Physics advanced laboratory designed for engaged learning experiences

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Carleton UNIVERSITY
Canada's Capital University

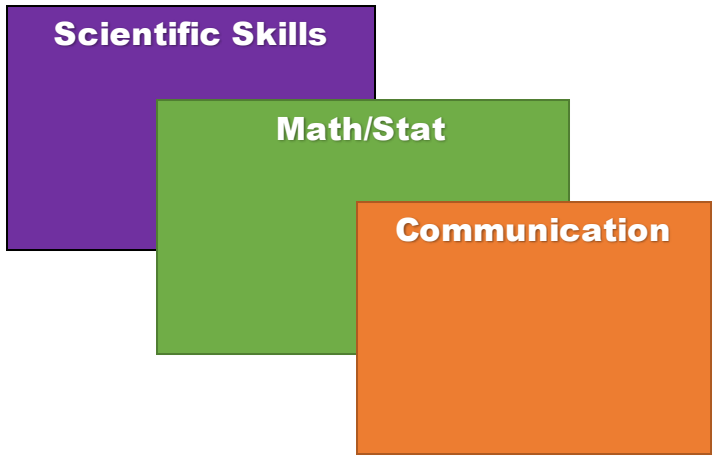
Motivations for this talk

- We wanted to evaluate our advanced laboratory experiments and review them based on:
  - Their alignment with different recommendations (Department, AAPT, etc…)
  - Employers or supervisors expectations
  - The level of engagement to motivate students
- Share and generate discussions about new experiments and potential topics that would be missing from our curriculum.

Difficulties to create a complete advanced lab curriculum

- Physics includes many subfields.
- Jobs with a physics degree are diverse.
- Students skills are developed at different levels.
- Labs are only a small fraction of a full degree.
- A new undergraduate astrophysics stream is offered this fall.

Physics laboratory skills development tree



E. Rollin 2017

Carleton University
Physics Department

Curriculum Committee
J. Armitage
April 2016

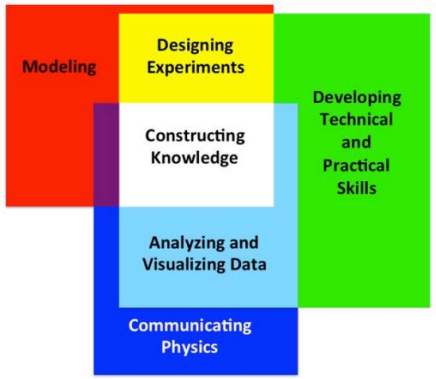
Learning outcomes

for

physics programs and courses

AAPT PHYSICS EDUCATION

AAPT Recommendations for the Undergraduate Physics Laboratory Curriculum



Report prepared by a Subcommittee of the AAPT Committee on Laboratories
Endorsed by the AAPT Executive Board
November 10, 2014

What Things Should Every Physics Major Know?

Chad Orzel, CONTRIBUTOR

I write about physics, science, academia, and pop culture. FULL BIO

Opinions expressed by Forbes Contributors are their own.

Over the weekend, cosmologist and author Sean Carroll tweeted about what physics majors should know, namely that "the Standard Model is an SU(3)xSU(2)xU(1) gauge theory, and know informally what that means." My immediate reaction to this was pretty much in line with Brian Skinner's, namely that this is an awfully specific and advanced bit of material to be a key component of undergraduate physics education. (I'm assuming an undergrad context here, because you wouldn't usually talk about a "major" at the high school or graduate school levels.)

Lab courses offered (3rd and 4th years)

PHYS 3007
Third Year Physics Laboratory: Selected Experiments and Seminars
Students complete a small number of experiments selected from modern optics, holography, atomic physics, nuclear spectroscopy, radiation, etc. An exercise on literature searches and student seminars on experimental and numerical methods are included.

PHYS 3606 and PHYS 3608
Modern Physics II (Modern Applied Physics)
Elements of condensed matter physics, semiconductors, superconductivity. Elements of nuclear physics, fission, fusion, power generation. Introduction to particle physics. Ionizing radiation: production, interactions, detection. Medical physics: radiation biophysics, cancer therapy, imaging.

PHYS 4007 and PHYS 4008
Fourth Year Physics Laboratory: Selected Experiments and Seminars
Students complete a small number of experiments selected from modern optics, holography, atomic physics, nuclear spectroscopy, radiation, etc. An exercise on literature searches and student seminars on experimental and numerical methods are included.

All the experiments offered in 3rd and 4th year labs

Atomic/Nuclear/Particle

- Alpha/Beta/Gamma Spectroscopy
- X-Ray Fluorescence
- X-Ray Diffraction
- Electron and Proton spin Resonance
- *Muon Life Time*
- Earth field NMR
- Pulsed NMR

Optics

- Laser Doppler Velocimetry
- Mach-Zehnder Interferometer
- *Holography*
- *Sonoluminescence*
- Zeeman Effect
- *Optical Pumping*
- *Saturated Absorption Spectroscopy*
- *Optical Tweezers*

E&M

- Hall Effect
- Haynes-Shockley Experiment
- Band Gap of Semiconductors
- Superconductivity
- Lock-in Amplifier

Others

- *Variable Stars*
- *Vacuum Techniques*

New experiments or modified recently for a more engaging experience, oriented for modern skill building.

Process to evaluate each experiment

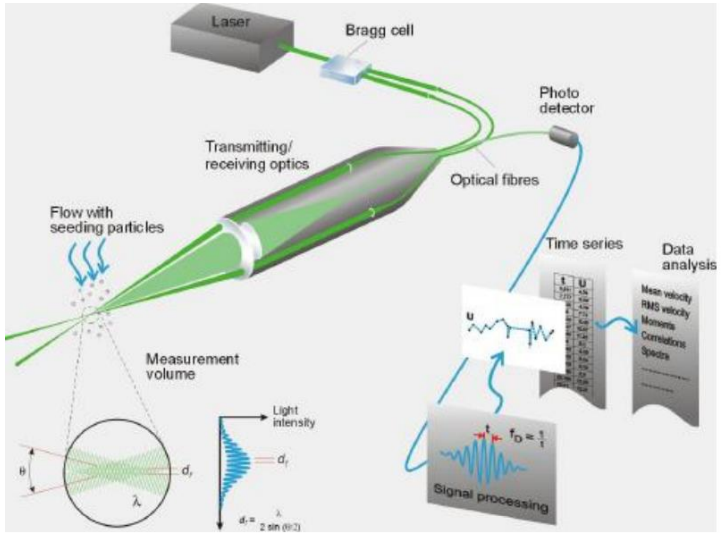
15 hrs

Thermodynamics and Fluids

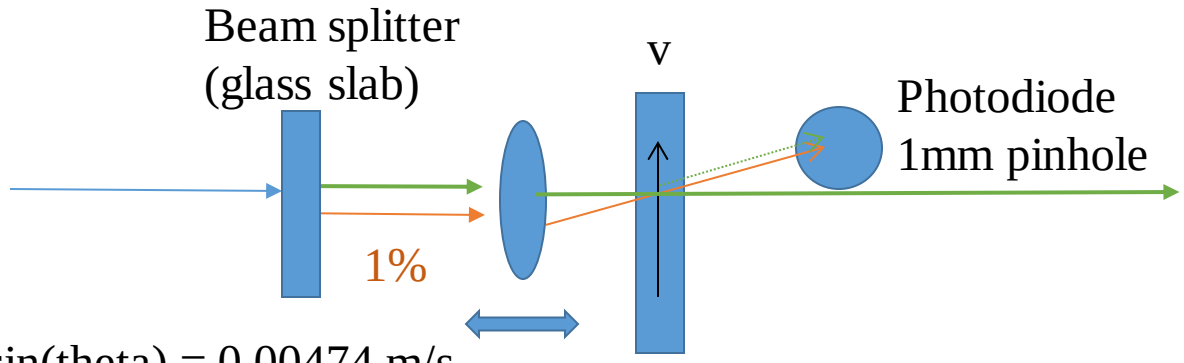
Optics

Math & Data Analysis

Laser Doppler Velocimetry, LDV



Typical water flow: 8 gal/h = 0.23 l/s
V ~ 3 m/s
Tube diameter = 15.9 mm
Laser: HeNe 474 THz



Measure water velocity profile across the radius.
Seeds are 1um spheres.

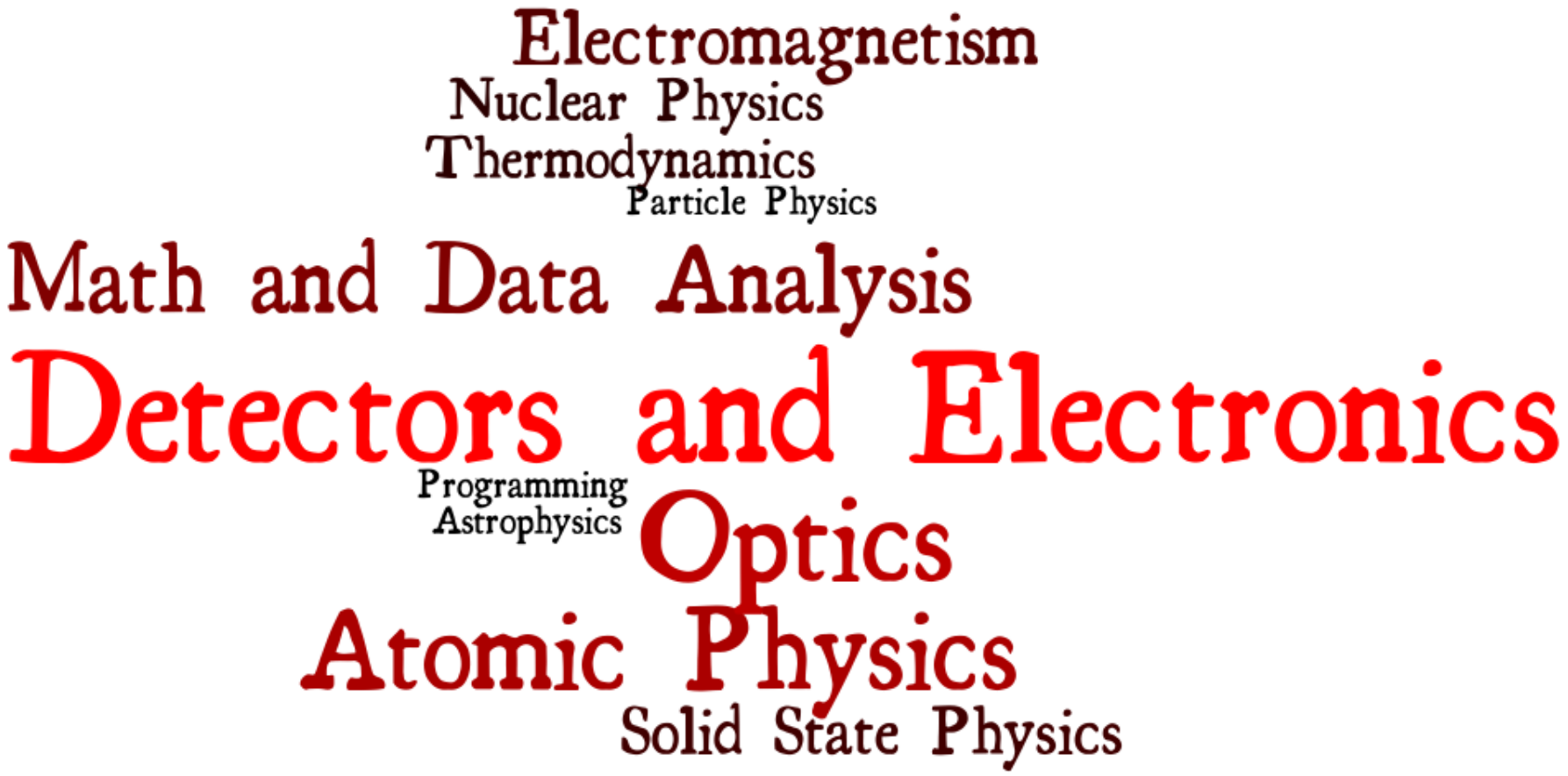
Suggestions :
PIV
Hot wire anemometry

Beating at 7500 Hz
(7500Hz*c)/474 THz = v*sin(theta) = 0.00474 m/s
v=1000*0.0047m/s
DAQ: SoundCard -> FFT
Software: Sigview ($)

(Laser Doppler Anemometry, LDA)
http://www2.cscamm.umd.edu/programs/trb10/presentations/LDV.pdf

Advanced lab topics word cloud

Does not include first and second year labs



Recommendations/Conclusions

- No need for a major reconstruction of our curriculum.
- New astrophysics experiments will be developped over the next 5 years.
- Experiments can me enhanced to make them more engaging and develop more skills with small changes. For example:
  - Letting students design their experiment, calibrate instruments, connecting cables, aligning optical elements.
  - Asking student to program a simulation or an analysis package of the experiment.
  - Removing the theory from the lab manual and instead giving a list of recommended articles.
  - …
- To develop extracurricular skills, we are working on a model to help students wanting to develop extracurricular skills (programming, electronics, job searching, etc…)

Open Discussion (if time permits)

- Have you done a similar review at your University?
- Have we missed something important?
- Any new experiments you want to share with us?
- How specialized/versatile should undergrad students be?