

Proposal for a Chemical Physics track in the Ph.D. Programs of the Chemistry and Physics & Astronomy Departments

Rationale

Solutions for many issues confronting society today demand an interdisciplinary approach. Fundamental problems in designing materials for energy production and utilization, basic issues in surface interactions and catalysis, and complex issues in biochemistry all benefit from combined chemical and physical approaches. For the mathematically inclined chemistry graduate students or the atomic-molecularly focused physics graduate students, this combined program builds on the strengths of these students while preparing them for careers at this recognized interdisciplinary boundary. Neither our current Chemistry nor Physics doctoral degree programs are designed to meet the curricular and research needs of these graduate students.

Since we now have a critical core of faculty in the two departments to support this bridging program, the time is right to launch this program in Chemical Physics. The procedures and requirements follow the model of the interdisciplinary Chemistry/Biotechnology program offered jointly by Chemistry and Biomedical Engineering and approved by the Graduate School of Arts and Sciences in 2002. Similar Chemical Physics programs are offered by Columbia University, Harvard University, University of Illinois, University of Minnesota, and The University of Maryland, among others. Compared with these programs, the proposed program at Tufts University is somewhat broader, including requirements in electricity and magnetism and in synthesis. These broader requirements reflect the thin boundaries between departments at Tufts University as well as the particular talents and interests of the Tufts faculty.

This program is not expected to be large – a maximum of 1-2 students per year with a steady-state population of 4-8 students – but will provide students in it with the optimum balance of course work to enable a successful career. In addition, constituting the research committee with members from the two departments (and possibly biomedical engineering as well) will give the student a broad base for engaging problems in this bridge field. These students are likely to bring unique qualities to the research groups that they join and to enhance collaboration between the participating departments.

Both the Chemistry (4/13/2009) and the Physics & Astronomy (9/13/2010) departments have discussed and approved of this interdisciplinary program in Chemical Physics. [NOTE – this document will be resubmitted to the two departments for approval, and this paragraph will then be updated.]

Faculty

Faculty members from the Chemistry and Physics & Astronomy departments will offer the core courses. These faculty as well as interested faculty from the School of Engineering will serve as academic and/or dissertation advisors. Currently these faculty members include:

Chemistry

- Jonathan Kenny – Physical, Environmental, and Analytical Chemistry
- Mary Shultz – Physical and Environmental Chemistry; Aqueous and Surface Chemistry
- Charlie Sykes – Physical and Surface Chemistry
- Arthur Utz – Physical and Materials Chemistry

Physics & Astronomy

- Peggy Cebe – Condensed Matter, Polymer Physics
- Roger Tobin – Experimental Surface Physics
- Cristian Staii – Nanoscience, biological physics, biomaterials

Biomedical Engineering

- Mark Cronin-Golomb – Laser Tweezers, Nonlinear Optics, Atomic Force Microscopy
- Fiorenzo Omenetto – Ultrafast Nonlinear Optics, Nanophotonics, Materials

The research advisor for a student in the program is normally chosen in the first year and may come from the Chemistry, the Physics & Astronomy, or the Biomedical Engineering Department. The student's research committee will consist of at least one member from the Chemistry Department and one from the Physics & Astronomy department in addition to the research advisor (a total of three committee members). The Chemical Physics Graduate Committee (see below) shall advise and guide the student until the research advisor is chosen.

Admissions and Administration

A Chemical Physics Graduate Committee consisting of three members, including at least one member from each department, shall be responsible for administering the program, including admissions and transfer decisions, curricular issues, monitoring student progress, and such other issues as may arise. The committee chair may come from either department and shall be appointed by the chairs of the two departments in consultation. Students wishing to transfer into this program after matriculation will also be reviewed by this committee, and the committee will make the transfer decision.

Students will apply through either the Chemistry or the Physics & Astronomy department indicating an interest in the Chemical Physics program, or join the program after matriculation at Tufts. Applicants from chemistry with a strong background in physics and mathematics, and applicants from physics with strong atomic and molecular backgrounds would be good potential candidates for the Chemical Physics program. Applicants will be reviewed by the Chemical Physics Graduate Committee in consultation with the graduate admissions committees of the two

departments and must satisfy the admission criteria for the doctoral program of the department to which they are applying.

Students already enrolled in the Chemistry or Physics doctoral program may apply to switch into the Chemical Physics program. The Chemical Physics Graduate Committee will review and decide on such transfer applications. Due to the different core requirements for Chemical Physics compared with either Chemistry or Physics, such transfers will be most likely in the first or possibly second year.

Each student in the program shall be formally enrolled in either the Chemistry or the Physics & Astronomy department (the “host department”). That department shall be responsible for monitoring and guiding the student’s progress and for providing financial, academic and professional support and guidance on the same basis as for students in the department’s other doctoral program(s).

Curriculum

The curriculum requirements consist of a melding of those of Chemistry with those of Physics & Astronomy and are typical of those required at institutions currently offering a Chemical Physics Ph.D. degree. The curriculum has more synthesis than does the core program in Physics and more electricity and magnetism than does the core program in Chemistry. These greater requirements are balanced with a greater flexibility in the elective courses. Together the elective and core courses are balanced between the two departments. The core program consists of seven, graduate-level classroom courses at least three of which must be Chemistry courses and three must be Physics courses. These are to be completed by the fourth semester in residence and include:

- Core courses
 - Two semesters of quantum/structure consisting of either Chemistry 133 or Physics 163 and either Chemistry 136 or Physics 164.
 - One semester of electricity and magnetism consisting of Physics 145 .
 - One semester of statistical-thermodynamics consisting of either Chemistry 131 or Physics 153.
 - One course on structure/bonding, to be chosen from among Chemistry 150 (intermediate organic), 151 (physical organic), 152 (advanced organic synthesis), 161 (advanced inorganic), and 162 (transition metals).
- Elective courses
 - Two additional courses from among Chemistry 132 (kinetics), 151 (physical organic), or 162 (transition metals) or Physics 131 (Classical Mechanics), 146 (Classical Electromagnetic Theory II), 173 (solid state) or 174 (solid state). Other appropriate courses may be substituted with the approval of the student’s advisory committee.

To provide the student with experience in oral presentation, two oral presentations are required: a public seminar by the end of the fourth semester and a presentation to the student’s research committee in the fifth semester. The seminar is based on current literature, can be presented in

either department and is evaluated by the research committee. The topic for the presentation to the committee is chosen by the student in consultation with the research committee. This presentation may be waived for students having at least a 3.3 average in the core courses. In addition, the student must prepare a written, original research proposal by the end of the eighth semester. This proposal shall be somewhat distinct from the thesis work and defended orally before the advisory committee.

Degree designation

The transcript of a student who completes the doctorate in this program will carry a notation of “Major Chemistry: Chemical Physics” or “Major Physics: Chemical Physics” depending on the student’s host department.

Students in the Chemical Physics program who do not complete the Ph.D. may receive a Masters degree in either Chemistry or Physics, provided that they fulfill the departmental requirements for the degree.

Resource needs

As indicated elsewhere, the core and elective courses are all currently offered either by the Chemistry department or the Physics & Astronomy department, hence no new faculty or courses are required or anticipated. There are sufficient participating faculty in each department to offer interested students ample choice of research mentors.

Student financial support shall be drawn from the Teaching Assistant budgets of the participating departments and the research grants of the participating faculty. No new resources for student support are needed.