Department of Physics and Astronomy

Self-Study Report 2019-2024

LEHMAN COLLEGE | CUNY

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Introduction

Overview of Lehman College

Lehman College has a unique role among The City University of New York's 25 senior and community colleges and honors, graduate, and professional schools. As the sole comprehensive public four-year college in the Bronx, Lehman serves as an intellectual hub, enriching its community both economically and culturally. Lehman's 14,400(update)- strong student body mirrors the diversity of its surrounding area, representing 92 different nationalities. Recognizing the scale and breadth of ambition in this community, Lehman offers a comprehensive selection of vocationally-oriented educational paths, including 80 major programs and 78 graduate programs in liberal arts and sciences, as well as several professional degrees and certificates.

Lehman College's core mission is to be an economic and cultural catalyst in the Bronx and a national engine for social mobility. This mission is reflected by the students it serves with 59% of undergraduates coming from households with incomes below $30,000, and around three out of five graduates being the first in their families to earn college degrees, with the same proportion born outside the United States. Moreover, around one in every five graduates is a parent. In 2020, Lehman College's dedication to socioeconomic mobility was acknowledged by the Brookings Institution, ranking fourth nationally among four-year universities for its success in propelling low-income students into the middle class. Lehman's contribution to the Bronx is also clear; over half of Lehman's 81,000 alumni remain in the community, contributing to the region as financial analysts, health care professionals, information technology practitioners, social workers, teachers, and elected officials.

In the last decade, Lehman has attained national recognition for exceptional growth. In 2017 the college hosted its largest enrollment since CUNY discontinued offering free admission in 1975, and in 2019, it graduated 3,676 students--its largest class ever. The college's robust growth is also evident in its retention and graduation rates. Since 2017, Lehman College has consistently exceeded the CUNY senior college average in retaining first-time, full-time freshmen by nearly 10%. Notably, the number of STEM students at Lehman has grown largely consistently, and at times at the highest rate across the entire City University of New York system, demonstrating a sustained interest and engagement in science, technology, engineering, and mathematics fields over time.

Lehman College and its faculty are committed to providing the education that students need to thrive in the constantly evolving twenty-first century workplace, and to facilitate their growth as participants and leaders in their communities—from local to global.

Overview of the Department of Physics and Astronomy

The Department of Physics and Astronomy is one of the 10 departments in the School of Natural and Social Sciences. We are comprised of seven full-time faculty members—one Distinguished Professor (Eugene Chudnovsky), five Full Professors (Luis Anchordoqui, Dmitry Garanin, Christopher Gerry, Daniel Kabat, Dimitra Karabali), and one Associate Professor (Matt O'Dowd), as well as one full-time staff member our administrative assistant Jamilah Majekodunmi. We currently employ on full-time sub-lines an Assistant Professor

(Giorgos Vernardos) and a Chief Lab Technician (Saaber Snoyeb). The Department

research staff also includes four postdoctoral research fellows and six graduate students. In addition, the Department employs several teaching adjuncts each semester.

The faculty in the Department of Physics and Astronomy are all active researchers who have made significant contributions to their various fields. Department members conduct major research programs in the areas of condensed matter physics, high-energy physics, quantum optics, and astrophysics. These programs are supported by major grants from the National Science Foundation, the U.S. Department of Energy, NASA, Schmidt Futures, and other federal and private sources.

Equal to our commitment to research excellence, the faculty of the Department of Physics and Astronomy are dedicated to our role as educators. We offer two degrees for majors in physics: a 38-credit B.A. degree and a 60-credit B.S. degree. These provide a solid foundation for a wide range of careers such as industrial research and development, engineering, computing, business management, consulting, medicine, law, research and teaching in physics and related sciences. The Department also offers a minor in physics and administers the Pre-Engineering program and offers a variety of basic courses designed for general education and for students in other departments. The Department works with the Department of Middle and High School Education and the School of Earth Sciences in preparing students and teachers for teaching physics and astronomy in secondary schools.

A core part of our mission is to enable undergraduate research. Physics majors and minors are encouraged to take advantage of the undergraduate research opportunities offered by our department.

Lehman College Mission, Vision and Goals

Lehman 2025, Lehman College's 2020-2025 strategic plan, lays out the current mission, vision, and goals of the College as follows:

Mission: Lehman College, an urban public institution and economic and cultural catalyst in the Bronx, is a national engine for social mobility and a vibrant center of discovery and creative work, providing a transformative educational experience while advancing equity, inclusion, and social justice.

Vision: Lehman College will be a nationally recognized leader in educational attainment and the expansion of knowledge through innovative curriculum and pedagogy, original research and scholarship, and enhanced digital solutions. The College will be a model of engaged citizenship and a leading force for a more just and sustainable world.

College Goals

The strategic plan seeks to realize the Mission and Vision of Lehman College through four broad goals, each with detailed objectives:

Goal 1: Educate, Empower, and Engage Students to Participate in a Global Society and Enhance Career Advancement.

1. Make substantial progress toward achieving the 90x30 challenge.
2. Engage in curricular renewal efforts to strengthen existing undergraduate and graduate academic programs and create new degree, certificate and related programs to meet the needs of current and future students and the workforce.

3. Provide a transformative educational experience that emphasizes experiential learning and high impact practices for all undergraduate and graduate students, prepares graduates to meet the challenges of the 21st century, enhances digital equity, and reflects the Characteristics of a Lehman Graduate.

Goal 2: Enhance Faculty and Staff Success.

1. Recruit, hire, develop, and retain outstanding faculty and staff committed to educational excellence, access, and equity that also model a culture of inclusive excellence.
2. Expand investment in excellence in research, scholarship, creative works, administrative and support services, and professional development.
3. Achieve recognition as a leader in innovative pedagogy and the adoption of evidence-based practices.
4. Build upon areas of cross-disciplinary strength to create pillars of outstanding achievement in research, scholarship, and creative work.

Goal 3: Sustain Growth, Vitality and Institutional Effectiveness.

1. Increase digital equity, optimize campus facilities, technologies, and related infrastructure.
2. Increase Lehman's financial foundation and flexibility through the growth of existing sources of revenue and by developing new revenue streams.
3. Enhance the College's institutional effectiveness and the success of compliance programs.

Goal 4: Embrace the Spirit of Community Engagement.

1. Advance the ideals of the College's namesake, Herbert H. Lehman, a champion for social justice, through research, scholarship and pedagogy that promotes the body of knowledge about social justice issues and expands Lehman's impact as a catalyst for intellectual, cultural, and economic growth in the region and beyond.
2. Increase the sense of community and connection to Lehman College among faculty, staff, students and alumni.
3. Increase impact on the Bronx community and the New York City region more broadly through educational, cultural and service opportunities.
4. Sustainability: Increase sustainable practices to reduce our carbon footprint, promoting environmental justice and supporting the climate goals of New York City and New York State.

Institutional Learning Goals

Lehman College's *Institutional Learning Goals* expand on Goal 1 in particular, with detailed strategies towards ensuring Lehman graduates are to a high level *educated*, *empowered*, and *engaged*. The descriptions and subgoals of these categories are:

1. Educated: Independent thinkers, who actively and skillfully cultivate the capacity to conceptualize, analyze, evaluate, synthesize and communicate.

a. Utilize critical thinking skills.
b. Demonstrate competence within at least one discipline.
c. Demonstrate skills in quantitative reasoning, information literacy, and research.

2. Empowered: Confident thinkers, who recognize the power of informed inquiry to solving

problems.

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a. Demonstrate outstanding communication skills in diverse media

3. Engaged: Citizens, who contribute to their local, national and global communities using reason, integrity, empathy, accuracy, humility, and civility.

a. Demonstrate multicultural, global and ethical awareness of diverse peoples and communities.
b. Demonstrate the ability to work collaboratively as part of a team.
c. Demonstrate the potential for leadership.

Department of Physics and Astronomy Mission and Goals

The mission of the Department of Physics and Astronomy can be summarized as follows:

To educate and inspire through physics. Whether from a single course or a full degree, physics offers its students important skills in quantitative reasoning and problem solving that are useful in any profession. We provide a complete program of courses in physics and astronomy at multiple levels, from introductory to graduate. These include several very popular Pathways offerings, multiple prerequisites for other majors and pre-med tracks, and of course a full curriculum for majors intending to pursue graduate school in physics.

To serve our students. We understand that the students of Lehman College have a great range of backgrounds, interests, and goals. To serve Lehman's unique level of diversity, we are committed to offering a comprehensive course catalog and to teaching to a wide range of levels of preparedness. We also believe that direct experience with research is essential for students wishing to enter scientific fields, and so are committed to granting research opportunities to all interested students.

To advance knowledge. We believe that a University is a vehicle for both education and discovery. In service of the latter, we are committed to maintaining active, world-class research programs that contribute to the advance of physics and astronomy. We achieve this through: 1) active grantsmanship, 2) regular publication of our work in top journals, 3) fostering local and international collaborations, 4)participating at a high level in the national and global scientific enterprise and discourse.

To support Lehman College. The Department of Physics and Astronomy is proud to support the operation of Lehman College through active participation in a wide range of committees and College programs. We also serve multiple Lehman departments by offering essential physics courses as prerequisites to their programs. Finally, we seek to raise the profile of Lehman College by actively advertising the College in our many activities.

To support our community. We are committed to supporting our local, national, and global communities through vigorous outreach programs that include popular science talks and other public events, from local events at Lehman and other Bronx venues, to national and international public events. We seek to broaden the scope of our outreach through the production of physics education videos and through popular articles in traditional media.

Synergy Between Department and College Goals

The Department of Physics and Astronomy is closely aligned with the Mission, Vision and Goals of Lehman College in many respects. In the following narrative, Mission and Vision

items of particular relevance to the Department are bolded, while Goals are referenced numerically and we link to the relevant section of the following report for more detail.

Over the past five years, our department has graduated 31 majors (Goal 1.1), who are overwhelmingly from underrepresented backgrounds, contributing to Lehman's status as an **engine for social mobility**. While some of our concentration students will go on to graduate school and careers in astrophysics, more will take the skills learned in their degree to a variety of STEM and quantitative fields. As we detail in Student Success and Prospects, our graduates enjoy exceptional job security and the potential for high average salaries.

Our graduates tend to end up in excellent graduate programs or in the workforce where they benefit from the high rate of high employment rates and high average salaries typical of physics graduates. Our efforts to inspire students through physics and astronomy has, for many, been a **transformative educational experience**.

Our commitment to enabling undergraduate research and high quality labs ensures experiential learning, while our focus on teaching rigorous quantitative and evidence-based thinking ensures a vocationally viable education (Goals 1.3, 2.3). This focus on undergraduate research and our participation in the AstroCom NYC mentoring program has also enabled us to build a strong major cohort (Goal 4.2).

As we detail throughout Programs and Curriculum we are committed to providing the education that our student body needs. This has required us developing an **innovative curriculum and pedagogy** (Goal 1.2) to serve the many students who come to us lacking a solid high school preparation in science and math. We discuss this issue in more detail in …

As discussed throughout Research, Faculty and Staff, we strive to be a **vibrant center of discovery** with a strong focus on **original research and scholarship** (Goal 2.2), and an ongoing effort to recruit world-class faculty and postdoctoral researchers (Goal 2.1). Our close connections with many world-class research institutions (described in Institutional Affiliations) is both a consequence and a driver of our research excellence (Goal 2.2) and in several cases enhances our cross-disciplinary strength (Goal 2.4). Our dedication to frontline research is reflected by our substantial success in acquiring major research grants from both standard and novel sources, as discussed in Funding (Goal 3.3).

Finally, some of our faculty are extremely active in outreach (Goal 4.3) and humanitarian activities, through which we strive to be a **force for a more just and sustainable world**.

Summary of Previous Self Study

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Staff and Infrastructure

Faculty and Staff

The Department currently has seven full-time faculty. Each links to a detailed description of our faculties' activities.

Full-Time Faculty

Professor Luis Anchordoqui
Distinguished Professor Eugene Chudnovsky
Professor Dmitry Garanin
Professor Christopher Gerry
Professor Dan Kabat
Professor Dimitra Karabali
Associate Professor Matt O'Dowd

Administrative Staff

Administrative Assistant: Jamilah Majekodunmi
Chief Laboratory Technician (sub-line): Saaber Shoyeb

Research Staff

Assistant Professor (sub-line): Dr. Giorgos Vernardos
Postdoctoral Research Fellow: Dr. Jorge Sorriano
Postdoctoral Research Fellow: Dr. James Chan
Postdoctoral Research Fellow: Dr. Thomas Paul

Current Faculty Roles

Department Chair: Matt O'Dowd
Undergraduate Advisor: Dimitra Karabali
Web Master: Dan Kabat
Senate Representative: Christopher Gerry
Assessment Coordinator: Dmitry Garanin

Space and Facilities

The Department of Physics and Astronomy is based in Lehman College's Gillet Hall, with the following rooms dedicated to Department activity:

GI-131	Department Office
GI-131-A	Chair's Office
GI-132	Faculty Office
GI-134	Faculty Office
GI-135	Modern Physics Lab
GI-136	Faculty Office
GI-139	Faculty Office
GI-229	Faculty Office
GI-235	CLT Office
GI-237	PHY 131/166/168 Labs
GI-329	Faculty Office

GI-335	Postdoc and Adjunct Office

GI-337	PHY 141/167/169 Labs
GI-337-A	Lab Equipment Storage
GI-RTN	Astronomy Lab Storage
GI-RTS	Astronomy Lab Storage

The following spaces are traditionally used by the Department for the bulk of their teaching:

GI-226	Lecture Hall
GI-226-A	Storage, Lecture Demonstration Equipment
GI-331	Upper Level Classroom and Astronomy Labs

The Department also maintains the Lehman Computing Cluster which is housed in the server room in Science Hall.

Programs and Curriculum

The Department of Physics and Astronomy offers two degrees for majors in physics: a 38-credit B.A. degree and a 60-credit B.S. degree. These degrees provide a solid foundation for a wide range of careers such as industrial research and development, engineering, computing, business management, consulting, medicine, law, research and teaching in physics and related sciences. The department also offers a minor in physics, which is an excellent complement to degrees in mathematics, computer science or other sciences.

Physics majors and minors are encouraged to take advantage of the undergraduate research opportunities offered by our department. The Department of Physics and Astronomy has active research programs in the areas of condensed matter physics, high-energy physics, quantum optics, astrophysics and observational astronomy. Undergraduate students who are interested in doing research are welcome to join our research groups. Our faculty's research is supported by grants from the National Science Foundation, the U.S. Department of Energy, and from other federal and private sources.

The Department also administers the Pre-Engineering program and offers a variety of basic courses designed for general education and for students in other departments. The Department cooperates with the Department of Middle and High School Education in preparing students and teachers for teaching physics and astronomy in secondary schools.

60-Credit Major in Physics, B.S.
The B.S. degree program in Physics is designed for students who are planning a career in physics research and/or college/university-level teaching.

PHY 168 - Physics I Scientists and Engineers
PHY 169 - Physics II for Scientists and Engineers
PHY 207 - Mathematics for the Physical Sciences
PHY 241 - Modern Physics
PHY 251 - Modern Physics Laboratory
PHY 301 - Intermediate Electricity and Magnetism
PHY 302 - Intermediate Mechanics
PHY 303 - Thermodynamics and Statistical Mechanics
PHY 400 - Introductory Quantum Mechanics
MAT 175 - Calculus I

MAT 176 - Calculus II

MAT 226 - Vector Calculus

In addition, students must take 6 credits in elective physics or astronomy courses at the 200 level or above, with the option to substitute one 100 level course with the Department's permission. Students must also take 6 credits in elective mathematics courses at the 200 level or above.

Suggested Course Map for B.S. Degree

	Fall	Spring
Year 1	MAT 172 (Precalculus) or MAT 175	MAT 175 (Calculus I) or MAT 176
Year 2	MAT 176 (Calculus II) or MAT 226	MAT 226 (Calculus III)
	PHY 168 (Physics I)	PHY 169 (Physics II) PHY 207 (Math. for Phys. Science)
Year 3	PHY 241 (Modern Physics)	PHY 251 (Modern Physics Lab)
	PHY 301 (Intermediate E&M)	PHY 400 (Quantum Mechanics)
	MAT elective	MAT elective
Year 4	PHY 302 (Intermediate Mechanics)	PHY 303 (Thermo. and Stat. Mech.)
	Physics elective (300 level or above)	Physics elective (300 level or above)
	PHY 489 (Independent Study)	PHY 489 (Independent Study)

38-Credit Major in Physics, B.A.

The B.A. program in Physics is designed for students who, although not planning a career in physics research and/or college/university-level teaching, have a strong interest in physical science, particularly physics, and wish to prepare for a career in which a good basic knowledge of physics is useful. Among such careers are the health professions, elementary and secondary school science teaching, patent-law practice, industrial management, and science journalism.

PHY 168 - Physics I Scientists and Engineers
PHY 169 - Physics II for Scientists and Engineers
PHY 207 - Mathematics for the Physical Sciences
MAT 175 - Calculus I
MAT 176 - Calculus II
MAT 226 - Vector Calculus

In addition, students must take 12 credits in elective physics or astronomy courses at the 200 level or above, with the option to substitute one 100 level course with the Department's permission.

19-Credit Minor in Physics

A minor in Physics consists of either PHY 166 and 167 or PHY 168 and 169, and at least three additional PHY or AST courses at the 200 level or above. With permission from the Chair one of these additional courses may be at the 100 level.

Course Offerings

The Department of Physics and Astronomy offers an extensive suite of courses each semester. Courses offered every semester include our algebra-based introductory physics sequence (PHY 166 & 167), alternating in an “on-sequence” and “off-sequence” cadence, with more sections (2 or 3) offered for the on-sequence course (PHY 166 in the Fall, PHY 167 in the Spring) compared to the off-sequence (1 or 2 sections). We offer sufficient labs to meet the enrollments of these classes (see Physics Labs below).

We also offer our course requirements for other majors every semester—PHY 140 and PHY 151 (see Service to Other Programs below). Additionally, the popular Pathways—Scientific World courses, AST 101 and PHY 131 are offered every semester with rare exceptions. AST 117 is offered most semesters depending on the availability of astronomy lab instructors.

Our level 200+ core major courses are offered in the sequence outlined in the description of the B.S. above, with some flexibility based on the needs of our current major cohort. Elective 200+ courses are also offered according to this sequence, but the choice of elective depends on the interest of our majors and the availability of our faculty. Finally, our independent study course, PHY 489, is offered whenever there is interest from our majors, which is almost every semester (see Undergraduate Research below).

The following table details the courses that were offered by semester over the past five years.

	AST Courses	PHY Courses
Spring 2019	101	131, 140, 151, 166, 167, 169, 207, 303, 400, 489
Summer 2019		140, 167
Fall 2019	101, 117	140, 151, 166, 167, 168, 241, 301, 489
Spring 2020	101	131, 140, 151, 166, 167, 169, 207, 251, 355, 489
Summer 2020		140, 166, 167
Fall 2020	101, 117	131, 140, 151, 166, 167, 168, 302, 307, 489
Spring 2021	101, 117	131, 140, 151, 166, 167, 169, 207, 303, 400, 489
Summer 2021		140, 166, 167
Fall 2021	101, 117	131, 140, 151, 166, 167, 168, 241, 301
Spring 2022	101	131, 140, 151, 166, 167, 169, 207, 251, 355, 489
Summer 2022		140, 166
Fall 2022	101, 117	131, 140, 151, 166, 167, 168, 302, 355, 489
Spring 2023	101	131, 140, 151, 166, 167, 169, 207, 303, 400, 489
Summer 2023		140, 166
Fall 2023	101, 117, 602	131, 140, 151, 166, 167, 168, 241, 301, 355, 489
Spring 2024	101, 117	131, 140, 151, 166, 167, 169, 207, 251, 400, 489

Physics Labs

A critical component of any physics education is a robust laboratory component. Our algebra- and calculus-based introductory physics tracks both include one lab session each week, designed to supplement the concurrent lecture material with real-world application and hand-on experience.

For the algebra-based General Physics courses PHY 166 & 167 students perform 8 labs for each course, with each lab being performed and written up in a single week. Four additional classes are devoted to recitations, in which students are guided by the instructor through physics problem solving activities. The following lab projects form our general physics laboratory curriculum:

PHY 166 Labs

1. Measurements & Uncertainty
2. Acceleration due to Free-Fall
3. Static Equilibrium
4. Newton's 2nd Law
5. Simple Harmonic Motion
6. Conservation Laws in Collisions
7. Rotational Equilibrium
8. Archimedes' Principle

PHY 167 Labs

1. Electrostatic Fields
2. Ohm's Law
3. Electric Circuits
4. Forces on Currents in Magnetic Fields
5. Specific Charge of the Electron
6. Refraction
7. Mirrors & Lenses
8. The Grating Spectrometer

Historically the algebra- and calculus-based physics courses were mixed together in combined lab sections that did all of the same experiments and recitations. Starting in Spring 2023 a new model was adopted, in which students in the calculus-based courses PHY 168 & 169 have a separate lab section. Compared to the algebra-based students they do fewer experiments, which frees up time to incorporate a significant number of group problem-solving sessions in the lab. In Fall 2023 the PHY 168 students did 7 experiments and 7 problem-solving sessions, while in Spring 2024 the PHY 169 students are doing 5 experiments and 7 problem-solving sessions. The problem-solving sessions are closely coordinated with the lectures and provide almost 30% more contact time with the instructor. Problems are distributed and the lab groups work together to solve them, while the instructor is available to answer questions and provide guidance as needed. The problem-solving sessions are graded just based on attendance. They are meant to build a collaborative and supportive learning community, with students encouraged to discuss the problems both within and across lab groups. They also provide a valuable opportunity for the instructor to initiate individual or small group discussions with everyone in the class.

The PHY 166/168 and PHY 167/169 labs are conducted in Gillet 237 and 337 respectively

The PHY 166/168 and PHY 167/169 labs are conducted in Gillet 237 and 337 respectively.

Service to Other Programs

The Department of Physics and Astronomy is proud to offer many courses that are requirements for the programs of other departments, both requisite and elective. Almost all of these are offered every semester, and we liaise with the departments in question when possible to determine convenient scheduling.

Health Programs

Pre-health students make up the bulk of the enrollments in our algebra-based introductory physics courses (PHY 166 & PHY 167). These subjects are an important component of the MCAT exam and are prerequisites for medical, dental, pharmacy, optometry, veterinary, and (most) physical therapy graduate programs.

Our *Physics of Sound* course (PHY 140) is a requirement for the Speech Pathology and Audiology B.A. (SPEA-BA) and typically serves 50-70 of these students every semester.

These courses are the most quantitatively rigorous most pre-health and SPEA-BA students will take at Lehman, and many of these students come to us poorly prepared for the course material. As such, these courses can present an impediment to their graduation. We take this issue very seriously, and so have implemented a number of measures to cater to these students

1. Extensive introductory/remedial mathematics is presented at the beginning and throughout all of these courses, and the level of teaching is calibrated to the needs of each class.
2. As detailed above in Physics Labs, dedicated problem-solving sessions have been added to PHY 166/167 labs, and additional remedial math is added to PHY 140 labs.
3. Care is taken to ensure all MCAT physics topics are covered in PHY 166/167 to ensure maximum relevance and value to pre-health students.
4. We take special care in assigning instructors for PHY 140

Other Science Majors

B.A. and B.S majors in both Biology and Chemistry also require introductory physics—typically PHY 166 & 167—however the Chemistry B.S. majors are required to take our calculus-based PHY 168 & 169 alongside our own Physics majors.

The B.S. in Earth Sciences requires our *Energy and Environment* course (PHY 151), which runs every semester with a consistent 50-60+ enrollments. We also serve the Certificate of Earth Sciences program with the elective (but very popular) *Astronomy of Stellar Systems* (AST 117).

Education Masters

When requested by students in the Education Department's MSEd program, we offer Stellar *Astronomy* (AST 602). This graduate-level astronomy course combines lectures from our AST 101 course with pedagogically-focused lab classes and projects. Just prior to this review period, we ran two semesters of a specially designed lab curriculum focused on the pedagogical

Pre-Engineering Transfer Program

Lehman College offers a Pre-engineering Transfer Program, administered by the Department of Physics and Astronomy. Students take introductory physics and math courses for two years before transferring to the School of Engineering at City College.

Freshman Year Initiative

We offer a section of AST 101 every semester at the request of FYI, scheduled according to FYI needs.

Assessment

During the period 2019-2023 both Introductory Physics lectures and Introductory Physics labs were assessed, based on Midterms and the Final exams for the lectures and on the lab reports for the labs. Labs were assessed in the periods 2019-2020 and 2020-2021, and Introductory Physics Lectures were assessed in the periods 2021-2022 and 2022-2023. Additionally, the upper-level undergraduate course PHY303 – Statistical Thermodynamics was assessed in the period 2022-2023.

The metrics, success criteria, and results for the Introductory Physics labs were in the two assessed periods were 1) Percentage of the lab reports that includes the formulas needed in the data evaluation (Success: 50%, Results: 76% and 64%); 2) Percentage of lab reports written according to the prescribed structure and exhibiting an reasonable effort to analyze and interpret results. (Success: 50%, Results: 41% and 71%); 3) Percentage of lab reports that have a physically relevant conclusion (Success: 50%, Results: 40% and 50%). In addition, we measured the ability of students to make scientific plots, and the result was as good as 65% and 69%. This is a considerable improvement in comparison to previous years, accounting to the shift towards computerization that our Department is pursuing.

The same for the Introductory Physics lectures is 1) Percentage of the exam problems solutions that use algebra without a fallback to numerical manipulations (Success: 50%, Results: 35% and 45%); 2) Percentage of the exam problems solutions that indicate the basic laws of physics used (Success: 60%, Results: 40% and 50%); 3) Percentage of well commented exam problems: (Success: 60%, Results: 30% and 42%); 4) Percentage of shared wrong solutions to the exam problems (Success: <10%, Result: 5%); 5) Percentage of the problems with the result assessed by the student (commented, tested): 30% (Success: 40%, Result: 30%).

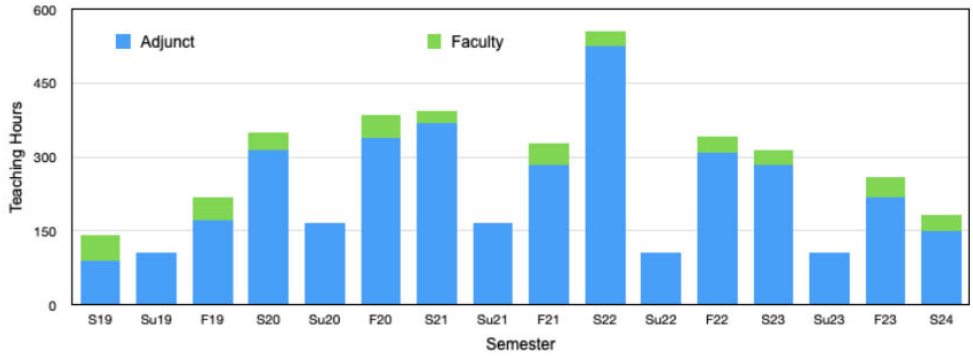
In the upper-level course (Statistical Thermodynamics in the Spring 2023) the criteria could be only qualitative because of a small number of students. The main outcomes are: 1) Most of the students understood basic physics principles and mastered the required mathematical methods. Most of the students got an “A” for the course. On the other hand, 2) solutions to the problems presented by the students mostly were just formula manipulations with very little explanations. Here more work is needed to teach them scientific writing. Similarly, 3) most of the students just stopped after obtaining the result without analysis.

Adjunct vs. Faculty Teaching

Due to the large number of non-majors served by the Department, we are obliged to hire adjuncts to cover many of our courses. Department faculty teach almost all of our courses

for physics majors, including calculus-based Introductory Physics, as well as at least one

section of our algebra-based Introductory Physics stream. Faculty also teach our more popular 100-level courses—AST 101/117 and PHY 151. All other courses are covered by adjuncts, including labs. On average, over the review period, 13% of teaching hours were covered by faculty. The figure below shows faculty versus adjunct teaching hours by semester. [CHECKING NUMBERS—SOMETHING IS WRONG HERE]



Curriculum Development

Adapting to Remote Learning

The COVID-19 pandemic presented a major challenge to educators everywhere, first with the need to rapidly develop an entire online curriculum, and then (and now) with the need to rectify the learning loss that occurred during remote semesters. The Department of Physics and Astronomy was no exception. As New York lockdowns went into effect we transitioned to fully online lectures and labs. That latter was a particular challenge, requiring the development of entirely new exercises not dependent on lab equipment.

Despite a tough teething period, the transition was as successful as we could hope. We maintained a reasonable pass rate, although the drop in student engagement was reflected in overall performance.

We still struggle with the learning loss experienced by students who took foundational courses during the remote semesters. This is especially true for students who took prerequisite math classes in this time: we have found that students entering both algebra- and calculus-based introductory physics need significantly more remedial math instruction than previously. We've done our best to provide this, although the expense is that we cover less of the curriculum, but still manage to cover material essential for MCAT exams.

We've also seen a downturn in the preparedness of our physics majors, with the most obvious deficiency being their knowledge of calculus. While all these students have passed their calculus prerequisites, it seems relatively little is retained when these courses are taken online. To rectify this, every spring we now teach PHY 207 (Mathematics of Physical Sciences; described below), which reviews and expands on the most important math for physics majors. Essentially all of our majors now take this in conjunction with PHY 169 in the semester prior to beginning their upper-level physics courses.

Online Modalities

We've now transitioned back to a mostly in-person program. However we did take the

opportunity to retain a small number of our most successful online offerings. Prof. Eugene

Chudnovsky's PHY 166 & PHY 167 sequence is the exception to the standard (and usually accurate) wisdom that introductory physics classes work better in person. Due to Prof. Chudnovsky's exceptional effort in developing a highly engaging online version of his course, his students perform just as well as in his previous in-person version. Moreover, an evening, online offering of introductory physics is exceptionally popular for our many pre-health students who also work and/or have family responsibilities. Note that labs and exams for this sequence are still in-person. All of our other introductory physics courses have returned to in-person modality.

We also offer an online version of our introductory astronomy courses, AST 101/117. This course employs a wide range of multimedia; especially visual media like telescope images, animations, and scientific simulations. As such, the course is especially suited to the online format. This modality allows us to teach many more students that we would in-person The average enrollment since beginning this modality is around 120 students, but recent growth has brought us up to 170 students in the current Spring 2024 semester—a number that we could not accommodate in any Lehman College auditorium.

Pathways

Prior to COVID-19, our last major change in course offerings was to meet the requirements of the Pathways initiative with the addition of four new courses (3 adapted to meet credit requirements, one brand new). Although these were introduced before this review period, the fine-tuning of the new course offerings have been an important part of curriculum development over the past five years.

Especially notable successes are PHY 151 (Energy and the Environment) which has become a prerequisite course for the major in Environmental Sciences and routinely fills its 60-student cap every semester, and AST 101 (Introduction to Astronomy) which has become one of the most popular *Scientific World* courses, with 184 enrollments in the current S24 semester between its two sections.

Required Core - Life and Physical Science

PHY 131 - Conceptual Physics (adapted from PHY 135)
PHY 141 - Sound, Speech, and Music (adapted from PHY 140)
PHY 151 - Energy and the Environment (new course developed for Pathways)

Flexible Core - Scientific World

AST 101 - Introduction to Astronomy (adapted from AST 117 - Astronomy of Stellar Systems)

Lab Upgrades

In 2014 We conducted a full revision of our manual for our Introductory Physics labs (PHY 166, 167, 168, 169), revising most labs and replacing some of the more antiquated ones. Since then our efforts have been to selectively update labs and equipment, along with the introduction of recitation sessions in which students solve physics problems as a group, guided by their instructor. This component was introduced to address the core challenge faced by most introductory physics students: applying the information learned in lectures to real problems—of particular importance to our many pre-health students with their impending MCATs!

We have just begun an upgrade of our Modern Physics Lab (PHY 251) labs. With $10,000 secured by Prof. Gerry, and in collaboration with Jorge Soriano, a variety of new equipment will be purchased to improve the PHY 251 experiments.

Description of Physics Courses

The courses taught at least once over the review period are described here, adapted from the Lehman Undergraduate Catalog.

AST 101 - Introduction to Astronomy (3 credits): Basic exploration of the science of astronomy and what it has taught us about our place in the universe. Topics include the history of astronomy, scales of the universe, the night sky, the moon, planets of the solar system, the Sun, Earth as an astronomical body, and life in the universe.

AST 117 - Astronomy of Stellar Systems (4 credits): Exploration of our universe covering basic properties of stellar systems, including planetary systems, stars, stellar evolution and remnants, galaxies and cosmology. This course shares the lecture component with AST 101, adding an astronomy lab component.

AST 602 - Stellar Astronomy (4 credits): Stars, interstellar matter, stellar systems. Laws of motion and gravitation. Techniques of astronomical observation. Basic concepts of astrophysics. Stellar evolution; special systems, including black holes, pulsars and galaxies. Basic cosmology. This course shares the lecture component with AST 101, adding a pedagogically-focused lab and writing component.

PHY 131 - Conceptual Physics (3 credits): Basic concepts and methods of physics. The nature of physical laws and the methods by which these laws are developed and tested. Topics include motion and energy; heat, light, and sound; the structure of matter; gravity, electricity, and magnetism.

PHY 140 - Physics of Sound (3 credits): Harmonic motion, waves, perception and measurement of sound, the physics of musical instruments and human voice, electrical reproduction of sound, acoustics of rooms, and environmental noise. Note: Recommended for students of Speech, Language, and Hearing Sciences to fulfill the requirements for ASHA certification. It is also appropriate for students who are interested in the physics of music.

PHY 151 - Energy and the Environment (3 credits): Energy as a physical concept, various forms of energy, conservation of energy, heat and thermodynamics, energy from fossil fuels, electrical energy and its generation, solar energy, nuclear energy. The environmental effects of the generation of energy, air pollution, global warming, nuclear radiation in the environment.

PHY 166 - General Physics I (5 credits): Algebra-based mechanics, heat, and sound. This course sequence (with PHY 167) is customarily taken by pre-medical and other pre-health students as well as pre-veterinary and most science majors not in the chemistry or physics B.S.

PHY 167 - General Physics II (5 credits): Algebra-based electromagnetism, geometrical and physical optics, and introduction to modern physics. This course sequence (with PHY 166) is customarily taken by pre-medical and other pre-health students as well as pre-veterinary and most science majors not in the chemistry or physics B.S.

PHY 168 - Physics I for Scientists and Engineers (5 credits): Calculus-based Physics:Motion, Newton's laws, work and energy, mechanics of rigid bodies, elasticity, mechanics of fluids, temperature, heat, kinetic theory of matter, wave motion, and sound. This course sequence (with PHY 169) is taken by physics and chemistry B.S. majors and those on the pre-engineering track.

PHY 169 - Physics II for Scientists and Engineers (5 credits): Calculus-based electrostatics, electrodynamics, geometrical and physical optics, and introduction to modern physics. This course sequence (with PHY 169) is taken by physics and chemistry B.S. majors and those on the pre-engineering track.

PHY 207 - Mathematics of Physical Sciences (4 credits): Mathematical techniques applied to solving physical problems. Techniques used include differential and integral calculus of one and many variables, infinite series, complex numbers, functions of complex variables, vector calculus, matrices and determinants, linear vector spaces, differential equations.

PHY 241 - Modern Physics (3 credits): Relativity; fundamental physical processes at the atomic level; introductory Schrodinger quantum mechanics; introductory nuclear physics; atomic and nuclear models.

PHY 251 - Modern Physics Laboratory (2 credits): Individual experimentation in selected areas of physics and introduction to analysis of experimental data.

PHY 301 - Intermediate Electricity and Magnetism (4 credits): Electrostatics, dielectrics, magnetism and electromagnetic induction, magnetic properties of matter, D.C. and A.C. circuits, Maxwell's equations.

PHY 302 - Intermediate Mechanics (4 credits): Dynamics of a particle. The harmonic oscillator. The central force problem - planetary orbits. Dynamics of systems of particles: rotation of rigid bodies.

PHY 303 - Thermodynamics and Statistical Mechanics (4 credits): First and second laws of thermodynamics, equation of state, entropy and other concepts of thermodynamics, applications to heat engines, and thermal properties of gases, solutions and solids; introduction to statistical mechanics.

PHY 304: Optics (3 credits): Reflection and refraction, interference, diffraction and polarization, lasers and holography.

PHY 305 - Digital Electronics (3 credits): Design of digital electronic circuits. Binary, octal, and hexadecimal number systems, Boolean algebra and logic gates, combinational logic (adders, subtractors, etc.), synchronous sequential logic, registers, counters, memory units, digital integrated circuits.

PHY 306 - Astrophysics (3 credits): Selected topics from celestial mechanics and stellar dynamics; stellar energy sources, pulsars, quasars, black holes, and relativistic cosmology.

PHY 307: Mathematical Physics (4 credits): Vector calculus, matrix and tensor algebra, Fourier and Laplace transforms, complex variable theory, and solutions of differential equations. Applications to problems in physics.

PHY 400 - Introductory Quantum Mechanics (4 credits): Wave and particle nature of matter and radiation. The uncertainty principle. Operators and the Eigen-value equations; Schrodinger formulation; stationary states. Harmonic oscillator and potential barrier problems. Angular momentum. Central potential and the hydrogen atom. Perturbation theory of energy levels. Spin and statistics.

PHY 489 - Independent Study (2-3 credits): Independent study or participation in a research project under faculty direction. Can be repeated for up to 6 credits in total.

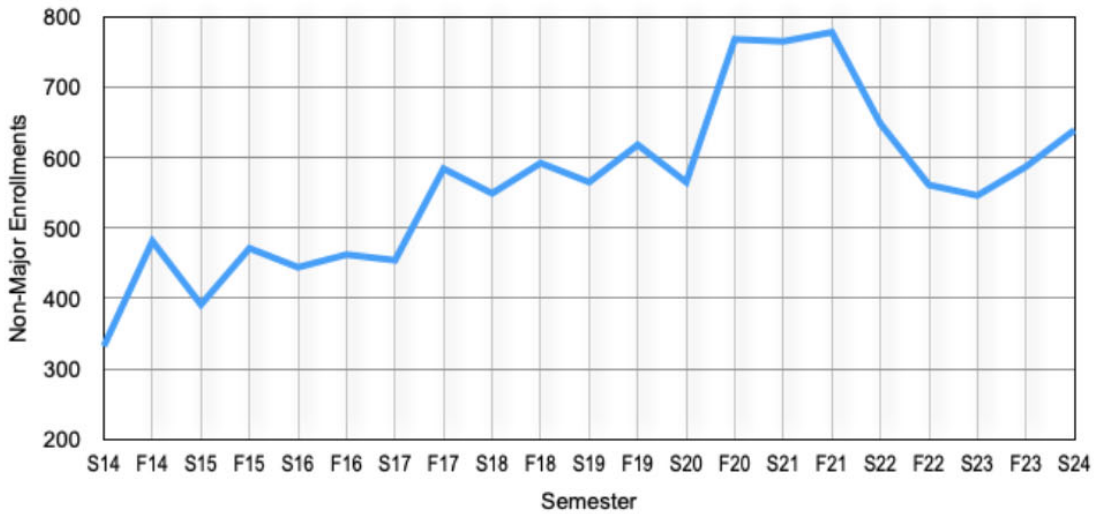
Students

Enrollment and Demographics

Lehman students served by the Department of Physics and Astronomy are quite representative of the general Lehman College student body - more than ..% female, more than ..% minorities. The average age is … Most of our students hold jobs, and many juggle their studies with full-time work and with family responsibilities. [WAITING ON DATA]

Non-Majors

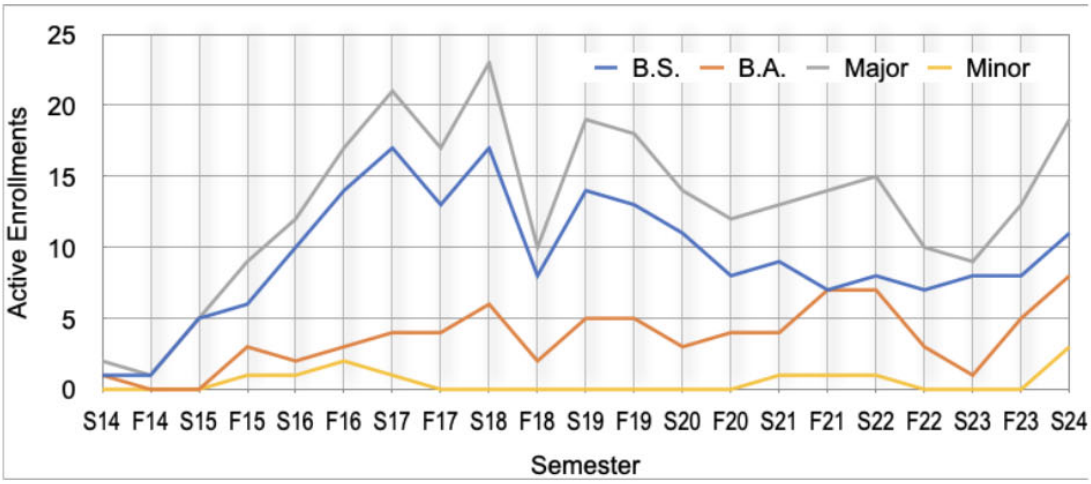
The bulk of students served by the Department have clear career goals *not* directly related to physics or astronomy. As discussed in Service to Other Programs, our courses are important requirements or popular electives to various health/pre-health tracks, the SPA-BS, and other science majors. In addition, our 100-level courses are very popular Pathways and FYI options. These various groups represent the bulk of the student population served by the Department, and we typically enroll >600 non-major students each semester. The following figure shows the total enrollments in Department of Physics and Astronomy courses for non-majors. We point out a steady increase in enrollments, approximately doubling the number of students served 10 years ago, albeit with some heavy fluctuations in the recent few years that reflects the drop in enrollments across Lehman and CUNY. However, even this downturn shows signs of being reversed in the past two semesters.



Majors

By comparison to the total number of students served by the Department, the number of physics majors is relatively small; the average size of our active major cohort over the past 5 years was a little over 14, and in that period we graduated 20 students with a B.S. and 11 with a B.A. This represents substantial growth compared to the previous 5-year period in which our average major size was 11.7, and in which we graduated 11 B.S. and 4 B.A. majors. We consider this a substantial success, especially given the enrollment challenges faced by Lehman and CUNY following the COVID-19 pandemic.

The graph below shows total enrollments in Department programs over the past decade. Due to the relatively small size of the cohort, there's quite a bit of fluctuation in our major size (some years we graduate a good fraction of our majors!) However the general trend of growth is apparent. Following the COVID-19 downturn we did reach a disconcerting low number, with ~10 students in Fall '22 and Spring '23. However this seems to have turned around and we appear to be on track to recovering the peak of cohort size.



Department Awards

The Department of Physics and Astronomy Awards Two Student Prizes each year. The *Ambuj Mukerji Award* goes to the student who demonstrates exceptional promise on the basis of grades in the first year physics course. The *Joseph A. Gillet Memorial Prize* goes to the student in his/her senior year who, in the opinion of the Department, has demonstrated the most knowledge in general physics. Over the review period these awards were granted to the following students:

Year	Mukerji Award	Gillet Prize
2019	Vladyslav Bodnar	Joseph Cruz
2020	Raynier Reynoso	Esteban Alcantara
2021	Bibi Khan, Jayslee Perez	No Awardee
2022	No Awardee	Anton Kyrylenko, Matthew Giaccio
2023	Neena Noble	No Awardee

Student Success and Prospects

Many of our majors have gone on to graduate school, including to prestigious programs at Yale, Columbia, Brown, and other top universities. Others go on to work in a variety of specialist fields, particularly in STEM, business and financial, and education. The American Institute of Physics finds that students graduating with B.S. majoring in physics have exceptional career prospects. Nation-wide, they find that one year out of a physics bachelor degree 52% of graduates are in graduate school and only 6% of physics graduates report being unemployed. The overwhelming majority of graduates move into STEM fields, and starting salaries for physics bachelors are the highest of the bench sciences and comparable to engineering degrees.

Undergraduate Research

Undergraduate Research Students

The Department of Physics and Astronomy has an active undergraduate research program, with students participating in research across our fields of study, but with particularly high activity in the fields of quantum optics (Gerry) and astrophysics (O'Dowd, Anchordoqui). This activity slowed during the COVID-19 remote period, but is now picking up pace again.

The following nine students have engaged on one or more research projects with Department faculty. This is around half the number from the previous 5-year period for the aforementioned reason, however we expect to recover and exceed those earlier numbers in the next year or two.

Esteban Alcantara - Advisor: Anchordoqui (2019) *
Claire Mechmann - Advisor: Anchordoqui (2019) *
Alexandra Bloshenko - Advisor: Anchordoqui (2021) *
Neena T. Noble - Advisors: Anchordoqui & Soriano (2023-2024)*, Gerry (2024)
Esmil Yapor - Advisor: Gerry (2020-2024)
Zahin Zahidul - Advisor: Gerry (2024)
Jennifer Abreu - Advisor: Anchordoqui (2024)
Nyamekye Fosu - Advisor: Anchordoqui (2024)
Michael Kwakye - Advisor; Anchordoqui (2024)

* These students published their research in peer-reviewed journals.

AstroCom NYC

AstroCom NYC (external link) is an NSF-funded program to provide research and career mentorship and tuition support for underrepresented minorities from CUNY to help them towards entry into graduate school in astrophysics and physics. Prof. O'Dowd and Anchordoqui serve as career and research mentors in this program. AstroCom NYC has operated for the past 12 years, and every year 1-3 Lehman students receive fellowships. The majority of Lehman alumni from this program have successfully gained admission to top graduate programs.

Graduate Students

Over the review period, members of the Department have mentored … students in the CUNY Graduate Centers Ph.D. Program in Physics.

Graduate students who graduated in in review period:

Jorge Fernandez Soriano - Advisor: Anchordoqui
Amel Derras-Chouk - Advisors: Chudnovsky & Garanin
Daniel Capic - Advisors: Chudnovsky & Garanin

Graduate students currently advised by Department faculty:

Aakash Marthandan (advisor: Kabat)
(Alex) Xiaole Jiang (advisor: Kabat)
Henry Best (advisor: O'Dowd)
Josh Fagin (advisor: O'Dowd)
Bridget Ierace (advisor: O'Dowd)
Vishal Verma (advisor: O'Dowd; co-advised by Quinn Minor, BMCC)
Antonina Maj (advisor: Karabali; co-advised by V.P. Nair, CCNY)
Abhishek Budarapu (project mentor: Gerry; advised by Vinod Menon at City College)

Research, Faculty and Staff

Research Groups

The Department of Physics and Astronomy is exceptionally active in research, with all seven faculty members engaging in frontline research in their respective fields. Details of each members' work is detailed under Full-Time Faculty, but these can be broadly categorized into five principle research areas. Additional detail on the research of individual faculty members can be found under their entries in Full-Time Faculty below.

Astrophysics
Professor Luis Anchordoqui and Associate Professor Matt O'Dowd head the astrophysics research group at Lehman College. Prof. Anchordoqui's efforts in astrophysics are centered on understanding the origin of cosmic rays and their use as probes of high energy physics, and exploring dark matter candidates and the link between string theory and cosmological parameters. Prof. O'Dowd's work focuses on understanding the origin and growth of supermassive black holes, in particular using gravitational lensing as a probe of quasars. His current major effort is to build a machine-learning pipeline for analyzing gravitational lensing data from the upcoming Legacy Survey of Space and Time on the Rubin Observatory

High-Energy Theory
Our high-energy theory group includes Professors Dimitra Karabali, Dan Kabat, and Luis Anchordoqui. Prof. Karabali works on topics in nonperturbative aspects of gauge theories and higher dimensional extensions of quantum Hall effect. Prof Kabat's goal is to understand quantum gravity, including quantum properties of black holes, and is currently working on a range of problems in string theory, quantum entanglement, and holography. Prof. Anchordoqui's activities in high-energy physics range from understanding particle interactions in colliders and general string phenomenology, to astrophysical and cosmological tests and implications of speculative models in fundamental physics.

Solid State Physics
Professors Chudnovsky and Garanin's current work is focused on nanomagnetism, with two primary projects: to understanding the formation and behavior of magnetic skyrmions for topologically protected information technology, and to understand microwave absorption by magnetic systems with random anisotropy, with applications for stealth technology.

Quantum Optics
Professor Gerry heads the Quantum Optics group at Lehman. His recent research activity has been spread over several topics in quantum optics and quantum atom optics, with many overlaps with quantum information processing. Of special concern has been the application of the photon number parity operator to quantum metrology and, more recently, of the atomic parity operator with applications to spectroscopy and atomic clocks using ensembles of two-level atoms.

Funding

The Department of Physics and Astronomy has a strong track record of grantsmanship. The major grants spanning the review period are detailed here. In addition to these, several PSC-CUNY and other smaller awards have been granted.

Title: *FutureLens: Gravitational Lensing and Machine Learning in the Era of Large Sky Surveys*
PI: Matt O'Dowd
Amount: 2.94M
Funding Body: Schmidt Futures
Award Period: 2020-2025

Title: *RUI: Nonperturbative analyses in field theory*
PI: Dimitra Karabali
Amount: 145,000
Funding Body: National Science Foundation
Award Period: 2019-2023

Title: *Collaborative Research: Entanglement, Geometry and the Physics of Fields, Strings* and Gravity
PI: Dan Kabat
Amount: $270,000
Funding Body: National Science Foundation
Award Period: 2021 - 2024

Title: *Collaborative Research: Investigations in Strings, Fields and Gravity*
PI: Dan Kabat
Amount: $210,000
Funding Body: National Science Foundation
Award Period: 2018 - 2021

Title: *Multidiscipline approach to the UV completion of the standard model: astrophysics, cosmology, and collider physics*
PI: Luis Anchordoqui

Amount: $220,000

23

Funding Body: National Science Foundation
Award Period: 2016 - 2021

Title: *EUSO-SPB2: Second generation Extreme Universe Space Observatory (EUSO) on board a Super-pressure Balloon (SPB)*
PI: Luis Anchordoqui
Amount: $514,156
Funding Body: NASA
Award Period: 2018 - 2023

Title: *Intersections of String Phenomenology, Cosmology, and Astrophysics*
PI: Luis Anchordoqui
Amount: $234,000
Funding Body: National Science Foundation
Award Period: 2021 - 2024

Title: *EUSO-SPB2 (Extreme Universe Space Observatory on a Super-pressure Balloon 2nd Generation) from Flight to Science Results*
PI: Luis Anchordoqui
Amount: $548,104
Funding Body: NASA
Award Period: 2023 - 2025

Chudnovsky's research in 2019-2024 has been supported by grants from the U.S. Department of Energy and the U.S. Air Force Office of Scientific Research.

Institutional Collaborations

We are committed to raising Lehman College to the global stage as a frontline physics research institution, and to ensuring our students have exposure to major international research programs and prominent scientists. In service of this, we have cultivated strong ties with multiple larger research institutions and facilities, the most important of which are listed here:

The American Museum of Natural History
The Lehman Astrophysics group enjoys a close relationship with the Astrophysics Department at the American Museum of Natural History. Lehman astrophysics research students have visitor status at the AMNH Astrophysics Dept., where they enjoy its vibrant research environment. Many have also participated in AMNH's mission of science education, communication and outreach. AMNH is also the home base for AstroCom NYC.

City College
Professors Kabat and Karabali are long-time members of the Lehman College–City College high energy theory group. There is a strong research collaboration among the members of the group, with a joint NSF grant providing support for graduate students and visitors. Shared office space is available, graduate students are often mentored jointly, and a weekly seminar series provides a focal point for the community.

University of Barcelona

Professor Chudnovsky's nanomagnetism group collaborates with a magnetism group at the University of Barcelona - Spain. This collaboration has resulted in four books, a few dozen research articles, mutual visits by faculty and students, and an annual international workshop jointly run by faculty from Lehman and the University of Barcelona since 2006.

Air Force Research Laboratory
For the past 12 years, Professor Christopher Gerry worked closely with the Air Force Research Laboratory in Rome, NY on information technology (cyber security) and on quantum technology. His regular summer visits have been funded by the Air Force Office of Scientific Research or through the Griffiss Institute

Columbia University
Professor Anchordoqui's work on the upcoming JEM-EUSO mission is in close partnership with Provost Professor Angela Olinto, who shares the associated NASA award with Prof. Anchordoqui. The JEM-EUSO activities at Lehman College are captained by Research Scientist Tom Paul who develops software for the balloon missions.

FutureLens Institutions
Prof. O'Dowd's FutureLens program is primarily based at CUNY, but three other institutions form important hubs for the program:

University of Montreal and MILA: The University of Montreal and the Montreal Institute for Learning Algorithms (MILA) serve as the second largest hub for FutureLens, and the CUNY and Montreal teams visit each other regularly. The Montreal team consists of two faculty, two postdocs, and several graduate students that receive significant funding from this program. That team is focused on developing new innovations in AI to serve this program, and towards that effort work closely with some of the world-class computer scientists at MILA, including the AI founding figure Joshua Bengio.

Center for Computational Astrophysics: The Center for Computational Astrophysics at the Flatiron Institute has become a central hub for New York astrophysics, and provides Lehman faculty and research students with access to another world-class research environment. The CCA has an agreement with FutureLens to grant Visiting Researcher status to our postdoctoral researchers and also to host our annual team meetings.

Stony Brook University: Prof. Simon Birrer, close collaborator with the FutureLens project, is a new faculty member at Stony Brook. FutureLens also funds 50% of his postdoctoral researcher Narayan Khadka, who is the official pipeline scientist for the entire Rubin/LSST lensing pipeline effort. We have just started a program of regular team visits between our institutions.

Faculty Research and Activities

Luis Anchordoqui

Luis Alfredo Anchordoqui received his Ph.D. in 1998 at Universidad Nacional de La Plata (UNLP, Buenos Aires, Argentina). He was a postdoctoral fellow at Northeastern University (Boston) from 1998 - 2006, and an Assistant/Associate Professor at the University of Wisconsin Milwaukee from 2006 - 2014. He is currently a Professor at Herbert H. Lehman

College of the City University of New York (CUNY). Anchordoqui is known for pioneering work in astrophysics contributing to uncover the starburst powering mechanism behind the origin of the highest energy cosmic rays. He also made important contributions to the theoretical understanding of high-energy collisions and the fundamental interactions of elementary particles. He contributed as well in the conceptual design of experiments to be installed inside the Forward Physics Facility (FPF) at the CERN Large Hadron Collider. His research has received more than 35,000 citations in the academic literature and has an h-index of 89.

Scholarship
In recent years Anchordoqui's research program primarily focused on phenomenological studies connecting string theory to experiment, thereby investigating its observable consequences for astrophysics, cosmology, and collider physics.

Specific aspects of this program include: theoretical modeling of time dependent stringy backgrounds and their potential cosmological implications; statistical analyses using Monte Carlo Markov Chain methods to constraint cosmological parameters which arise in string-inspired models; building on dark matter candidates within the dark dimension scenario; setting up uniform 5-dimensional inflation; mitigating the tensions in cosmological parameters via anti-de Sitter—de Sitter transition; forecasting beyond Standard Model physics models that could be tested at the Forward Physics Facility.

As a secondary objective Anchordoqui continues with his studies in high-energy astrophysics to uncover the sources of the highest energy cosmic rays.

Anchordoqui is a member of the Pierre Auger Collaboration, the JEM-EUSO Collaboration the FPF Initiative, and is Convener of Forward Physics Facility Working Group: Light Hadron Production

During 2019 - 2024 Anchordoqui published 76 papers in peer review international journals and 4 are under review. Out of the 76 papers, 23 were published as a member of the Auger and JEM-EUSO Collaborations.

Professional and Public Service and Outreach
Anchordoqui was a topical convener of the 2021 High Energy Physics Community Planning Exercise (a.k.a. "Snowmass") in the Cosmic Frontier: Cosmic Probes of Fundamental Physics (CF7). He contributed to the write up of snowmass white-papers on: the Forward Physics Facility, the tensions in cosmological parameters, ultra-high-energy cosmic rays, cosmic neutrinos, and beyond SM effects on neutrino flavors, as well as the CF7 and CF reports.

Anchordoqui is a member of the High Energy Physics Advisory Panel (HEPAP) of the U.S. Department of Energy (2022 - 2024).

Anchordoqui developed and supervised the research project of Susanna Weber, a student from Mamaroneck High School, for which she won the first place in the Physics and Astronomy competition for Westchester Science and Engineering Fair, and a gold medal at the G.E.N.I.U.S. Olympiad Science Fair at Oswego. The work has been published in the International Journal of High School Research.

Due to the recent global health concerns Anchordoqui adapted some of his interests to

research in health sciences. He has published research related to COVID-19 and its

airborne nature (see publication list for details). This research has been featured in the New York times and used to assist in safety measures currently being implemented.

Department, College, and CUNY service
Anchordoqui was the Deputy Chair of the Department of Physics and Astronomy at Lehman College from January 2021 to January 2022.

Eugene Chudnovsky

Eugene Chudnovsky received his undergraduate, graduate, and postdoctoral education at Kharkiv University in Ukraine, and joined the faculty of Lehman College in 1988, and has been a CUNY Distinguished Professor since 1999. Chudnovsky is a Fellow of the American Physical Society, elected in 1993 for his "seminal contributions to random ferromagnetism, macroscopic quantum tunneling, and hexatic order in high-temperature superconductors". He is best known for his work on quantum tunneling of magnetization, molecular magnetism, and the theory of amorphous ferromagnets.

Scholarship
Chudnovsky's work in the last five years has focused on magnetic skyrmions for topologically protected information technology (supported by the U.S. Department of Energy) and on microwave absorption by random magnets for stealth technology (supported by the U.S. Air Force Office of Scientific Research). During the COVID-19 pandemic, he contributed to research on the spread of airborne infection. In 2019-2024 Chudnovsky published 25 articles and made 8 invited presentations at science meetings.

The main accomplishments on skyrmions include computation of skyrmion-skyrmion interaction in a ferromagnetic film, derivation of skyrmion mass due to spin-phonon interaction, studies of pinning and deformation of skyrmions by defects, computation of damping of skyrmion motion by nonlinearities, a suggestion of skyrmion-based binary and quaternary memory, investigation of quantum states of nanoscale skyrmions, and studies of melting of skyrmion lattices. A general framework for the conservation of angular momentum in spin-phonon processes has been developed.

Accomplishments on microwave absorption by random magnets include a demonstration of the promise of random magnets for stealth technology, the discovery of the spatial localization of microwave absorption, computation of temperature dependence of microwave absorption and the integral absorbed power, scaling theory of microwave absorption by amorphous magnets, and demonstration (in collaboration with Barcelona experimentalists) of the advantages presented by using bilayer magnetic systems for microwave absorption.

Professional and Public Service and Outreach
He serves as a reviewer of NSF and DOE grant applications and for articles submitted to Nature, Physical Review, and numerous other physics journals. Outside CUNY, Chudnovsky has co-organized and co-chaired (together with Prof. Javier Tejada of the University of Barcelona) the Annual International Workshop on Microwave Research and Applications in Comaruga, Spain. He also co-chairs the Committee of Concerned Scientists – a human rights organization charged with defending scientists from abuses throughout the world.

In recent years Chudnovsky has given numerous media interviews on his human rights work, on the spread of airborne COVID-19 infection, and on his work (together with Prof. Luis Anchordoqui) on the possibility of nuclear life in stars.

Department, College and CUNY Service
In 2019-2024 Chudnovsky served on Lehman and CUNY Distinguished Professor Committees, Graduate School Admission Committee, Lehman Committee on Research, Lehman Committee on Professors of Excellence, and Lehman Honors Committee.

Awards
Chudnovsky is a recipient of the 2024 Andrei Sakharov Prize of the American Physical Society, awarded to him for "*For decades of leadership of prominent campaigns on behalf of oppressed scientists, including chairmanship of the APS and New York Academy of Sciences human rights committees and co-chairing of the Committee of Concerned Scientists.*"

Dmitry Garanin

Dmitry Garanin graduated from the Moscow Institute of Physics and Technology in 1978 with M.S. and B.S. degrees, defended his PhD in theoretical physics in 1985 at the Moscow State University in 1985. After teaching at the Moscow Institute of Radioengineering, Electronics, and Automation (MIREA) (1984-1989) and working as a research professor there (1989-1992) immigrated to Germany where he worked at the Universities of Hamburg and Mainz, as well as at the Max-Plank Institute in Dresden. Since the Fall of 2005 member of the Physics Department. Member of the CUNY Doctoral Faculty, New York, since 2006. Fellow of the American Physical Society since 2013.

Scholarship Statement
Dmitry Garanin is a member of the Nanomagnetism group within the Department, together with professor Chudnovsky. The main research interests include analytical and numerical investigation of statics and dynamics of magnetic materials with static randomness such as random anisotropy and topological structures in low-dimensional magnets, such as vortices and skyrmions.

One of the recent research projects is melting of the skyrmion lattice on the temperature and the magnetic field. One of the approaches is considering skyrmions within the full model of classical spins on the lattice. Another approach is a simplified one considering skyrmions as point particles with repulsion previously established by our group.

Another project is microwave absorption by magnetic systems with random anisotropy. These materials were shown by us to be good broadband microwave absorbers. We computed the absorption at different temperatures and developed scaling methods that allow us to reduce the system to a smaller system with a larger random anisotropy that is easier to solve numerically.

Professional and Public Service and Outreach
Dmitry Garanin is a referee for scientific journals including Physical Review, European Physical Journal, Journal of Physics: Condensed Matter, Journal of Magnetism and Magnetic Materials, as well as for the NSF. Member of the Program Committee of the International Workshop on Magnetism and Superconductivity, Comaruga – Spain.

Department, College and CUNY service
Department Assessment coordinator. Department scheduling coordinator.

Christopher Gerry

Professor Gerry graduated from the University of Maine with a BA in physics in 1972 and an MS in physics in 1974, and received his Ph.D. in physics from the State University of New York at Albany, 1979. He has held faculty positions at Seton Hall University, The University of Minnesota, Morris, St. Bonaventure University, Amherst College, and Polytechnic University before coming to Lehman College in 1998. His main areas of research are theoretical quantum optics, quantum metrology and atom optics, including the quantum mechanics of trapped ions. Prof. Gerry is a Fellow of the American Physical Society and a member of Optica, formerly known as the Optical Society of America.

Scholarship

Prof. Gerry's recent research activity has been spread over several topics in quantum optics and quantum atom optics, with many overlaps with quantum information processing. Of special concern has been the application of the photon number parity operator to quantum metrology and, more recently, of the atomic parity operator with applications to spectroscopy and atomic clocks using ensembles of two-level atoms.

More specifically, they have worked on the problem of so-called multiphoton interference at a beam splitter, which led to an extension of the Hong-Ou-Mandel (HOM) effect. It was found that, by mixing a single photon with coherent light at a 50:50 beam splitter (versus combining two single photons in the original HOM effect), the probability of equal numbers of photons in both output beams is zero, as in the original effect. More complicated interference fringes were obtained by mixing 2 and the 3 photons with coherent light at a beam splitter.

In the area of quantum atom optics, Prof. Gerry's team studied the occurrence of spin squeezing (a signature of entanglement among the atoms) in superpositions of atomic coherent states for a collection of two-level atoms, as well as planar squeezing. Entanglement in atomic systems can lead to improvements in Ramsey spectroscopy and atomic clocks.

Prof. Gerry also proposed a scheme for a quantum random number generator based on the measurement of photon number parity. This was later realized in the laboratory of Olivier Pfister at the University of Virginia, leading to a joint paper that was published in Nature Photonics. A review article on the use of the parity operator in the context of quantum metrology was published in AVS Quantum Science in 2021.

The second edition of Prof. Gerry's book, *Introductory Quantum Optics*, coauthored with Sir Peter Knight, FRS, was published in 2024. The book received glowing endorsements from Girish Agarwal, FRS, at Texas A&M University and Mile Pagett, FRS, at the University of Glasgow.

Professional and Public Service

Prof. Gerry has reviewed manuscripts submitted for publication in Physical Review A, Journal of the Optical Society B, Optics Express, and Annalen der Physik, and also reviewed a grant proposal for the National Science Foundation.

He also serves as an external member of the Master's thesis committee for Erric Russo of Rochester Institute of Technology.

Department, College, and CUNY service

Prof. Gerry is the Department Representative on the Lehman College Senate

Dan Kabat

Prof. Kabat works on gravitational aspects of string theory, in particular the AdS/CFT correspondence. The ultimate goal of this research is to understand quantum gravity, including quantum properties of black holes, in a mathematically well-defined setting. Prof. Kabat received his PhD from MIT and held postdoctoral positions at Rutgers University, New York University and the Institute for Advanced Study. He joined the faculty at Columbia University before joining Lehman College in 2008. Prof. Kabat is a member of the American Physical Society.

Scholarship

One recent theme of Prof. Kabat's research has been the phenomenology of a moving braneworld. One conventionally considers a braneworld at rest. Putting the brane in motion spontaneously breaks worldvolume Lorentz invariance. This leads to a variety of curious effects: signals can travel faster than light and even backwards in time. Moreover, radiative corrections can induce Lorentz-violating terms in the braneworld effective action. (3 publications, additional work in progress)

Another research theme is entanglement in quantum mechanics and quantum field theory. Prof. Kabat developed a group-theoretic classification of multi-party entanglement in finite-dimensional systems, based on quotients of the local unitary stabilizer group. He also developed a Euclidean geometric prescription for defining and evaluating a regulated form of entanglement entropy in quantum field theory. The prescription avoids the need to tensor-factor the Hilbert space. (3 publications)

Prof. Kabat also investigated the so-called modular Hamiltonians of Tomita - Takesaki theory for states obtained by weakly perturbing the vacuum of a conformal field theory. (2 publications)

In line with his main interest, Prof. Kabat investigated the holographic reconstruction of a bulk AdS spacetime. Reconstruction of spinor fields and dressed gauge fields were considered and an algebraic approach to bulk reconstruction was outlined. (3 publications) In other developments, Prof. Kabat considered the behavior of axion-like dark matter around a black hole. He also elucidated aspects of anomalies in quantum field theory and quasinormal modes in potential scattering. (3 publications)

Professional and Public Service and Outreach

Prof. Kabat serves as a Divisional Associate Editor for Physical Review Letters. During the review period he also reviewed articles for Journal of High Energy Physics, Physics Letters B, Journal of High Energy Astrophysics, Physical Review D, SciPost, European Physical Journal C, and Classical and Quantum Gravity. He has conducted grant reviews for the Department of Energy, the Simons Foundation and the National Science Foundation.

Prof. Kabat co-organized a series of workshops hosted by the Initiative for the Theoretical Sciences at the CUNY Graduate Center. During the review period these workshops ranged from "Conformal Bootstrap and Related Ideas" in November 2019 to "Modern Perspectives on Symmetry" scheduled for March 2024. A total of 8 workshops were organized.

Prof. Kabat gave a series of guest lectures to docents at the American Museum of Natural History covering "Black holes and gravitational waves," "Dark matter and the cosmic web,"

and "Life and death of stars". He also delivered a summer colloquium at Barnard -- Nevis, "What is a black hole?".

Department, College and CUNY service
Prof. Kabat served as Department undergraduate advisor until 2023 and is a member of the department P&B committee. For Lehman College he serves on the pre-health evaluation committee (HealthBridge admissions and committee letter preparation), and as the College Conflicts Officer (financial conflicts on grant proposals). For one year he served on the budget and long-range planning committee of the Lehman Senate. For the CUNY Graduate Center Prof. Kabat is Deputy Executive Officer of the physics PhD program and a member of the Auxiliary Enterprise Corporation board.

Dimitra Karabali

Dimitra Karabali completed her Ph.D. at Yale University in 1986 and held postdoctoral positions at Brandeis University, City College at CUNY, Syracuse University and the Institute for Advanced Study in Princeton. She was an assistant professor at Rockefeller University and she joined the faculty of Lehman College in 1998. Prof. Karabali conducts research in theoretical high energy physics, with a recent focus on nonperturbative aspects of gauge theories and higher dimensional quantum Hall effect.

Scholarship
Prof. Karabali and collaborators, using novel techniques, have made significant progress in analyzing nonperturbative phenomena such as quark confinement and mass gap generation that are not yet analytically understood through Quantum Chromodynamics (QCD). They have studied these phenomena in the lower dimensional, but physically relevant setting of (2+1) dimensional Yang-Mills theory, and have found excellent agreement on string tension, Casimir energy and other nonperturbative probes are in excellent agreement with lattice calculations. They are currently working on extending these ideas to four dimensions.

Prof. Karabali and collaborators have formulated higher dimensional extensions of integer Quantum Hall effect (QHE) and studied a variety of aspects in these systems, such as the dynamics of edge excitations, the topological bulk effective actions and the corresponding transport coefficients, such as Hall conductivity and viscosity, the entanglement entropy, etc. Some of these results are of direct experimental interest, since higher dimensional QHE can now be engineered using the idea of synthetic dimensions. Efforts to extend the analysis to the case of fractional QHE in higher dimensions are underway.

Karabali has published 7 articles in peer reviewed journals since 2019: 4 of them are on nonperturbative aspects of gauge theories and 3 on higher dimensional quantum Hall effect.

Professional and Public Service and Outreach
Prof. Karabali is a regular reviewer for a variety of physics journals such as: Physical Review D, Physical Review B, Nuclear Physics B, International Journal of Modern Physics B. She is a regular external reviewer for promotion and tenure for physics faculty in a number of institutions in the USA and abroad. During the 2021 NSF site visit to the Kavli Institute for Theoretical Physics, she gave the invited presentation to the visit team: *Work and experience as a KITP scholar*. Prof. Karabali has served as judge in annual regional high-school science competitions (WESEF).

Department, College and CUNY service

Department, College and CUNY service

Prof. Karabali served as Department Chair for three terms, from 7/2006-7/2012 and 7/2018 to 1/2021. She has served on the Department FP&B committee from 1999 to present and as Department Undergraduate Advisor from 2015-2019 and 2023-present. She has served on many College committees, including the Salary Above Base Committee (2022), the Honorary Degree Committee (2020), the HealthBridge Steering Committee, (2019-present), the Fellowship Leave Award Committee (2006-2012, 2018-2020), and the Pre-Health Advisory Committee (2010-2020).

In addition she has served on CUNY Executive Committee of the Physics Ph.D. program, (2006-2012 and 2018-2021), the search committee for faculty positions for the Initiative for Theoretical Sciences at the Graduate Center, (2018-2019), the Qualifying Examination Committee for the Ph.D. Program in Physics, (2003, 2004, 2020), the CUNY-FRAP committee for PSC-CUNY awards (2000-2003, 2019-2020), and the supervisory/thesis committee of several CUNY physics doctoral students.

Awards

- Scholar at the Kavli Institute of Theoretical Physics at Santa Barbara, California, for 2000-2002, 2013-2015 and 2020-2022
- Selected as Lehman Professor of Excellence 2021-2024

Matt O'Dowd

Matt O'Dowd graduated with a Ph.D. in Astrophysics from the University of Melbourne in 2004. He then held a postdoctoral position jointly with Melbourne University and the Australian Gemini Office before a second postdoc at Columbia University. He joined the faculty of Lehman College as an Assistant Professor in 2011 and was granted tenure with promotion to Associate Professor in 2018. His research is in extragalactic astrophysics, and focuses on active galactic nuclei, black holes, and gravitational lensing.

Scholarship

Prof. O'Dowd's FutureLens collaboration has two primary and connected goals: 1) to understand the physics of Active Galactic Nucleus (AGN) central engines, and 2) to develop machine learning tools and infrastructure for the analysis of gravitational lensing data in the next generation of large and time-domain surveys.

O'Dowd's team takes a few different approaches to Goal 1: Through detailed modeling of the effect of gravitational microlensing on AGN inner structure, they seek to understand how to predict and analyze "caustic-crossing events" in which this structure strongly magnified bin a manner that enables its measurement down to the scale of the central supermassive black hole. A complementary approach is reverberation mapping, in which one observes the propagation of brightness fluctuations originating from the inner regions throughout AGN structure and so can constraints that structure based on the time lag in the response of different AGN components. O'Dowd's team has created the most sophisticated models to date of this effect, and demonstrated that with novel machine learning methods, AGN properties can be inferred from long-term observations of these fluctuations.

Goal 2 serves O'Dowd's science goals, but will also provide critical tools for the larger gravitational lensing community. O'Dowd partially funds the collaboration team at Stony Brook University, which is leading the development of SLSIM - the official gravitational lens

modeling pipeline for the LSST/Rubin Strong Lensing and Dark Energy Science

Collaborations. Meanwhile the team at the University of Montreal are building Caustic - a complementary machine-learning pipeline for lensing, applicable to a broad range of surveys, whose fully autodifferentiable architecture will enable fast and self-consistent inference and uncertainty analysis using realistic models. O'Dowd's Lehman College team is responsible for several of the components of these pipelines.

Six publications cover the Lehman-led components of this work.

Professional and Public Service and Outreach
Prof. O'Dowd is a very active science communicator. He is the writer, host, and co-producer of the long-running PBS show Space Time on YouTube (external link). With over 3 million subscribers and 376 episodes (at time of writing), this is one of the largest and longest-running science education channels on YouTube. Prof. O'Dowd is also regularly invited on podcasts (e.g. ext. links: RadioLab and StarTalk Radio) and to give popular science presentations at various public events.

Department, College and CUNY service
Prof. O'Dowd has served as Department Chair since 6/2021 and on the Department FP&B committee from 2015 to present, as well as Department Webmaster (2013 - 2018) and Department Assessment Coordinator (2015 - 2018). For Lehman College he has served on number of pre-health-serving committees: the HealthBridge Steering Committee, (2021 - 2022), the Fellowship Leave Award Committee (2023 - present), and the Pre-Health Evaluation Committee (2018 - 2022) and the Pre-Health Advisory Board (2021 - present). He served on the search committee for the Dean of NSS (2019 - 2020)

He has also served various roles for the PhD. Program in Physics at the CUNY Graduate Center, including: member of the Admissions Committee (2013 - present), Deputy Executive Officer (2015 - 2019), and member of the Executive Committee (2021 - present).

Non-Faculty Researchers

Jorge Fernandez Soriano
Dr. Soriano is currently working in Prof. Chudnovsky's group together with Prof. Garanin, and is focused on increasing the computational efficiency of codes previously developed within the group to conduct simulations on the behavior of skyrmions in magnetic materials.

Thomas Paul
Dr. Paul works with Prof. Anchordoqui on projects related to elucidating the origin and nature of the highest energy cosmic rays ever observed. Dr. Paul is currently coordinating the simulation effort for the POEMMA balloon with radio experiment, which will prototype novel technologies for detection of cosmic radiation from low Earth orbit. The experiment will be flown aboard a NASA super pressure balloon within the next few years.

Giorgos Vernardos
Dr. Giorgos Vernardos works with Prof. O'Dowd on multiple gravitational lensing and machine learning projects related to the FutureLens project.

James Chan
Dr. James Chan also works with Prof. O'Dowd on the FutureLens project, with a focus on

modelling quasar variability.

Summary

Strengths and Challenges

Strengths
The Department of Physics and Astronomy has some clear strengths:

1. We are an exceptionally productive research department with a superb track record of high-impact publication and successful grantsmanship.
2. We provide critical courses to a large number of students over a wide variety of programs.
3. Our students have access to excellent undergraduate research opportunities, including access to world-class institutions, facilities and collaborations.

Challenges
The main challenges faced by the Department have to do with our size, and include:.

1) With only seven department members, the administrative burden falls on relatively few individuals, and this is not significantly offset by our small major cohort due to the large number of non-majors we serve.
2) With so few faculty, there are cases where we have to assign adjuncts to teach classes that are best taught by faculty—in particular the algebra-based introductory physics courses.
3) Our relatively low number of majors means we must run smaller upper-level courses. Due to our very large 100-level courses, we've been permitted to run the needed courses consistently. However a larger major cohort would improve this situation.

The following goals are designed to address these challenges.

Hiring Goals

The Department is currently conducting two searches—for a tenure-track Assistant Professor and for a Chief Laboratory Technician, and are at the stage of reviewing applications for both.

A primary goal of the Assistant Professor hire is to strengthen our major program by offering exciting undergraduate research opportunities and by helping to build our new Concentration in Astrophysics—in particular by developing a new course in computational astrophysics. The new hire will also improve (but not solve) our high adjunct-to-faculty teaching ratio.

The Chief Laboratory Technician position is to replace our previous CLT, Elpidio Jiminez, who retired in 2020. We were not given permission to hire a new CLT because of the CUNY-wide hiring freeze and then the ongoing University and College financial concerns. As a result, we struggled on by hiring Saaber Shoyeb as an adjunct CLT, and just recently on a CLT sub-line.

Our Next Faculty Hire
The current Assistant Professor search will result in our first faculty hire in 10 years, with the last being Anchordoqui in 2014. This represents a significant slowdown in our department's growth rate (the previous was O'Dowd in 2011). While we don't imagine we'll be able to

growth rate (the previous was O'Dowd in 2011). While we don't imagine we'll be able to

make another hire on a short timescale due to CUNY's ongoing budgetary challenges, we certainly hope to make that hire before another decade passes! We feel that a reasonable timescale for that hire is 3-5 years.

That hire will address the evolving needs of the Department, which can't be entirely predicted at this time. However, we expect that our excessive adjunct-to-faculty ratio and our relatively small major cohort will not be fully solved on this timescale. To address these issues, the next hire will have a strong undergraduate teaching record and the capacity to attract new majors through exciting undergraduate research opportunities.

Program Growth

At its pre-COVID peak, our major consisted of .. students. Our first goal is to recover these numbers and then sustain and grow the major at a moderate rate of 3-5 students per year. The measures we're taking to achieve this are:

1. Assigning faculty or other excellent instructors to teach most introductory physics classes when possible. These have in the past been a good recruiting ground for majors, and having faculty teach these classes increases our chance to inspire students to study physics.
2. Offer even more undergraduate research opportunities. Undergraduates are increasingly interested in research experience, for its own sake and for the weight it has in graduate school applications. We can attract new majors by expanding our already solid undergraduate research program with a judicious new hire (see above) and by continuing to expand these efforts by existing faculty.
3. Adding a Concentration in Astrophysics to our B.S.-- see Curriculum Goals and Appendix A.

Curriculum Goals

1. Upgrade labs: this is an ongoing process. Over the next 5 years we expect to have completely replaced all remaining older lab equipment.
2. Introduce Astrophysics Concentration: The Department is planning to introduce a Concentration in Astrophysics to its B.S. Physics Major. Details may be found in Appending A.
3. New Course: Quantum Information & Quantum Computing. Prof. Gerry taught a trial version of this course in Spring 2018 and it attracted great interest from both Physics and Computer Science majors. Given the rise in importance of these topics, we plan to list this as a regular elective offering.

Appendix A: Astrophysics Concentration

The Department of Physics and Astronomy is developing an Astrophysics Concentration for our Bachelor of Science in Physics. This effort has two goals: to entice students both at Lehman and across New York City to a degree with exceptional vocational prospects, and to grow Lehman's status as a hub of computational astrophysics research in New York City.

The concentration will add select topics in computing and astrophysics to our current physics major, will provide opportunities for undergraduate research with our astrophysics faculty, and will connect students to the vibrant New York astrophysics research community. The

and will connect students to the vibrant New York astrophysics research community. The

curriculum is designed to ensure that its graduates are highly competitive applicants for top graduate schools in any physics field, and to train students with quantitative and computing skills applicable to a wide range of STEM careers straight out of this degree.

The popularity of astronomy and astrophysics with the Lehman student body is evidenced by the consistent high enrollments in our introductory astronomy course every semester (170 students in Spring '24). The enthusiasm for this field presents a great opportunity on two fronts. First, an undergraduate focus on astrophysics will be a powerful tool for attracting Lehman students into a vocationally-focused STEM program that is designed to supply the motivation and mentorship needed for timely graduation. Second, as the *only astrophysics concentration in the CUNY system*, we have the opportunity to attract talented students from across New York to Lehman College.

Lehman's current astrophysics faculty, Prof. Luis Anchordoqui and Assoc. Prof. Matt O'Dowd, are leaders in their respective fields of astro-particle physics and extragalactic astrophysics. Along with the hire from our current faculty search, and with our strong connections to the New York astrophysics community, we are in a position to offer students in the concentration exposure to world-class undergraduate research opportunities.

Curriculum for Astrophysics Concentration

Students will be part of our Bachelor of Science in Physics, and will complete the requirements for this 60-credit major, with 36 credits in core PHY courses and 12 credits in core MAT courses. The remaining 12 credits will be in Astrophysics Concentration courses.

- AST 101: Introduction to Astronomy (3 credits; can substitute AST 117) —- History of astronomy, scales of the universe, the night sky, Earth as an astronomical body, stars and stellar remnants, introduction to cosmology. Instructor: varies.
- PHY 307: Astrophysics (3 credits): —- Foundational concepts in stellar and galactic astrophysics, including physics of stars and stellar remnants, galaxy evolution, quasars, observational methods in astronomy. Instructor: Prof. Matt O'Dowd
- PHY 309: Computational Methods in Astrophysics (3 credits): —- New course in modern computational methods with application to astrophysics research, with focus on machine learning; see attached syllabus. Instructor: Dr. Giorgos Vernardos
- PHY 310: Cosmology (3 credits, currently taught as PHY 355) — Physics of the large-scale universe, including Big Bang theory, introduction to general relativity, Friedmann equations, dark energy, cosmic microwave background. Instructor: Prof. Luis Anchordoqui

In years 3 and 4 students will also participate in undergraduate research with astrophysics faculty. Optionally, students may gain credit for this as independent study (PHY 489) in year 4. Students will also be encouraged to take elective courses in computer science depending on their needs and experience.

The following represents the suggested 4-year plan for the Astrophysics Concentration:

	Fall	Spring
Year 1	MAT 172 (Precalculus) or MAT 175 AST 101 (Intro. Astronomy)	MAT 175 (Calculus I) or MAT 176
Year 2	MAT 176 (Calculus II) or MAT 226	MAT 226 (Calculus III)
	PHY 168 (Physics I)	PHY 169 (Physics II)

		PHY 207 (Math. for Phys. Science)
Year 3	PHY 241 (Modern Physics)	PHY 251 (Modern Physics Lab)
	PHY 301 (Intermediate E&M)	PHY 306 (Astrophysics)
	MAT or CMP elective	PHY 309 (Comp. Methods in Astrophys.)
Year 4	PHY 302 (Intermediate Mechanics)	PHY 303 (Thermodynamics and Stat. Mech.)
	PHY 310 (Cosmology)	PHY 400 (Quantum Mechanics)
	PHY 489 (Astro. Research Project)	PHY 489 (Astro. Research Project)

Learning Outcomes

Students completing the Astrophysics Concentration will acquire the following competencies:

- Scientific knowledge: knowledge and understanding of essential concepts and methods in physics and astrophysics.
- Problem solving: ability to formulate mathematical and quantitative descriptions of physical phenomena; ability to solve complex problems by integrating conceptual and quantitative understanding, logical reasoning, and mathematical and computational methods.
- Experimental competency: ability to formulate hypotheses and design and implement hypothesis-testing experiments, with proper use of instrumentation and computing.
- Scientific computing: ability to learn and use a variety of software for scientific modeling, analysis, and visualization; ability to develop such software using current programming languages and methods, including machine learning techniques; ability to employ modern computing resources such as GPU clusters.
- Data analysis: competency in analyzing data from experiments and simulations, including with statistical and uncertainty analysis, model testing, and data presentation.
- Communication skills: ability to communicate scientific concepts and experimental results in written and oral form.

Appendix B: Faculty CVs