MASTER'S TO PHD PHYSICS BRIDGE PROGRAM: IMPACT ON A DEPARTMENT

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Education Director's Meeting

University of Pennsylvania

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International Materials Research Congress update

- See presentation under MRSEC Director's meeting

  MRSEC Recruiting/Outreach Activities

  IMRC 2016

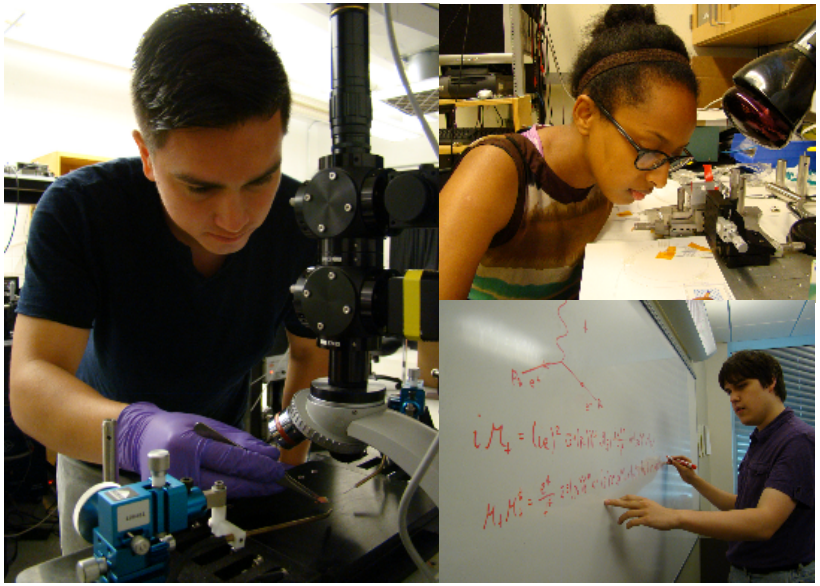
  Mark Hersam, Northwestern University

Overview

- Master's-to-PhD Physics Bridge Program facilitates admissions and program reflection and evaluation.
  - Program overview
  - Placement once students arrive through PER based placement exams
  - Graduate course enhancement through tutorials
  - Looking at retention and graduate student experience (very preliminary)

Diversity : Master's-to PhD Bridge Program

- **Goal: To prepare and develop talented URM's for PhD program**

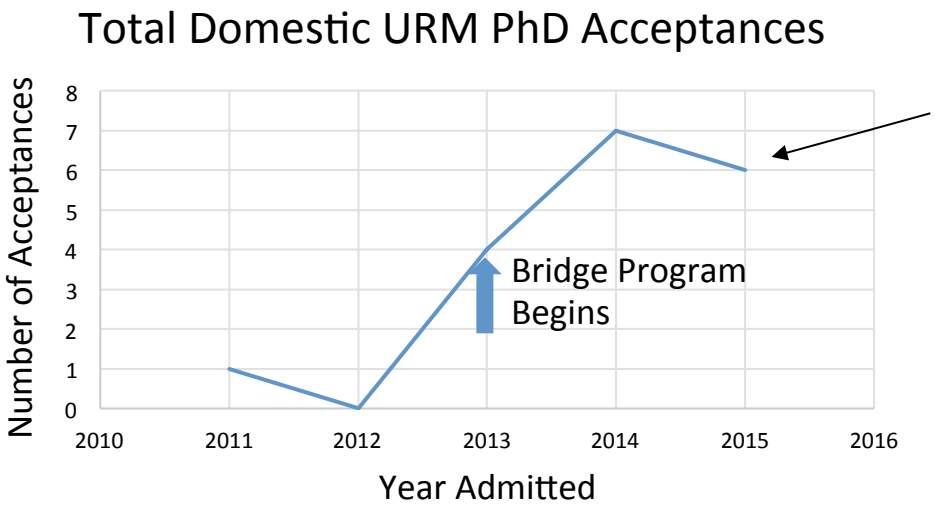


- 2 year Master's degree program
  - Critical upper undergrad/grad courses
  - Join research lab
  - Comprehensive mentoring
  - Special group-work tutorial sessions for core courses
  - 3 students recruited/year
- 5 CEM Faculty + 1 Staff on Leadership Team

12 students to date:
- 6 matriculated into OSU PhD program
- 4 currently in bridge program
- 1 matriculated to another program
- 1 applying to another program

Diversity: Bridge Program

Direct Impact on Traditional Ph.D. Program



URM's were 20% of all OSU 2015 acceptances (does not include bridge students)

- More than doubling of grad applications from pre-bridge years
- Enhancement of graduate-level courses: group-work sessions.
  - CEM is co-supporting a post doc for research-based improvements.
- Broadening impact to other departments:
  - Astronomy, MSE.

Assessment of Incoming Students

- 4 1-hour assessments: quantum mechanics, classical mechanics, electricity and magnetism, and statistical mechanics
- Open-book
- Mixture of qualitative and quantitative questions
- Designed to identify students whose knowledge and/or problem-solving sophistication is not what it should be for grad classes

Example Questions:

> 4.) (15 pts) Consider the Hydrogen atom. Calculate the expectation values (a) (5 pts) $\langle r \rangle$, (b) (5 pts) $\langle L^2 \rangle$, and (c) (5 pts) $\langle T \rangle$ (kinetic energy), when the hydrogen atom is in the $1s$ state.

Note: We test calculation ability in (a), conceptual understanding in (b), and (c) can be done either through calculation or trivially through the use of the Virial Theorem.

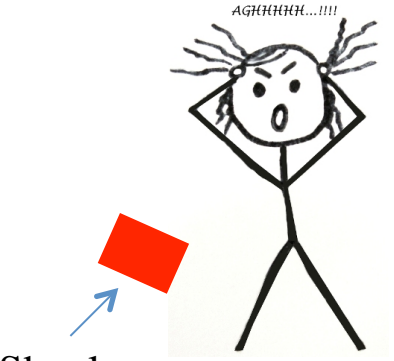
Enhancing Classroom Learning : Tutorials

- Weekly 1-hr meetings
- Open to all students, required for bridge fellows
- Students answer conceptual questions and short calculations in groups of 2-4
- May be single-topic, scaffolded tutorial or may be survey of relevant topics
- Always tuned to be very relevant to course (lecture, homework, etc)
- Materials developed for grad QM, EM, and undergrad QM, EM, and classical

Sample conceptual question:

2.) Describe to your neighbor how the exponential of an operator even makes sense. For conversational purposes, let us consider a specific example: why can I write $e^{-i\hat{H}t/\hbar}|E_n\rangle = e^{-iE_n t/\hbar}|E_n\rangle$? Here $|E_n\rangle$ refers to the n^{th} energy eigenstate.

Question proved very effective at generating discussion, and at prompting students to admit a lack of clarity



Enhancing Classroom Learning : Tutorials

Questions try to combine necessary math skills with good physical intuition:

Let $|\psi_n\rangle$ be the n^{th} energy eigenstate of the harmonic oscillator, with $|\psi_{n=0}\rangle$ being the ground state. (a) Find the set of all m such that $\langle\psi_n|x^m|\psi_n\rangle = 0$ using very basic logic, and the known properties of the states $|\psi_n\rangle$ (no calculation). (b) Prove your claim from part (a) using raising and lowering operators.

Questions try to be transparently relevant to homework and other coursework, but always with non-trivial differences:

Your homework asks you to prove that $\left[a,\left(a^\dagger\right)^n\right] = n\left(a^\dagger\right)^{n-1}$. Can you make a similar claim about $\left[a^\dagger,\left(a\right)^n\right]$? If so, find this commutation relation and state what assumptions you make. If not, explain why you cannot.

Diversity: Physics Retention

Goal: to improve diversity and retention in physics graduate program

- Logistics of integrating into the department
- Issues of identity, belonging, etc
- Special attention paid to issues disproportionately affecting URMs
- Study is just beginning

Summary

- Bridge program has implications that have positively impacted our current traditional PhD program.
- Program has increased the number of URMs in our graduate program, both through the bridge program, as well as the traditional PhD program.
- Interest in other departments at OSU for starting a Bridge program.