George Halal

CV as of May 2021

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Education

2019–2024	**Stanford University**, *Stanford, CA, USA*.
	○ **Ph.D.** Physics (in progress), **GPA:** 4.00/4.00, **Quals:** 07/08/2021
	○ **Advisors:** Chao-Lin Kuo & Susan Clark
	○ **Courses include:** Machine Learning, Deep Learning, Signal Processing and Linear Systems, and Statistical Methods in Astrophysics
2015–2019	**Lehigh University**, *Bethlehem, PA, USA*.
	○ **B.S.** Physics & Applied Mathematics, *Summa Cum Laude*, **GPA:** 3.97/4.00
	○ **Thesis:** *"Machine Learning Applications to Jet Flavor Tagging and Centrality and Event Plane Determination in Relativistic Heavy-Ion Collisions"*

Computing Skills

Languages	Python, MATLAB, C++, LabVIEW, Arduino, LaTeX
ML	PyTorch, Keras (TensorFlow backend), scikit-learn
Technical	emcee, pyGTC, dynesty, incredible, Healpy, Meander, PySM, ROOT, PYTHIA, FastJet
CAD	SolidWorks, AutoCAD
Tools	Git, Slurm, Vim, Microsoft Office
Links	https://github.com/georgehalal/ https://georgehalal.github.io/

Laboratory Skills

Hardware	Vacuum & Cryogenic Technologies, Ultrasonic Cleaning, Epoxying, Metalworking (incl. Soldering & Magnetic Drilling), Woodworking, 3D-Printing
Electronics	Oscilloscope, Function Generator, Multimeter, Lock-in Amplifier, High Voltage & Low Voltage Power Supplies

Languages

Fluent	English & Arabic
Proficient	French

▬▬ Research Experience

DATA ANALYSIS PROJECTS:

2020–present   **BICEP & HI Data Correlations for CMB & ISM Physics**, *Advisors: Chao-Lin Kuo & Susan Clark*, Stanford University.
- Develop statistical tests for quantifying the significance of the correlation between 21-cm neutral hydrogen (HI) based foreground maps and BICEP/Keck (BK) data, comparing that with the significance of the correlation between HI and Planck data.
- Optimize the HI model and algorithm design using correlations with BK data.
- Infer dust properties in the BK region and improve the understanding of the interplay between dust and magnetic fields in the interstellar medium.
- Subtract the HI contribution from BK data to set better constraints on the search for primordial gravitational waves from cosmic inflation.

2020   **Bayesian Inference of Dust Model Parameters**, *Advisor: Chao-Lin Kuo*, Stanford University.
- Simulate a Galactic magnetic field, modeling the emission of aligned galactic dust grains to produce dust polarization maps.
- Perform Bayesian analysis on the model's parameters using data from BICEP/Keck and study their posterior distributions.

2020–Present   **Machine Learning Techniques for Stochastic Generation of Observed Galaxy Properties [rotation]**, *Advisors: Daniel Gruen & Risa Wechsler*, Stanford University.
- Develop a conditional Wasserstein generative adversarial neural network with gradient penalty (cWGAN-GP) to generate observed galaxy properties in wide-field surveys, given true galaxy properties from deep-field surveys and a set of sky maps that characterize observations.

2020   **Machine Learning Techniques for Modeling the Transfer Function of Galaxy Detection in Wide-Field Surveys [rotation]**, *Advisors: Daniel Gruen & Risa Wechsler*, Stanford University.
- Using deep neural network, find the probability of detecting a galaxy in a specific location in the sky, given the observing conditions, and model how its observed properties vary from its true properties.

2019   **Machine Learning Techniques to Search for 2-Neutrino Double-β Decay of ^{136}Xe to the Excited State of ^{136}Ba in EXO-200 [rotation]**, *Advisor: Giorgio Gratta*, Stanford University.
- Develop a deep learning model consisting of a concatenation of different neural networks, each of which is best at learning the output of different input variables, on Monte Carlo simulations. Run the trained model on real data to search for this decay and set a limit on its half-life.

2018–2019   **Machine Learning Techniques for Tagging Heavy-Flavor Jets at RHIC**, *Advisors: Helen Caines & John Harris*, Yale University.
- Simulate proton-proton and heavy-ion collisions at RHIC energies, cluster final state particles into jets, and add detector effects.
- Develop a deep learning model made of a concatenation of Long Short-Term Memory (LSTM) and fully-connected networks on a list of discriminators to classify charm, bottom, and light jets.
- Develop a new jet tagging strategy for RHIC.

2018–2019   **Machine Learning Techniques for Centrality & Event Plane Determination with the STAR Event Plane Detector**, *Advisors: Rosi Reed & Michael Lisa*, Lehigh University & The Ohio State University.
- Develop a machine learning model to identify the centrality of a collision, based on which of the detector tiles are hit during a given collision using UrQMD simulations.
- Develop another model to identify the second-order event plane of a collision by minimizing the difference between the event planes measured by the east and west detectors using real data.

2017–2018   **Performance Analysis of the STAR Event Plane Detector**, *Advisor: Rosi Reed*, Lehigh University.
- Analyze data collected by the detector that was installed for the RHIC 2017 run, colliding protons and gold ions, to optimize its final design.
- Compare the detector's measurements to the other detectors at the STAR experiment, and verify that the electronics work properly.

2016   **Di-hadron & Jet-Hadron Correlations in Proton-Proton Collisions**, *Advisor: Rosi Reed*, Lehigh University.
- Simulate particle collisions, and analyze the azimuthal angular correlations between back-to-back hadrons and jets to study quenching effects.

HARDWARE PROJECTS:

2019   **Detector R&D for the nEXO Experiment to Search for Neutrinoless Double Beta Decay [rotation]**, *Advisor: Giorgio Gratta*, Stanford University.
- ○ Build and operate a set of tests to understand complicated electron emission phenomena when high voltage is applied in liquid xenon.
- ○ Design and build a new liquid xenon TPC test setup, including cryogenics and controls.
- ○ Analyze data collected from these tests.

2016–2018   **Building an Event Plane & Centrality Detector for the STAR Experiment**, *Advisors: Rosi Reed & Michael Lisa*, Lehigh University & The Ohio State University.
- ○ Build and test a detector designed such that when a minimum ionizing particle (MIP) hits one of the optically-isolated tiles of this detector, which are made of plastic scintillator, photons are generated through scintillation. The photons then travel through wavelength-shifting fibers embedded in the tiles to clear optical fibers to be detected by silicon photo-multipliers (SiPMs).

2017   **Cosmic Ray & Radioactive Source Testing of the Event Plane Detector**, *Advisors: Rosi Reed & Michael Lisa*, The Ohio State University.
- ○ Build two teststands that make use of cosmic rays and a radioactive source to quantify the quality and uniformity of the different sectors of the detector.
- ○ Connect different electronics boards to each other and to silicon photomultipliers (SiPMs) to digitize the signals detected.
- ○ Perform different calculations, such as the distance an electron from the radioactive source can travel through different materials before stopping.
- ○ Analyze data collected from these tests.

▬▬▬ Research Grants

2018   **Eckardt Scholar Research Project Grant**.
For conducting research at Yale University

2017   **CAS Undergraduate Research Grant**.
For conducting research at The Ohio State University

2017   **Summer Research Participation Fellowship**.
For conducting research at Lehigh University

First-Author Publications

In Progress **"BICEP & HI Correlations for HI-Based Foreground Model Optimization,"** *The Astrophysical Journal*

In Progress **"Machine Learning Techniques to Search for Two-Neutrino Double-Beta Decay of ^{136}Xe to the Excited State of ^{136}Ba in EXO-200,"** *Phys. Rev. C*

Honors & Awards

2019 **Leigh Page Prize (declined)**, *Yale University*.
A prize awarded by the Yale Physics Department to the top students accepted into the Ph.D. program.

2019 **Dean's Fellowship (declined)**, *Columbia University*.
A five-year fellowship awarded to the top students accepted into the Graduate School of Arts and Sciences at Columbia University

2019 **E. Raymond Binkley Prize**, *Lehigh University*.
A monetary prize awarded to the top-ranking senior majoring in physics.

2019 **LR Writing Award (tied for 1st place)**, *Lehigh University*.
A monetary prize awarded to the authors of 7 papers chosen to be published in the Lehigh Review journal.

2017 **Malcolm J. Gordon, Jr. Physics Prize**, *Lehigh University*.
A monetary prize awarded to the top-ranking sophomore majoring in physics.

2015–2019 **Dean's List**, *Lehigh University*.

2015–2019 **Merit Scholarship**, *Lehigh University*.

2015–2019 **Eckardt Scholar**, *Lehigh University*.
A highly selective honors program at Lehigh University with special benefits.

Teaching & Outreach

2020 **Mechanics and Special Relativity:** first in the advanced physics series.

2020 **Stanford PIE Program:** mentoring students from underrepresented groups in physics on applying to doctoral programs.

▬▬▬ Research Communication Experience

CONFERENCES & WORKSHOPS:

2019 **"Search for Excited State Decays with Machine Learning"**, *EXO-200 Collaboration Meeting*, Stanford, CA

2019 **"Feasibility of Tagging Heavy Flavor Jets at RHIC with Machine Learning"**, *APS April Meeting, Session L15.6*, Denver, CO

2019 **"Machine Learning Techniques for Tagging Heavy Flavor Jets at RHIC"**, *ML@STAR Workshop*

2019 **"Machine Learning Techniques for Tagging Heavy Flavor Jets at RHIC"**, *2nd JETSCAPE Winter School and Workshop*, Texas A&M University, College Station, TX

2018 **"Feasibility of Tagging Heavy Flavor Jets at RHIC Using Machine Learning"**, *The STAR Winter Analysis Meeting*

2018 **"Machine Learning and Optimization with the Event Plane Detector"**, *The STAR Collaboration Meeting*, Lehigh University, Bethlehem, PA

2017 **"A Centrality and Event Plane Detector for STAR to Complete the Phase Diagram of Quantum Chromodynamics"**, *APS Division of Nuclear Physics (DNP) Meeting, Section EA.075*, Pittsburgh, PA

SEMINARS & SYMPOSIA:

2021 **"BICEP & HI Correlations for ISM and CMB Physics"**, *KIPAC Tea*, Stanford University, Stanford, CA

2020 **"Conditional Generative Adversarial Networks and Gaussian Processes"**, *KIPAC Machine Learning Seminar*, Stanford University, Stanford, CA

2019 **"Neural Networks: a Quick-start Guide"**, *Lehigh Astro-Particle-Nuclear Physics Seminar*, Lehigh University, Bethlehem, PA

2018 **"Feasibility of Jet Flavor Tagging at RHIC"**, *Lehigh Astro-Particle-Nuclear Physics Seminar*, Lehigh University, Bethlehem, PA

2018 **"Machine Learning for Heavy Flavor Jet Tagging"**, *Yale Wright Laboratory Undergraduate Summer Research Symposium*, Yale University, New Haven, CT

2018 **"An Event Plane Detector to Better Understand the Strong Force"**, *Lehigh Astro-Particle-Nuclear Physics Undergraduate Research Symposium*, Lehigh University, Bethlehem, PA

2018 **"Introduction to Machine Learning in Physics"**, *Lehigh Astro-Particle-Nuclear Physics Seminar*, Lehigh University, Bethlehem, PA

2017 **"An Event Plane Detector to Understand the Structure of Quantum Chromodynamics"**, *Lehigh Physics Undergraduate Research Symposium*, Lehigh University, Bethlehem, PA