physics is one of these critical areas of expertise, and the department is in a position to provide unique service to the university community along these lines."

(2) "Research activities at Oakland reflect a number of factors, primarily connected to the educational objective. Members of the faculty derive more insight and detailed experience in newer, developing areas of physics as a result of their research. Not only are they enabled to communicate more effectively, but students also have the opportunity to be exposed to first-hand techniques and understanding."

(3) "The Department of Physics ... is primarily a research department. We see this orientation as the most important component of the overall department mission, namely to serve the community in terms of its educational needs in physics."

c. Operationalization of the unit's goals into outcomes for student learning.

(1) "The students will master the theories of classical and modern physics in the advanced courses."

(2) "Doctoral students will develop the skills to perform publication quality research."

(3) "Students will be trained by researchers in applied and computational physics to develop the research skills necessary for a career in the corresponding areas of physics."

d. Description of the methods by which progress toward the operationalized unit goals will be measured.

The Department of Physics will employ the assessment tools described below.

Alumni Survey (a-c)
A survey of Oakland physics alumni will be conducted every 2 years. A copy of the survey is attached to this document. The survey contains a series of questions designed to determine if the students were properly prepared for their careers and how the students perceive their experience at Oakland University in general and more specifically the Department of Physics instruction and facilities.

Completion of PhD Dissertation (b-c)
Each student will be required to take 42 credits of dissertation research culminating in a PhD thesis that contains publication quality research. The standard Oakland University grading system will be used.

Student Publications (c)
The number of publications that have students as co-authors will be monitored to directly measure the programs goal of stimulating cutting edge research.

e. List the individual(s) who have primary responsibility for administering assessment activities.

In what follows the "assessment committee'' refers to a group comprised of the assessment representative (currently W. Zhang), the faculty adviser (currently E. Surdutovich) and Department Chair (currently A. Slavin).

Initiation of the alumni survey is the responsibility of the assessment representative. The assessment representative will be responsible for the collection of the surveys and initial statistical analysis. Each member of the assessment committee will read the open-ended questions on each individual survey. The committee will then prepare a report summarizing the results.

Grading of the PhD dissertation will be the responsibility of the faculty member advising the student and at least one other faculty member who has expertise in the research area covered in the scientific research. The assessment representative will be responsible for collection of statistics and analysis of results.

f. Describe the procedures used in your academic unit for translating assessment results into program changes.

The assessment committee will meet periodically to review the results of the assessment measurements and assess whether program changes are required to achieve the program goals. If it is determined that changes are required, the assessment committee will prepare recommendations that will be presented and discussed by the entire physics faculty. The entire faculty will then determine which recommendations should be implemented. Once implemented, the impact of the changes will be evaluated using the assessment tools described earlier.

4. Library Review

Kresge Library currently has a sizable number of subscriptions to online physics journals, providing adequate support for research in all areas of Physics (see Appendix IV for the detailed Library Review). We do not envision a large need for requesting any additional subscriptions in the short term. Our current subscriptions should only be enhanced by a few titles: Nature Physics, Nature Materials, Nature Nanotechnology, Physics of Fluids, and Europhysics Letters (online subscriptions).

5. Labs and Lab Equipment

Microwave magnetics and multiferroics lab.
We are well-equipped for recruitment and training of graduate students to pursue a research career in microwave magnetics and multiferroics. Facilities for sample synthesis include dual beam RF sputtering, tape casting, high temperature furnaces, microwave furnace, and hot-pressing. We have a scanning probe microscope with AFM, EFM and MFM for the characterization of bulk, single crystal and nanosystems. Structural characterization facilities include an X-ray diffractometer and a scanning electron microscope. Magnetic characterization facilities, such as a Faraday balance and a Quantum Design squid magnetometer, are also available. State-of-the-art instrumentation is in place for high frequency characterization from 1 kHz to 110 GHz. Three vector network analyzers over this frequency range, a 3-GHz Agilent materials analyzer, an X-band ferromagnetic resonance system and a magnetoelectric measurement system are some of the high frequency measurement systems available.

6. Planning Narrative

How the program will help promote the Role and Mission of the University (OU in 2020)

a. Excellent academic and professional instruction: The new program will generate professionals who will be able to either follow academic careers in Physics, or work in private and public research labs, participating in the development of new technologies, be it in computer simulation or materials development and characterization.

b. High-quality basic and applied research and scholarship: The faculty at the Department of Physics are leaders at OU in volume of publications and external funding. This trend will continue and be reinforced by attracting the enrollment of qualified graduate students from Michigan, other states in the nation, and other countries.

c. Responsive and effective public and community service: The Department of Physics at OU has been an important source for the region in the development of talented high school and community college students, through their formal and informal enrollment in research activities throughout the year.

d. Comprehensive schedule of student development activities: OU students will be offered the possibility of continuing their education after majoring in one of the sciences, by enrolling in the new Ph.D. program. They will engage in research with one of the faculty in the program and attend a comprehensive set of upper level courses, thus obtaining, besides a Ph.D. degree, the technical knowledge necessary to be successful in the current high-tech economy.

7. Benchmark proposed program against other similar programs in table format

Unique features of the Program

We have analyzed three Universities in the State of Michigan, which have Physics Departments similar to the one at OU, and which have Ph.D. programs. These are:

- Michigan Technical University:
  https://www.mtu.edu/physics/graduate/applied-physics/

- Western Michigan University:
  https://wmich.edu/physics/academics/graduate-programs

- Central Michigan University:
  http://www.cst.cmich.edu/phd-sam.html

While the first two universities offer more traditional programs in Physics, i.e., without a well-defined focus in specific fields, Central Michigan University offers a Ph.D. in the Science of Advanced Materials, a model which is more akin to the one being proposed at Oakland. However, the focus of the proposed program is in Computational and Applied Physics, areas which do not have a direct overlap with Science of Advanced Materials. We believe that our focus on Computational as well as Applied Physics makes our program unique within the State of Michigan. The computational track is an option that is not generally present within Physics Ph.D. programs and naturally lends itself to collaboration with researchers in computational chemistry and computational engineering. This will give our students a broad range of possibilities for research projects and future careers. Since the majority of faculty to be involved in the program are related to basic Condensed Matter Physics, this focus will be exploited in the advertisement and recruiting of students. The proposed program will therefore be much more focused compared to those of Michigan Technical University and Western Michigan University, with which our program, given its size, would be competing more directly. However, irrespective of any current or future programs in Michigan, we believe that our program will count with several strengths which will help us attract quality students to Oakland:

1) Our computational facilities have greatly improved in the last three years; we were awarded a Major Research Instrumentation (MRI) grant from the National Science Foundation, which added more than $200,000 in equipment to the current facilities (already worth around $150,000).

2) The number of international faculty in the department, all having strong links in their countries of origin, provides an additional source of qualified students the program can count on. Our researchers span multiple collaborations in Europe, Asia, Latin America, and Canada, besides strong collaborations with many important research centers in the US. These links will be heavily exploited through direct advertisement of the new program.

3) As already mentioned above, the concentration of the program in Computational and Applied Physics, with emphasis in Materials Science, will make the task of recruiting students easier. One of the focuses of research, nanotechnology, given the current push for investment in this area and its prospects for becoming an important part of the high-tech economy (not only in Michigan but around the world) will enhance the appeal of the program.

8. Unique Features of the Program

The program is unique for several reasons. First, the emphasis on applied and computational physics rather than a broad emphasis on all of physics makes the program different than other programs in the state. Second, the Department of Physics is different than most other departments because of its research accomplishments, both in scholarship and in external funding. For example, the department has four of OU's Distinguished Professors (Chopp, Slavin, Srinivasin, Xia).

9. Budget Narrative

The Ph.D. program in Applied and Computational Physics plans to begin in the fall term of 2019. We anticipate beginning with 4 full time students and growing gradually to 15 in years four and five of the program. This should require six graduate assistantships (TA positions), three of them are required starting from year one, another three are required starting from year two. Every graduate student will have a TA position for the first two years of his/her graduate studies. After that a student will be supported from the external grants of his/her research advisor.

We have not included expenditures for clerical support, supplies and services and telephone; they will be provided by the Department. Library subscriptions are included in the budget. We expect the proposed graduate program to have a substantial impact on the department's undergraduate program. A department with active graduate program in applied and computational physics is much more attractive for undergraduate students. We intend to administer the graduate program in ways consistent with the department's overall commitment to both its undergraduate and graduate curriculum.

Increase in external funding

We anticipate that the new graduate program will substantially increase the research productivity of faculty members and therefore lead to the increase in external funding, obtained by faculty members of the Department of Physics. Currently, every faculty member obtains on the average more than $150,000 per year. Although, some faculty members (associated with the Medical Physics program) can have graduate students, working on topics in Medical Physics, most of the faculty members do not have an opportunity to mentor graduate students. It is expected that every graduate student will lead to 10-15% increase in external research funding of his advisor. To be conservative, we do not include this increase in funding in the budget, but we do believe our estimate is reasonable.

Appendix I: Faculty Qualifications

The Department of Physics has always been committed to excellence in teaching, research, and service. Many times our searches for new faculty positions resulted in our first choice accepting the position. All full-time faculty members (and one of our part-time instructors) have earned Ph.D. degrees. The faculty members in applied physics have expertise in multiferroics, sensors, and microwave devices, magnetoelectric composites, nonlinear dynamics (including magnetic properties of materials, spin waves), amorphous magnetic oxides, thin film production techniques, properties of alloys, Raman spectroscopy, lasers, high pressure experimental techniques, and the properties of semiconductors and fullerenes. The research in these areas has been highly successful. The expertise and research of the faculty in applied physics has many industrial applications and will be essential for the new program. The faculty in computational physics have expertise in relativity and astrophysics, computational condensed matter physics (including electron transport at low temperatures and quantum fluctuations, numerical methods applied to strongly correlated electrons), nonequilibrium statistical mechanics, phase separation and pattern formation (including spinodal decomposition, Ostwald ripening, eutectic solidification, order/disorder transitions and amorphous/crystal transitions, thermal convection in classical and granular fluids, flame front propagation explosive crystallization, instabilities and phase separation in classical and granular fluids).

The Medical Physics faculty are presently running a very successful Ph.D. program. Their guidance will be essential for the success of the Applied and Computational Physics Ph.D. program. The Medical Physics faculty will also be involved in teaching several of the experimental and computational methods courses needed in the new program. In addition, some research techniques presently used by the Medical Physics faculty (for example, NMR imaging or agent-based discrete simulations) have applications both to Medical Physics and to the study of the properties of materials. Therefore, it is expected that some Medical Physics faculty will also do research and supervise student research in the framework of the new program.

Some of the departmental strengths, as demonstrated by the faculty research areas, are highlighted in **Appendix I**. In addition to publishing papers (faculty members published 75 papers in scientific refereed journals during the 2017-2018 academic year), Department of Physics faculty members are involved in many other scholarly activities. During the 2017-2018 academic year, 90 presentations at national and international meetings, as well as government and commercial laboratories, and major universities all over the world, were given by our faculty. Most of our faculty now hold research grants from external agencies, such as federal funding agencies (NSF, NIH, DOE, etc.), non-profit agencies (Research Corporation, Petroleum Research Fund, etc.) or private industry. During the 2017-2018 academic year, the faculty received over $ 360.000 of new external grants. Faculty members review grant proposals for NSF, NIH and other funding agencies. They also serve on the editorial boards and reviewer panels of many international journals. Department faculty have organized conferences and chaired sessions at international conferences.

Ilias Cholis
Assistant Professor
B.S., National Technical University of Athens, Greece (2004)
Ph.D., New York University, New York (2010)
Research Fields

- Dark matter phenomenology
- Theoretical High Energy Astrophysics

Current Research Interests
Dr. Cholis joined OU in 2018 after postdocs at Fermi national Accelerator laboratory and Johns Hopkins University. Already he has over 50 publications in astrophysics. He is a world expert on cosmic ray and gamma ray astrophysics, with an emphasis on astrophysical evidence for dark matter annihilation. He has also studied gravitational wave astrophysics, and in particular the investigation of black holes as a dark matter candidate.

Michael Chopp
Distinguished Professor
B.S., Brooklyn College, New York (1967)
Ph.D., New York University, New York (1975)
Research Fields

- Development and treatment of stroke
- Applications of MRI in biomedical areas

Current Research Interests
Dr. Chopp has continued his leadership of an outstanding research group at Henry Ford Hospital (HFH). An internationally recognized expert in the development and treatment of stroke, Dr. Chopp was one of a small international group of scientists invited by the World Health Organization to Geneva to discuss how best to study and treat this disease. In support of his research, Dr. Chopp received major grants from the NIH to HFH. A significant fraction of OU graduate students work in his laboratory. The focus of Dr. Chopp's research is the development of treatments for stroke. His goal is to salvage affected brain tissue. He and his group have recently identified novel death pathways of brain cells after stroke. After the onset of a stroke, brain cells undergo self-destruction, a form of programmed cell death. This suicidal process is programmed by genetic alterations. They have identified proteins and genes responsible for the promotion of this form of cell death. With this knowledge, they may be able to intervene to inhibit this process. Dr. Chopp and his group have recently identified methods to induce the production of new brain cells. This discovery may yield important therapeutic benefits for a range of neurological injuries and degenerative diseases. They also found that after a stroke secondary events contribute to the increase of dead tissue. A major contributing factor to this secondary injury is the influx of white blood cells into the region of damage. They have identified the signaling molecules that target these cells to the site of injury and have blocked the function of these molecules. Using this therapeutic approach the amount of injured brain tissue is decreased by a factor of two and significantly reduced damage from stroke.

Ken Elder
Professor
B.Sc., University of Guelph (1984)
Ph.D., University of Toronto (1989)
Research Fields

- Non-Equilibrium Statistical Mechanics
- Phase Separation and Pattern Formation
- Computational Condensed Matter Physics

Current Research Interests
The research of Dr. Elder is devoted to understanding the complex structures or patterns that emerge in non-equilibrium phenomena. Such patterns are ubiquitous in nature, from double helix structures in DNA to the beautiful array of snowflake shapes. More importantly these patterns often control key material properties and biological functions. Unlocking the enormous potential of such structures lies in the ability to make efficient predictions. Unfortunately, this task is complicated by the complexity of interactions between various system components. For this reason computational modeling has proved to be an invaluable tool. The bulk of Dr. Elder's research has been devoted to the development of methods to model non-equilibrium phenomena in materials physics. This research has included studies of spinodal decomposition, Ostwald ripening, eutectic solidification, order/disorder transitions and amorphous/crystal transitions, Rayleigh-Benard convection, flame front propagation explosive crystallization, the decay of supercurrents in superconducting rings, the motion of charge density waves, the absorption of liquids by random media (or imbibition) and phase separation in fluids.

More recently Dr. Elder has worked on the development a phase field model method that resolves microscopic length scales on mesoscopic times scales. This differs from traditional atomic or molecular dynamics (MD) approaches that are limited by the atomic time (femtoseconds) and length (nanometers) scales. It also differs from standard phase field methods that describe mesoscopic scales which cannot describe microscopic details and are often limited to overly simplified descriptions. The advantage of this new 'phase field crystal' method is that it naturally incorporates the physics contained at the microscopic level on time scales many orders of magnitude larger than traditional atomic methods. It is not twice or ten times faster than conventional MD (this level of speed can be achieved by incremental improvements in computational power and algorithms) but can be millions or billions times faster. Dr. Elder and collaborators have used this method to conduct large scale numerical simulations of a variety of technologically important processes or phenomena including, epitaxial growth, the strength of nano-crystalline materials, spinodal age hardening and dislocation climb, glide and annihilation.

David Garfinkle
Professor
B.A., Princeton University (1980)
Ph.D., University of Chicago (1985)
Research Fields

- General Relativity

Current Research Interests
Dr. Garfinkle's current research focuses on the properties of singularities in general relativity. Singularities are states of infinite density and infinite tidal force. They occur when a star collapses to form a black hole or at the big bang at the beginning of the universe. Mathematical results due to Hawking, Penrose and others tell us that singularities occur under a wide variety of circumstances. However, these results tell us very little about the nature of these singularities. Since gravitational collapse is described by Einstein's field equations of general relativity, in principle the properties of singularities can be found by examining the properties of solutions of Einstein's equations. In practice Einstein's equations are too complicated to solve, except in very simple cases. However, with modern high speed simulations of Einstein's equations. Dr. Garfinkle's projects involve using simulations of this sort to work out the properties of singularities. In particular Dr. Garfinkle is involved in three main projects: (i) scaling in gravitational collapse, (ii) properties of the generic singularity and (iii) collapse of gravity waves. Project (i) involves the collapse of objects that either do or do not form black holes depending on the initial concentration of energy. Especially interesting is the behavior, discovered by M. Choptuik, of the collapse at or near the critical value of concentration that separates those objects that form black holes from those that do not. These collapses show various scaling properties that Dr. Garfinkle is investigating numerically and attempting to explain. Project (ii), in collaboration with Dr. Berger and others, attempts to find the behavior of objects as the singularity forms. Dr. Garfinkle and his collaborators find indications that this behavior becomes comparatively simple as the singularity is approached. Project (iii) explores the question of whether a naked singularity (one not hidden inside a black hole) can form. The project involves computer simulations of the collapse of gravity waves. Strong enough concentrations of gravity waves should form a singularity, and if a black hole event horizon does not form, then the singularity could be seen by outside observers.

Evgeniy Khain
Associate Professor
B.Sc. in Physics, Hebrew University of Jerusalem, Israel (1995)
M.Sc. in Physics, Hebrew University of Jerusalem, Israel (2000)
Ph.D. in Physics, Hebrew University of Jerusalem, Israel (2005)
Research Fields
- Modeling of collective behavior in biological systems
- Statistical physics far from equilibrium
- Pattern formation and nonlinear dynamics
- Driven granular gases, instabilities in granular flows

Current Research Interests
Biological physics: During the recent years, the newly developing field of biological physics has experienced a tremendous growth. The overall goal of Dr. Khain's research is to identify and describe basic physical mechanisms which govern complex biological processes. He investigates the collective behavior of a large number of living cells. Biological multicellular systems are an exciting example of stochastic non-equilibrium systems. They exhibit numerous physically interesting and biologically important collective phenomena, ranging from wound healing to tumor growth. Dr. Khain's

primary goal is to model the growth of malignant brain tumors, which can not be treated by current therapies. He takes a physical approach, which consists in formulating minimalist models with a small number of parameters, in order to determine the role of basic biological processes, such as cell proliferation, cell motility, cell-cell adhesion, etc., in growth patterns of brain tumors. Dr. Khain investigates these problems using both continuum modeling of basic biological processes on the multi-cellular level (reaction-diffusion equations) and discrete stochastic modeling of cells on a lattice.

Physics of granular matter: Granular materials are ubiquitous in nature and of great importance in industry. Recently, granular matter (matter composed of macroscopic particles interacting dissipatively) attracted significant attention of physicists, since it presents a fascinating example of intrinsically non-equilibrium systems. Fluidized granular media exhibit a variety of symmetry-breaking instabilities and pattern-formation phenomena. The understanding these instabilities is necessary for the development of quantitative models of granular flow, which have various industrial applications. Dr. Khain's research focuses on driven granular gases, as well as on phase separation in a dense shear granular flow. Currently he investigates the challenging problem of rapid dense shear flows. It is known that transport coefficients of hard sphere fluid diverge at the density of dense close packing. However, there is recent evidence that the coefficient of shear viscosity diverges at a lower density than other constitutive relations. This may result in a coexistence of “solid-like” and “fluid-like” layers in dense shear flow, resembling the most intriguing problem of shear-band formation. Dr. Khain investigates these problems employing granular hydrodynamics and comparing the theoretical predictions in a series of molecular dynamics simulations.

Alberto Rojo
Professor
Ph.D. Instituto Balseiro, Bariloche, Argentina (1990)
B.S. Instituto Balseiro, Bariloche, Argentina (1985)
Research Fields

- Electron transport at low temperatures
- Quantum fluctuations

Current Research Interests
Many electron properties in two layer systems: In 1992, together with G. D. Mahan, Dr. Rojo discovered the effect of non-dissipative drag (NDD) on superconductors and mesoscopic systems. He plans to continue this line of research, exploring various applications of this fascinating effect. Dr. Rojo's work in this area has stimulated significant experimental and theoretical activity. NDD results from the coupling of the zero point charge fluctuations between two systems with no tunneling from one to the other. Dr. Rojo has discussed and summarized its current status and its relation with the dissipative current drag in his recent review article. In collaboration with his graduate student Joe Baker he has studied both analytically and by two different numerical methods the effect of disorder on NDD in order to make contact with experiments. A related effect that has bearing on the coupling between non-tunneling systems is the eddy current coupling between a superconductor and a normal, highly conducting system. He is involved in an ongoing collaboration with the experimental group of C. Thomsen and

A. Goñi at the Technische Universität in Berlin, where the effect was observed for the first time in the InSb/GaAs system. The experimental results are in quantitative agreement with Dr. Rojo's theoretical predictions. He is seeking external funding to strengthen the collaboration in which further ramifications of this very interesting and significant effect will be explored.

Squeezing and control of quantum noise: Another project that has been particularly successful since Dr. Rojo's arrival at Michigan was his work on phonon squeezing, a field that falls within his interest in zero point fluctuations. In preliminary calculations he had identified the mechanism of pulses acting on harmonic systems as a means of producing squeezing. For the case of phonons the effect corresponds to a time modulation of the amplitude of the zero point fluctuations in the atomic positions within the solid. Dr. Rojo started collaboration with R. Merlin's group, who measured the effect using ultra fast optical pulses. The experiment constituted the first observation of the squeezing effect in condensed matter, and could have exciting future applications in device physics and in several areas where, in general, a "stroboscopic" control over the quantum noise might be necessary. A very important question to be addressed in the future is: what other excitations can be squeezed in condensed matter, and what are the possible applications? Part of Dr. Rojo's future research effort will be devoted to answering these questions.

Bradley Roth
Professor
B.S., University of Kansas (1982)
Ph.D., Vanderbilt University (1987)
Research Fields
- Biological Physics
- Computational Physics

Current Research Interests
Electrical Stimulation of Cardiac Tissue: Heart disease is the leading cause of death in the United States. Yet, decades of cardiology research has not resolved many questions about the mechanisms of electrical stimulation of cardiac tissue. The goal is to use mathematical modeling and computer simulations to resolve some of these questions. In particular, Dr. Roth studies how the anisotropy of cardiac tissue influences the distribution of transmembrane potential in cardiac tissue during stimulation.

Spiral Waves in the Heart: Many cardiac arrhythmias are thought to be caused by spiral waves of electrical activity. The core, or tip, of such a spiral wave may be stationary, or it may meander through the tissue in a complicated pattern. Dr. Roth is trying to understand how the anisotropy of cardiac tissue influences the pattern of meander. This topic is important, because it may affect how a non-lifethreatening fast heart beat (a ventricular tachycardia) may degrade into lethal ventricular fibrillation.

Andrei Slavin
Distinguished Professor
M.Sc., St.Petersburg Tech Univ, Russia (1974)
Ph.D., St.Petersburg Tech Univ, Russia (1977)
Research Fields

- Linear and nonlinear dynamics of magnetic excitations in magnetic films, multilayers, and finite-size samples: spin waves, solitons, instabilities
- Applications of linear and nonlinear spin waves in microwave signal processing

Current Research Interests
The research interests of Dr. Slavin are in the linear and nonlinear magnetization dynamics in magnetic micro- and nano-structures. He is doing theoretical research on the spectra of microwave spin-wave modes confined in magnetic nano-structures and array of magnetic nano-elements. In particular, he is working on the self-localized nonlinear eigenmodes of magnetic nano-structures and on the linear and nonlinear dynamics of magnetic vortices.

Another important topic of his research is spin-transfer-torque effect in magnetic nano-structures and development of microwave oscillators based on this effect. He is working on the development of a comprehensive theoretical model describing current-induced magnetization dynamics (both deterministic and stochastic) in magnetic nano-pillars and nano-contacts.

Dr. Slavin is also working on parametric nonlinear processes in magnetic films including Bose-Einstein condensation (BEC) of magnons under the influence of parametric pumping at a room temperature and storage and parametrically induced recovery of microwave signals in magnetic films.

Gopalan Srinivasan
Distinguished Professor
M.Sc., Madurai University (India) (1975)
Ph.D., Indian Inst.Tech. (Bombay, India) (1980)
Research Fields

- Thin film magnetism
- Ferromagnetic resonance

Current Research Interests
Dr. Srinivasan is involved in the physics and applications of the magnetoelectric interaction phenomena in multiferroics. Studies are performed on such interactions in ferromagnetic-ferroelectric composites over a wide frequency, from 1 Hz to 110 GHz. The composites are potentially useful for sensors, transducers, miniature antennas and microwave devices. The research is supported by grants from NSF and DoD.

Eugene Surdutovich
Adjunct Assistant Professor
M.Sc. Moscow Institute of Physics and Technology, Moscow, Russia (1989)
Ph.D., Wayne State University, Detroit, Michigan (1998)
Research Fields

- Multi-scale inclusive approach to physics phenomena relevant to proton/ion-beam cancer therapy

Current Research Interests:
Dr. Surdutovich's research interests lie in the field of proton- and ion-beam therapies, which are becoming more and more accepted treatments for malignant tumors. Protons and ions are more advantageous projectiles than the now common photons because they may cause less damage to the regions surrounding tumors and thus induce fewer side effects. This is especially important if the side effects are crucial for the patient's quality of life. As a physicist, Dr. Surdutovich is interested in developing a multiscale inclusive approach that would allow a thorough calculation of the efficiency of DNA damage in proton/ion-beam cancer therapy. This method is based on the analysis of different physical, chemical and biochemical phenomena that take place during irradiation by ions. Each phenomenon determines pertinent distances, times, and energies and contribute to the inclusive model of the therapy. This will eventually lead to rigorous calculation of beam energies, dosages, energy deposition rate, and other characteristics of proton/ion-beam therapy.

Yuejian Wang
Associate Professor
Ph. D. in Physics, Texas Christian University (TCU), USA (2006)
M. Sc. in Physics, Stephen F. Austin State University (SFASU), Texas, USA (2002)
B. Sc. in Engineering Physics, Tsinghua University, Beijing, China (1996)
Research Fields

- High Pressure Physics
- Optics
- Material Physics

Current Research Interests:
Dr. Wang studies a material's optical properties, elasticity, plasticity, phase stability, and chemical reactivity, and also the microstructure evolution of defects, grain size, and grain boundaries. He makes new materials under pressure conditions tunable over a range of more than six orders of magnitude from ambient to the pressure of over 1 million atmospheres.

Yang Xia
Distinguished Professor
M.Sc., Massey University, New Zealand (1989)
Ph.D., Massey University, New Zealand (1992)
Research Fields

- NMR microscopic imaging (µMRI)
- Polarized light microscopy (PLM)
- Fourier-transform infrared imaging (FTIRI)
- Detection of osteoarthritis at its early stages
- Applications of micro-imaging in biomedical areas

Current Research Interests:
Quantitative Microscopic Imaging of Biological Tissues: Dr. Xia's major research effort has been concentrated on multidisciplinary microscopic imaging study of articular

cartilage. Osteoarthritis is a common disease affecting 33% of the US population (CDC Report, Oct 24, 2002); and cartilage degradation is an early event that occurs in this disease. Microscopic imaging may offer a way to provide early diagnosis of this disease. His cartilage research, continuously supported by the National Institutes of Health (NIH) since January 1999, is currently funded by an R01 grant from NIH.

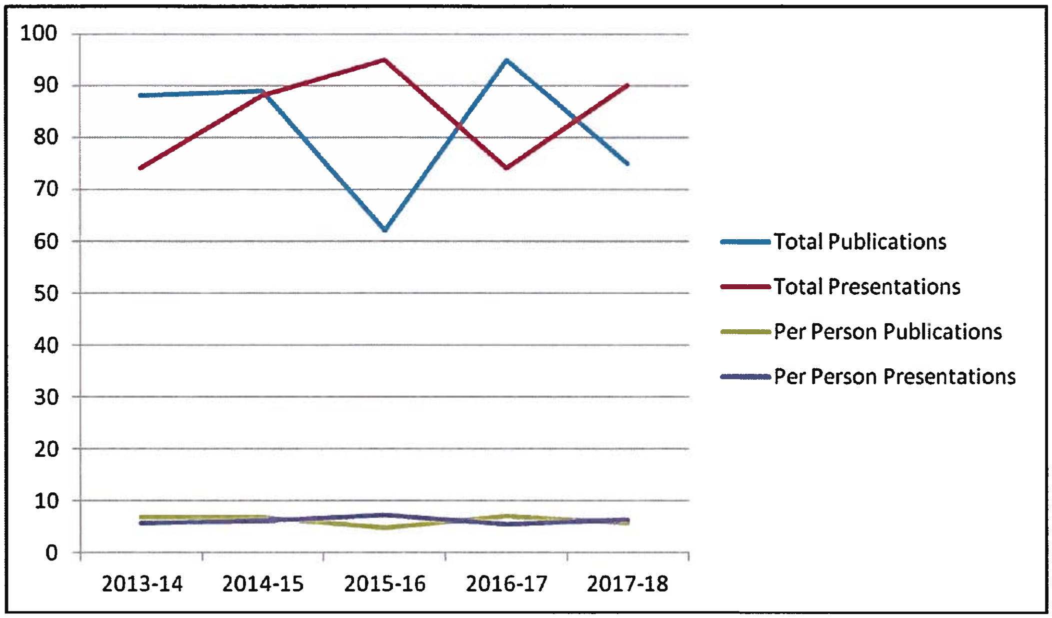
Wei Zhang
Assistant Professor
B.S. Peking University (2008)
Ph.D. University of Seattle (2013)
Research Fields

- Magnetism
- Spintronics
- Nanoscience

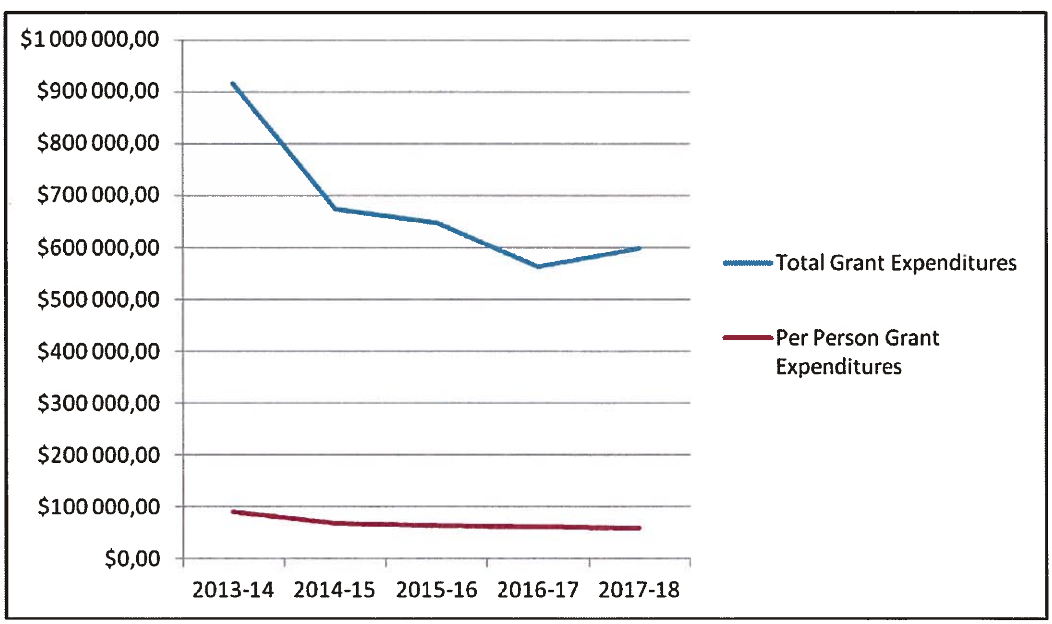
Current Research Interests
Zhang's research topics explore a broad range of magnetism and spintronics phenomena. The research examines the properties of quantum-mechanical effects of electron spins such as their novel magnetic textures and spin-orbit effects, rather than conventional electron charge, to seek potential optimization of low-power, high-capability electronics devices. Recent focus has been on spin-orbitronics, spin-caloritronics, and magnomics. He explores the synthesis and characterization of novel magnetic heterostructures of metals, oxides, and two-dimensional materials at their nanoscale, and investigates their applications in energy-efficient electronic devices.

Appendix II: Faculty Research Productivity and External Funding

Research Productivity, 2013-2018



Total External Grant Expenditures, 2013-2018



ATTACHMENT B

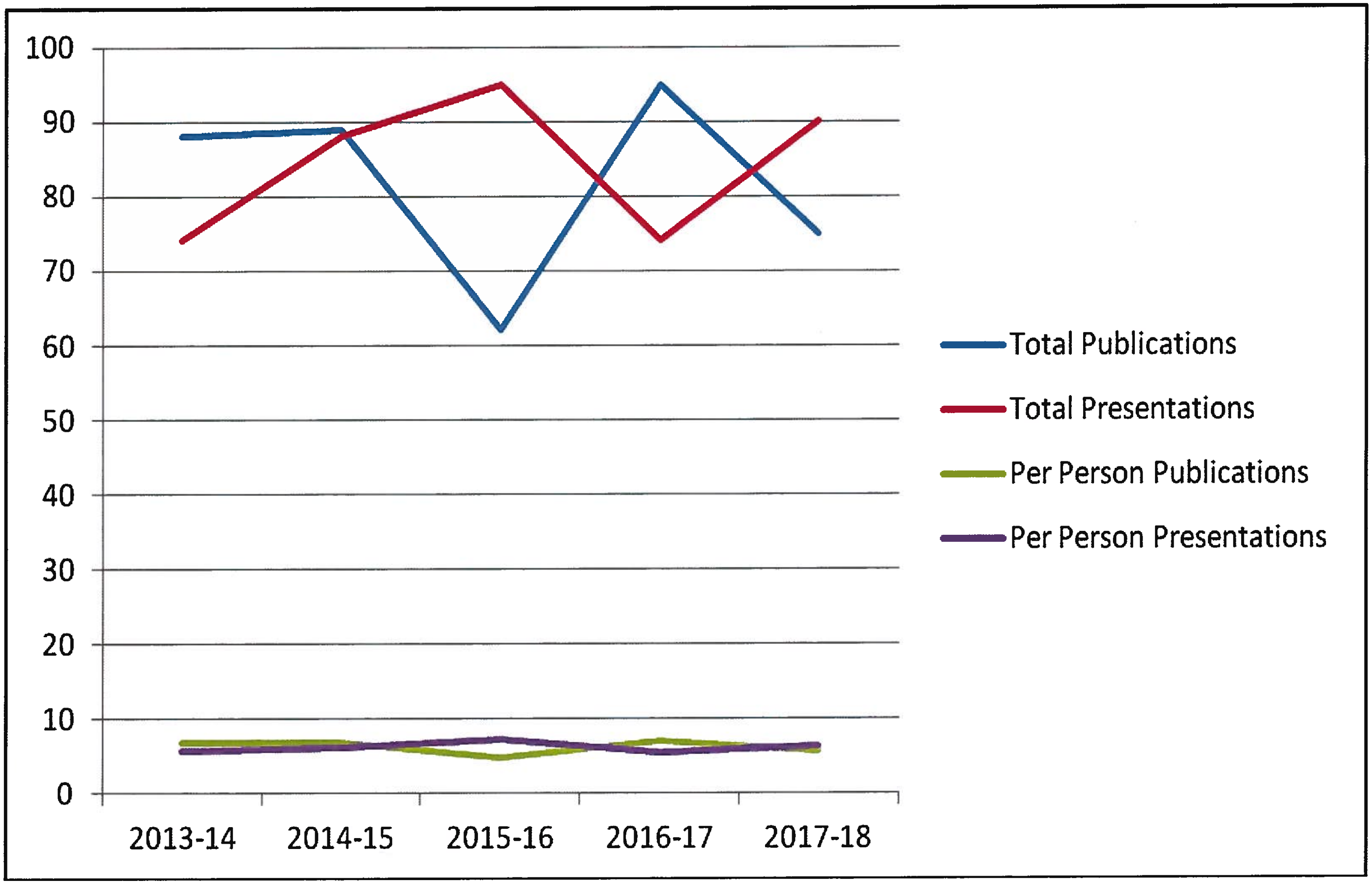
College of Arts and Sciences
Program: PhD Applied and Computational Physics
Program Inception: Fall 2019
Five-Year Budget: FY20 - FY24
Fund: TBD
Date: October 24, 2018

		Budget Year 1	Budget Year 2	Budget Year 3	Budget Year 4	Budget Year 5
Revenue Variables:						
Headcount		**4**	**7**	**10**	**14**	**15**
Average credits per year per major		**24**	**24**	**24**	**24**	**24**
Total Credit Hours		**96**	**168**	**240**	**336**	**360**
Undergraduate (lower)		0	0	0	0	0
Undergraduate (upper)		0	0	0	0	0
Graduate		96	168	240	336	360
Total FYES		**6.00**	**10.50**	**15.00**	**21.00**	**22.50**
Undergraduate (cr.÷30)		0.00	0.00	0.00	0.00	0.00
Graduate (cr.÷24)		0.00	0.00	0.00	0.00	0.00
Doctoral (cr.÷16)		6.00	10.50	15.00	21.00	22.50
Tuition Rate Per Credit Hour						
Undergraduate (lower)		$ 429.75	$ 429.75	$ 429.75	$ 429.75	$ 429.75
Undergraduate (upper)		$ 498.00	$ 498.00	$ 498.00	$ 498.00	$ 498.00
Graduate		$ 738.00	$ 738.00	$ 738.00	$ 738.00	$ 738.00
Revenue						
Tuition		$ 70,848	$ 123,984	$ 177,120	$ 247,968	$ 265,680
Other		$ -	$ -	$ -	$ -	$ -
Total Revenue		$ 70,848	$ 123,984	$ 177,120	$ 247,968	$ 265,680
Compensation						
Salaries/Wages						
Faculty Inload Replacements	6301	$ -	$ -	$ -	$ -	$ -
Faculty Salaries	6101	$ -	$ -	$ -	$ -	$ -
Faculty Overload	6301	$ 15,000	$ 15,000	$ 15,000	$ 15,000	$ 15,000
Part-time Faculty	6301	$ -	$ -	$ -	$ -	$ -
Visiting Faculty	6101	$ -	$ -	$ -	$ -	$ -
Administrative	6201	$ -	$ -	$ -	$ -	$ -
Administrative - IC	6221	$ -	$ -	$ -	$ -	$ -
Clerical	6211	$ -	$ -	$ -	$ -	$ -
Student	6501	$ -	$ -	$ -	$ -	$ -
Graduate Assistantship Stipend	6311	$ 42,000	$ 84,000	$ 84,000	$ 84,000	$ 84,000
Out of Classification	6401	$ -	$ -	$ -	$ -	$ -
Overtime	6401	$ -	$ -	$ -	$ -	$ -
Total Salaries/Wages		$ 57,000	$ 99,000	$ 99,000	$ 99,000	$ 99,000
Fringe Benefits	6701	$ 1,200	$ 1,200	$ 1,200	$ 1,200	$ 1,200
Total Compensation		**$ 58,200**	**$ 100,200**	**$ 100,200**	**$ 100,200**	**$ 100,200**
Operating Expenses						
Supplies and Services	7101	$ -	$ -	$ -	$ -	$ -
Graduate Assistant Tuition	7726	$ 53,136	$ 106,272	$ 106,272	$ 106,272	$ 106,272
Travel	7201	$ -	$ -	$ -	$ -	$ -
Telephone	7301	$ -	$ -	$ -	$ -	$ -
Equipment	7501	$ -	$ -	$ -	$ -	$ -
Library	7401	$ 23,168	$ 24,677	$ 26,296	$ 28,035	$ 29,901
Lab Startup	7101	$ -	$ -	$ -	$ -	$ -
One Time Investment/Program Startup Cost		$ -	$ -	$ -	$ -	$ -
Total Operating Expenses		**$ 76,304**	**$ 130,949**	**$ 132,568**	**$ 134,307**	**$ 136,173**
Total Expenses		$ 134,504	$ 231,149	$ 232,768	$ 234,507	$ 236,373
Net		$ (63,656)	$ (107,165)	$ (55,648)	$ 13,461	$ 29,307

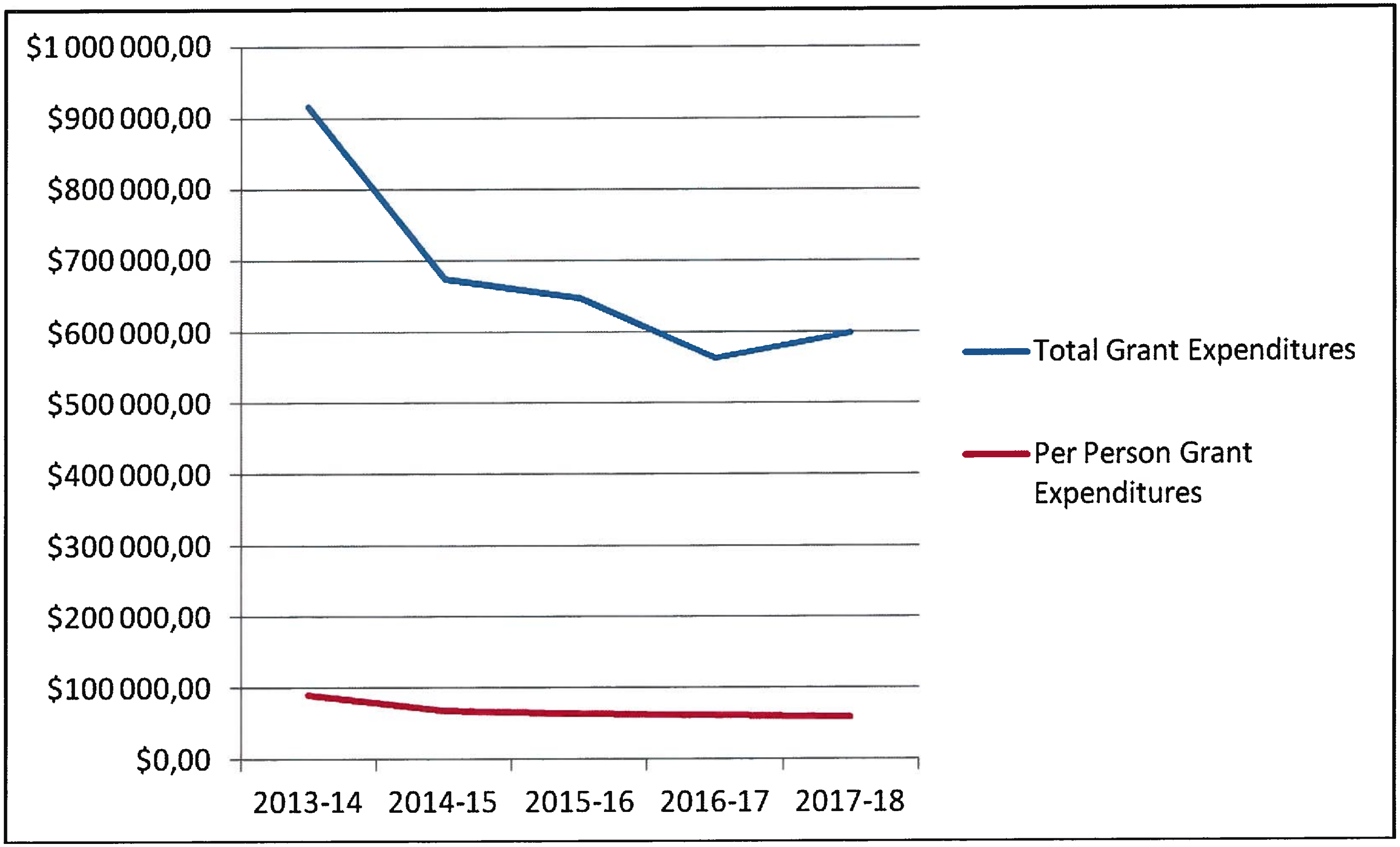
Ph.D. program in
Applied and Computational Physics

Department of Physics
Oakland University

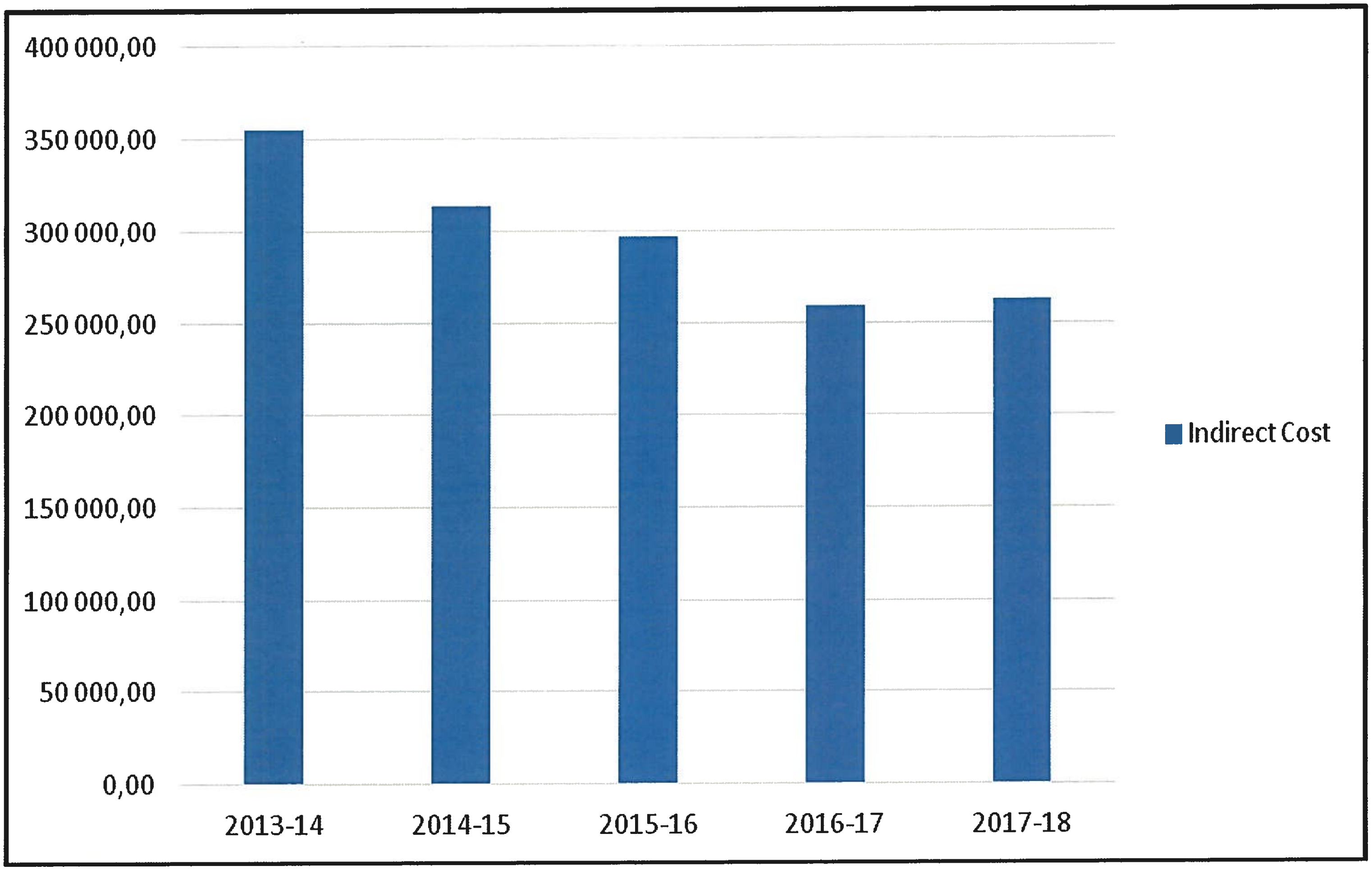
Research Productivity (2013-2018)



External Grant Expenditures of the OU Physics (2013-18)



Indirect costs of the OU Physics (2013-18)



Research Productivity of the OU Physics (2017-18)

Faculty	External Grant Expenditures	Indirect Cost	# of Publications	# of Presentations
Chopp			15	9
Elder	40,510.81	20,255.43	7	4
Garfinkle	32,995.72	16,332.89	5	7
Khain			1	3
Rojo			1	12
Roth	52,709.15	12,977.17	2	3
Slavin	79,102.55	39,362.21	11	27
Srinivasan	52,677.05	26,074.59	12	5
Surdutovich-adjunct prof.			3	2
Tyberkevych-research prof.	124,921.99	62,461.01	7	4
Wang – on sabbatical WI18	3,013.82		2	1
Xia	211,287.59	85,215.01	6	9
Zhang	875.20		3	3
Totals	**$598,093.88**	**$262,678.31**	**75**	**90**

Existing PhD Program in Medical Physics (established 1983)

44 PhDs awarded

16 current students

Research performed at: OU, Beaumont and Henry Ford Hospitals

Outstanding Dissertation Awards:

2011 Ben Buller
2010 Kishor Karki
2007 Deborah Janks

1st OU graduate James Mattiello is a co-inventor of MRI Diffusion Tensor Imaging

Faculty

Mike Chopp – Distinguished Professor, **h-index=86**
Fellow of AHA

Yang Xia – Leader in NIH funding at OU

Brad Roth – Director, Biomedical Research Center,
Fellow of APS

Evgeniy Khain – KITP Scholar

Eugene Surdutovich – Expert in Proton Therapy

Adjunct faculty at Beaumont and HF Hospitals

PhD Program in Applied and Computational Physics

Applied

Andrei Slavin
Professor, h-index =60
Fellow of the APS and IEEE
OU Distinguished Professor

Gopalan Srinivasan
Professor, h-index =53
OU Distinguished Professor

Vasyl Tyberkevych
Research Associate Professor,
h-index = 45

Wei Zhang
Assistant Professor, h-index =24

Yuejian Wang
Associate Professor, h-index =18

Computational

David Garfinkle
Professor, h-index =24
Fellow of the APS

Ken Elder
Professor, h-index =53

Alberto Rojo
Professor, h-index =20

Ilias Cholis
Assistant Professor, h-index=31

Curriculum for the new PhD Program (48 credits)

7 core courses (26 credits) +
Research seminar (2 credits)

Applied Physics Program

One required core course for Applied Physics (4 credits)

2 electives, chosen from the list for **Applied Physics** program (8 credits)

2 free electives (8 credits)

Computational Physics Program

One required core course for Computational Physics (4 credits)

2 electives, chosen from the list for **Computational Physics** program (8 credits)

2 free electives (8 credits)

Tentative budget of the new PhD Program

Headcount		4	7	10	14	15
Tuition		$ 70 848	$ 123 984	$ 177 120	$ 247 968	$ 265 680
Total Revenue		$ 70 848	$ 123 984	$ 177 120	$ 247 968	$ 265 680
Faculty Inload Replacements	6301	$ -	$ -	$ -	$ -	$ -
Faculty Salaries	6101	$ -	$ -	$ -	$ -	$ -
Faculty Overload	6301	$ 15 000	$ 15 000	$ 15 000	$ 15 000	$ 15 000
Student	6501	$ -	$ -	$ -	$ -	$ -
Graduate Assistantship Stipend	6311	$ 42 000	$ 84 000	$ 84 000	$ 84 000	$ 84 000
Out of Classification	6401	$ -	$ -	$ -	$ -	$ -
Overtime	6401	$ -	$ -	$ -	$ -	$ -
Total Salaries/Wages		$ 57 000	$ 99 000	$ 99 000	$ 99 000	$ 99 000
Fringe Benefits	6701	$ 1 200	$ 1 200	$ 1 200	$ 1 200	$ 1 200
Total Compensation		**$ 58 200**	**$ 100 200**	**$ 100 200**	**$ 100 200**	**$ 100 200**
Supplies and Services	7101	$ -	$ -	$ -	$ -	$ -
Graduate Assistant Tuition	7726	$ 53 136	$ 106 272	$ 106 272	$ 106 272	$ 106 272
Travel	7201	$ -	$ -	$ -	$ -	$ -
Library	7401	$ 23 168	$ 24 677	$ 26 296	$ 28 035	$ 29 901
Total Operating Expenses		**$ 76 304**	**$ 130 949**	**$ 132 568**	**$ 134 307**	**$ 136 173**
Total Expenses		$ 134 504	$ 231 149	$ 232 768	$ 234 507	$ 236 373
Net		$ (63 656)	$ (107 165)	$ (55 648)	$ 13 461	$ 29 307

External letters of support

Argonne NATIONAL LABORATORY

Valentine Novosad, PhD
Senior Materials Scientist
Magnetic Films Group, Materials Science Division
Medium Energy Physics Group, Physics Division
Argonne National Laboratory
9700 South Cass Avenue
Energy Sciences Building
Argonne, IL 60439

1-630-123-5507 (ph)
1-630-123-7777 (fax)
novosad@anl.gov

September 24, 2018

Andrei N. Slavin
Professor and Chair
Department of Physics
Oakland University
Rochester, MI-48309

Re: Ph.D. Program in Applied and Computational Physics

Dear Prof. Andrei N. Slavin,

It is my pleasure to endorse a new Ph.D. Program (in Applied and Computational Physics) at the Physics Department of the Oakland University.

Today's scientist must be prepared to deal with a rapid evolution of technological concepts, a highly interconnected world, and complex problems that require interdisciplinary approaches to advance fundamental science or to address pressing needs of modern society. The proposed Ph.D. Program with unique cross-cutting options will provide students with the means to integrate and synthesize disciplinary depth with breadth of interests, visions, and skills for successful interdisciplinary research careers in industry or academia. The Faculty members at the Physics Department of the Oakland University are world-class scientists. Among the 11 tenured and tenure-track professors at Oakland four are the Fellows of the American Physical Society and one is also a Fellow of the IEEE. Recently Oakland has hired a very talented former employee of Argonne – Prof. Wei Zhang - who made the experimental program at Oakland even stronger.

The Physics Faculty at Oakland pursue high-quality research projects funded by major federal agencies, including NSF, NIH, US ARMY, DARPA, etc. Thus, PhD students in the new Program, after passing a qualifying examination, could be supported by the research grants of the Physics Faculty. Physics Department at Oakland has an adequate number of experimental laboratories and computational facilities. Interdisciplinary research opportunities exist through participating Faculty from other departments across the Oakland campus. Furthermore, additional training as well as the employment opportunities for the graduates of the proposed PhD Program exist within my home institution, Argonne National Laboratory, one of the U.S. Department of Energy's oldest and largest national laboratories for science and engineering research located just 25 miles southwest of Chicago. Argonne hosts a number of large scientific user facilities are available through peer review process, including Advanced Photon Source, Center for Nanoscale Materials, Electron Microscopy Center and Argonne Leadership Computing Facility.

In conclusion, the proposed PhD program encompasses a balanced interdisciplinary research and educational opportunities for students and faculty. I find this proposal to be very timely, well-planned and targeting achievable goals. Owning to significant accomplishments, professional and personal qualities of the Faculty members, I am convinced that this program will undoubtedly further strengthen already impressive academic and research standings of the Oakland University

Please do not hesitate to contact me if you have any further questions.
Yours truly,

V. Novosad.

Andrei N. Slavin, Chair
Department of Physics
Oakland University
Rochester, MI 48309

February 2, 2012

Dear Dr. Slavin,

The Department of Defense presented the Science, Technology, Engineering and Mathematics (STEM) Education and Outreach Strategic Plan for 2010–2014. The plan lays out our vision to develop a diverse, world-class STEM talent pool for DoD that will also benefit the Nation. DoD has a long history of supporting STEM initiatives at local, regional, and national levels. At military installations and DoD laboratories, our scientists and engineers—military and civilian—support science, mentor our scholarship and fellowship recipients, and partner with science and math educators.

A STEM-literate citizenry is critical if the Nation is to compete more effectively in the global marketplace. The production of foreign STEM talent is growing exponentially, and U.S. institutions of higher education are facing greater competition for talent. Those challenges affect U.S. security interests, domestically and internationally, and they affect DoD's ability to optimize discovery and innovation.

The National Defense Education Act, signed into law in 1958, authorized DoD to increase the flow of talent into science and engineering, fund enrollment into higher education, and enhance public understanding of science and technology. The act came on the heels of the Soviet Union's launch of the Sputnik I satellite and the resulting commitment by the United States to regain dominance over its Cold War adversary in scientific and technological disciplines.

Foreign nations have expanded their educational capabilities to the point that they are surpassing U.S. In 2005 China granted nearly four times as many engineering degrees as the United States. In addition, a comparison of college graduation rates for all fields among the Organization for Economic Co-operation and Development (OECD) member countries showed that the US fell from first place in 1995 to fourteenth in 2007. The bottom line is that other countries are producing many more scientists and engineers than the United States.

Therefore we believe that the development of a new Ph.D. Program in Applied and Computational Physics in the State of Michigan will benefit the progress of advanced technologies and help the automotive and defense industry in creation of next generation advanced automotive and combat vehicle systems.

Given the present need for qualified engineers and scientists, we can only feel encouraged considering the development of such a potentially important resource as Applied and Computational Physics Ph.D. Program.

Sincerely yours,

Ms. Pamela Watts, Dean

TARDEC University