Boston QuarkNet Center

2020-2021 Annual Report

 With teachers in our area, as well as the rest of the country, coping with several challenges posed by teaching some students remotely and teaching some students in person, we did not hold our usual fall and winter meetings this year. Finally, in 2021 with COVID vaccines readily available and students returning to school full-time, we decided to have a meeting on May 18 via Zoom and a summer workshop in person an August 3-4.

May, 18, 2021

 Thanks to all members and guests who attended our first Boston QuarkNet Zoom meeting and made it so enjoyable - Scott Carlson, Mike Hirsh, Brooks Hedstrom, Jon Kelley, David Kurtz, Nicole Preiser, Brandon Schmidt, Jamison Smith, Mike Wadness. We were pleased to have Ken Cecire from QuarkNet Central on board also.

 We began the evening with a brief chat. We shared the pleasure of meeting again and the difficulties of teaching students in this past pandemic year. Ulrich Heintz, our Mentor from Brown University, gave an illuminating talk on parity conservation and non-conservation in physics. Ulrich’s talk placed the theory of T. D. Lee and C. N. Yang (Nobel Prize 1957 for both) in a wider context of conservation laws, including the link that Emy Noether made between the continuous symmetries of spatial translation, spatial rotation, and time translation and our familiar linear momentum, angular momentum, and energy conservation laws. He clarified the distinction between polar and axial vectors and between scalars and pseudoscalars. His description of the experiments of Wu and Lederman was helpful in clarifying details of their experimental procedures. Beyond that, he took on CP symmetry violation and the experiment of Cronin and Fitch (Nobel Prize 1980). As Ulrich noted, these symmetry violations in physical processes can explain some but not all the prevalence of matter over antimatter in the universe. So, the observed prevalence of matter remains problem waiting for a solution (and a Nobel Prize).

 After Ulrich’s talk, we voted in favor of holding an in-person workshop this summer. Rick Dower offered to prepare a workshop on "Photons: X-rays and Gamma Rays.”

August 3-4

  August 3-4 saw our first in-person QuarkNet meeting since February 2020. Bryan Dunn, the new Science Chairman and physics teacher at Roxbury Latin School, hosted Mike Hirsh, Mike Wadness, Tim Fitzgibbon, Abe Phelps, Mark Zagaski, Dave Kurtz, John Kelley, Scott Carlson, and RIck Dower at our usual meeting spot in the Physics Lab at Roxbury Latin School. We also had the pleasure of Ken Cecire’s company from QuarkNet Central. The workshop focused on the developing understanding of x-rays and gamma rays with some examinations of current activities involving each type of photon.

  We began with old friends and new members of our group glad to, once again, greet each other in person. Then Rick made a presentation on the history of the photoelectric effect and provided an activity in which workshop participants plotted Robert Millikan’s data to see his verification of Einstein’s photoelectric equation and measurement of the value of Planck’s constant (*h*). Rick noted the Perimeter Institute exercise

 ( <https://resources.perimeterinstitute.ca/collections/featured/products/investigating-plancks-constant-with-leds?variant=36262297990> , available for free) for physics students that uses LEDs to measure the Planck’s constant value in a kind of inverse photoelectric process.

  Rick gave presentations on the early history of x-ray research and on Henry Moseley’s use of x-rays to show the connection between atomic number and nuclear charge in his 1913 and 1914 papers. After lunch, the participants worked with Moseley’s data to examine that connection themselves. Following that we had a Zoom presentation by Dr. Pat Slane on the Chandra X-ray Astronomy satellite - how it worked and some of what its investigations have found. A recording of our Zoom session, including Q&A can be found at:

<https://us02web.zoom.us/rec/share/x85GROqOPvllDpPsVBf1la5YW--ALAloO2rzrRCSXSbQgTKzE_iY3skrIpQayIj8.S8ZfuSe_mdIZ0Fk1> Passcode: 0^vsI2R2   .

  We finished the first day with a look at the diffraction pattern of a helical spring from a retractable pen and an exercise that use that diffraction pattern as an analogy to the DNA diffraction pattern of Rosalind Frankiln’s famous Photo 51 that was used by Watson and Crick to confirm their determination of the double helix structure of DNA.

  On day two, we looked at the use of x-ray fluorescence spectrometry (first suggested by Henry Moseley) with modern instrumentation to examine the elemental composition of materials from pigments in old paintings to scrap metals to mineral ores. Rick gave a presentation on x-ray astronomy to supplement Pat Slane’s account yesterday. The Rick gave a presentation on gamma rays including an image of his bone scan produced by 141 keV gamma rays from Tc-99m.

After a quick review of relativity formulae relating energy, momentum, and mass (followed by lunch), we engaged on an activity in which we analyzed Arthur Compton’s data on the inelastic scattering of x-rays and gamma rays. Compton’s work in 1923 (Nobel Prize in 1927) along with his Nobel lecture and subsequent *Scientific America*n article established the use of the term “photon.” We wrapped up our activities by measuring the half-life of Ba-137m that emits 662 keV gamma rays and hearing about recent observations of PeV gamma rays from the Crab Nebula and other cosmic sources.

  The workshop concluded with teachers developing implementation plans for possible use of some of the ideas and activities into their classroom plans for the year.

  Ken kindly posted the implementation plans on our Boston center page on the QuarkNet website.

  Since the conclusion of the workshop, Rick has developed updated student versions of the activities along with teacher’s versions in which calculations, derivations, and answers to questions are provided. All of these are posted, along with the slide presentations used during the workshop on the QuarkNet website at  <https://quarknet.org/content/boston-quarknet-summer-workshop-2021>.

  A good time was had by all, and we look forward to another gathering later this fall.