

# 2017-2018 Boston QuarkNet Center Annual Report

## **February 8, 2018**

After some initial socializing and snacks, Chris Fuchs (Physics Professor at UMass Boston) gave an engaging talk that wove together ideas about quantum mechanics (The quantum-mechanical wavefunction describes our ideas about reality; it is not a description of reality.), probability (Probability estimates are in our heads, not items in the world.), and pragmatist American philosophy (We create our understanding of the world as we experience it. The world is not separate, immutable, and predetermined.). After some Q&A, we went back to the snacks and finished the evening with information about the Particle Physics Masterclass presented by Mike Wadness.

The interest and questions of Ayo Awobode, Tim Fitzgibbon, Gerry Gagnon, Mike Hirsh, Robert Moore, Ken Rideout, Hema Roychowdhury, Phil Thornton, Mike Wadness, and Rick Dower made the meeting a success.

## **March 17, 2018 – CMS Masterclass at Northeastern University**

After demonstrations of alpha and cosmic ray particle tracks in a cloud chamber and magnetic bending of an electron beam in a cathode ray tube, adults and students introduced themselves. Then Darien gave a talk about particle physics, CERN, the LHC, and the CMS detector. Mike walked us through the Masterclass data analysis process before lunch. After lunch at the Northeastern Student Center with physicists, the students were split into two groups: one to take a tour of a biophysics lab and the other to start the CMS particle event analysis task. After the first group finished its tour, the groups switched activities. When the second group returned from its tour, all the students working in pairs from different schools started analyzing CMS events in earnest. Pairs were able to categorize about 70 to more than 100 events before we had to conclude that exercise and look at the whole group data in anticipation of our video conference with students from Minnesota, Quito, Ecuador, and Bogota, Columbia. The neutral particle mass histogram of our student data showed clear peaks at the expected masses for the J/Psi, Upsilon, Z, and Higgs particles with relatively little background confusion. In spite of some technical difficulties with our video and audio equipment, the conference went well with Q&A among the various groups and the Moderators at Fermilab.

We wrapped up after shortly 5 pm, and the students, teachers, and event organizers went home happy after another informative and enjoyable learning experience.

## **May 22, 2017**

We had a convivial spring meeting this past Tuesday. Robert Moore hosted us in his Physics Lab at Roxbury Latin School. Mike Wadness brought his two growing boys. George Odell, Tim Fitzgibbon, and Mike Hamblin were there, and Ayo Awobode joined us for a finale. Rick Dower brought the picnic. We started with the “Collide”

cover by Howie Day of the CERN lyrics and moved on to a conversation between Newton and Einstein set to a tune from the musical *Wicked*. Mike Wadness showed a clip of a conversation in which Bill O'Reilly argues for the existence of God based on his purported inability to explain the action of tides, coupled with Neil deGrasse Tyson's response. George Odell showed portions of his favorite "Crash Course" videos. We all agreed on the student (and teacher) interest generated by videos from Veritasium, Physics Girl, and Minute Physics.

### **August 14-15, 2018**

Seven intrepid physics teachers, Mike Hamblin, Tammy Kjonaas, Tim Fitzgibbon, Scott Carlson, Mike Hirsh, Jamison Smith, and Amanda Harnden, braved the August heat and joined Rick Dower in the Physics Lab at Roxbury Latin for our summer workshop, "Black Holes and Other Astronomical Beasts." Acquaintances were renewed, our new participant, Jamison (from Thayer Academy) introduced, and snacks consumed as we gathered.

Rick expressed thanks to the Roxbury Latin School Headmaster, faculty, and staff. Then he started the workshop with a brief introduction to fundamentals in astrophysics – Astrophysics 101, and a comment about the recognition, 100 years ago that some stars, including Sirius B, are incredibly hot, dim, small, and dense, *i.e.* white dwarfs. The teachers worked with observational data to determine the distance to the Sirius A-B system and the mass, luminosity, radius, surface gravity, and density of each component. Mike Hirsh gave an illustrated talk (based on Kip Thorne's *Black Holes and Time Warps*) about the historical development of ideas about white dwarfs, neutron stars, and black holes. After a few notes from Rick about radio astronomy and the discovery of pulsars by Jocelyn Bell and Anthony Hewish in 1967, we started working with data on the binary pulsar, PSR 1913+16, discovered by Russell Hulse and Joe Taylor in 1975 before breaking for lunch.

After lunch Rick demonstrated a paraffin wax comparative photometer that can be used, with an incandescent light bulb, to estimate the luminosity of the Sun. Pieces of paraffin and aluminum foil to make the photometers were given to all. After that we tackled Penn State activities on matching templates to gravity wave signals from coalescing stars of various types and calculating properties of neutron stars based on a simulated gravity wave signal. Then it was back to calculations to see the influence of gravitational radiation on the PSR 1913+16 orbit. The original observations and calculations by Hulse and Taylor were recognized by the Nobel Prize in 1993.

Our second day of the workshop began with a Skype commentary by Raheem Barnett from Thailand, moderated by his father, John, who was present with us, about a project to make a cyclotron. Raheem began the project when he was a student at a local school before going off to Princeton. He graduated this past June. Now he hopes to pass on the parts of the project that he completed to another student who can try to finish the construction.

After saying good-bye to John Barnett, Rick showed the Veritasium video (<https://www.youtube.com/watch?v=EAyk2OsKvtU>) about the LIGO observation of coalescing neutron stars (GE170817) a year ago and the confirming observations with gamma-ray and optical telescopes. While in a video mood, we watched the Perimeter Institute video about black holes (available free for download as part of their Black Holes education package).

Rick talked briefly about the transition from idea to evidence about black holes with the advent of x-ray astronomy in the 1960s, particularly with the discovery of Cygnus X-1 and its optical companion, HDE226868. Then we worked through an exercise on the Cygnus X-1 system adapted from the Perimeter Institute. After lunch, Rick showed photos of the LIGO installation in Livingston, Louisiana, and we engaged with an exercise, produced by Joe Camato, that used the LIGO signal GW150914 to determine some characteristics of the merging black holes that produced the signal. Mike Hirsh gave us a chance to test our hearing while listening for black hole merger chirps in the midst of a noisy signal on the site Cardiff University site <http://blackholehunter.org/game.html>. We made it to Level 7 on the test.

We finished the work of the day with some Rick's photos of the European Southern Observatory 8.2 m telescopes in Chile, youtube videos of stars orbiting around the 4-million-solar-mass black hole at the center of the Milky Way ([https://www.youtube.com/watch?v=u\\_gggKHvfGw](https://www.youtube.com/watch?v=u_gggKHvfGw), <https://www.youtube.com/watch?v=FdUeBOY6KbQ>), and another Perimeter Institute exercise to see how that supermassive black hole mass is calculated.

Finally, Ulrich Heintz, just back from a particle physics conference in Viet Nam, showed us some photos from the conference, brought us up to date of the latest upper limits from analysis of LHC data, and invited us to participate in the public science part of the Providence Water Fire Festival on Saturday September 22. All are invited to attend, and Ulrich is looking for volunteers who want to assist with some of the science activities at the Festival. Please contact him ([ulrich\\_heintz@brown.edu](mailto:ulrich_heintz@brown.edu)), if you are interested. We departed the workshop tired but happy with all that had been accomplished and with ideas for classroom applications of Newtonian gravitational dynamics to some of the most recent and exciting developments in astrophysics.

