

PHY 591 · Spring 2027 · graduate, 3 credits

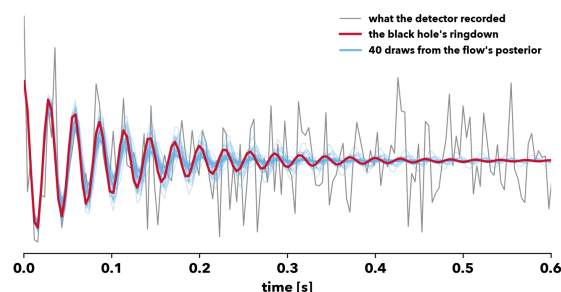
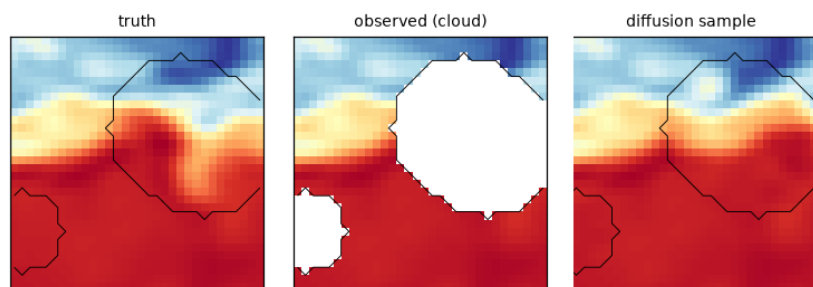
AAI4STEM

Applications of AI Methods Across STEM Disciplines

AlphaFold, AI weather forecasts, gravitational-wave inference – a handful of ideas behind all of them. Learn those ideas by **building them from scratch**, and by testing them on real scientific data against the methods they claim to beat.

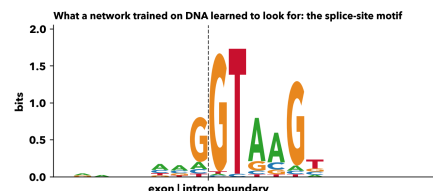
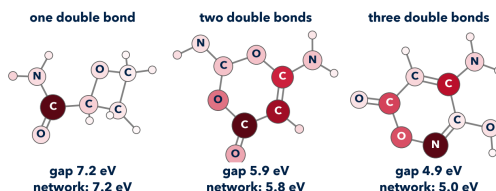
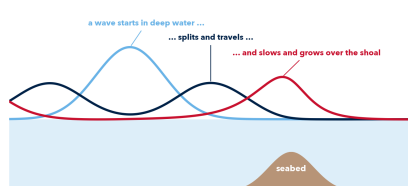
Tue & Thu
11:00-12:15

Swan Hall 211
Jan 26 – May 3



Seeing through clouds. Gulf Stream sea-surface temperature from satellite: the true field, what the satellite saw, and a diffusion model's reconstruction of the missing ocean.

Hearing a black hole. A ringdown buried in detector noise, and the posterior a normalizing flow infers for its frequency and damping time.



A network that knows physics. A coastal wave slowing and growing over a shoal, solved by a network trained on the equations of shallow water.

Where a network looks. Asked for a molecule's energy gap, a graph network learns on its own to focus on the double bonds.

Reading DNA. Shown 2 200 stretches of primate DNA, a convolutional network learns on its own the few letters that mark where an intron begins: the splice-site motif.

How the course works

- **Four weeks of foundations:** a two-week refresher of probability and regression, then a compact deep-learning primer – networks, training, regularization – with hands-on PyTorch labs every week.
- **Seven method modules,** each pairing an architecture with a science and measuring it against the field's classical method (see below). One seminar and one lab per module.
- **A team project** (2-3 people) growing from a mini-project into a capstone you present in the final week, with guest domain experts where the science lives. Laptop first; URI's Unity GPU cluster when it matters.
- **Grading:** team project 65 %, homework and labs 25 %, participation 10 %.

Who it is for

Master's and PhD students in physics, engineering, oceanography, biology, chemistry, mathematics – anyone with data and a scientific question. Taken CSC 461/561? Part I is a quick review. Advanced undergraduates by permission.

You need

Linear algebra, multivariable calculus, basic probability; working Python (NumPy, Matplotlib, Jupyter). No prior deep learning required. Textbook free online: Bishop & Bishop, *Deep Learning* (2024), bishopbook.com.

Seven applied AI method modules

Graph networks

molecules
vs. chemical
descriptors

Physics-informed nets

coastal waves
vs. a numerical
solver

Neural ODEs

measles
vs. the TSIR
model

CNNs, transformers

genomics
vs. position
weight matrices

Normalizing flows

black holes
vs. the exact
posterior

Diffusion models

ocean satellites
vs. classical gap
filling

Reinforcement learning

building energy
vs. thermostat,
optimal control

How to enroll

Register for **PHY 591 - 0001** (the catalog currently lists it under the generic title "Special Problems"). Capped at 20; register early.

Michael Pürer

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Office hours Tue & Thu 1:00-2:00 PM
Questions about fit? Just write.