Quantum Mysteries Camp
Student Session Options

This unique camp is designed for secondary students who are curious and want to learn more about black holes, dark matter, relativity, particle physics, bubble chambers, and other quantum phenomena. Students attending the camp will select (four topics from the list below) they want to learn about. There are nearly 20 topics to choose from and the topics vary in math background requirements. To register and select topics go to https://goo.gl/dgcsLk. The $10 registration fee includes a light lunch and t-shirt.

Session #1
Seeing Black Holes with an Earth Size Telescope

Black holes are regions of space where gravity is so strong that nothing can escape, not even light. To date, everything that scientists know about black holes is based on scientific models and indirect observations. The Event Horizon Telescope (EHT) hopes to change this. The EHT is a network of radio telescopes spanning the globe whose goal is to take the first ever image of the black hole at the centre of the Milky Way Galaxy (Sgr A*) and its immediate surroundings. This session will focus on what EHT is, how it works, and why it is important. (minimum of Algebra I and Geometry recommended)

Session #2
Estimating the Mass of a Supermassive Black Hole

Observational evidence of stars orbiting the centre of the Milky Way Galaxy gives compelling evidence of the existence of a supermassive black hole. The supermassive black hole is called Sagittarius A*, or Sgr A*. Using a technique called adaptive optics, pioneering work has allowed astronomers to clearly see the orbital motion of stars near the centre of the Milky Way Galaxy. This session will use orbital data and Kepler’s third law to estimate the mass of Sgr A*.(Algebra II recommended)

Session #3
How Do you Make a Black Hole?

Black holes are mysterious regions of space where gravity is so strong that not even light can escape. They are created when very massive stars run out of nuclear fuel, stop burning, and collapse in on themselves. This session will explore the lifecycle of stars and their ultimate fates and how mass of a star dictates whether it ends up as white dwarf, a neutron star, or a black hole. (no math prerequisite)

Session #4
Where Does a Black Hole Come From?

How are black holes created? What astronomical processes give birth to these mysterious objects? This session will explore the competing forces acting inside stars to understand how intense gravitational forces can ultimately lead to the creation of black holes. The session will include an investigation of the general stellar life cycle and what determines whether a star ends its life as a white dwarf, a neutron star, or a black hole. (completion of Algebra I recommended)

Session #5
Why You Can’t Escape from a Black Hole

One of the most frequently made statements about black holes is that “nothing can escape from a black hole." But what does this exactly mean? And why can't anything escape? In this session you will explore this statement, first, from the perspective of Newton's theory of universal gravitation and conservation of energy using the concept of escape velocity then consider it from the perspective of Einstein's model of gravity (general relativity) using a simple hands-on water-based model of a black hole. (completion of Algebra I recommended)

Session #6
Functions of the Global Positioning System (GPS)

The GPS broadcasts signals that require incredibly precise timing information. To facilitate this, each GPS satellite houses an atomic clock capable of measuring time to within a fraction of a nanosecond. The GPS is so precise it must take into account the effects of Einstein's theory of relativity-both special relativity and general relativity. This session will introduce you to Einstein's theory of relativity and how it relates to the current use of GPS by your iPhone, computers, and technology. (no math requirement)

Session #7
Evidence Supporting Dark Matter

Physicists have observed many other galaxies and most are now convinced that, on average, dark matter accounts for 90% of the mass of every single galaxy in the universe. By measuring orbital speeds of stars within Triangulum, physicists have calculated the mass of this galaxy. This session will help you understand principles underlying orbital speed and the relevance to dark matter. (completion of Algebra I recommended)

Session #8
Current Theories of Dark Matter

This session will provide background as to the competing theories for dark matter as well as failed theories. Discussion will also include advanced math for gravitational lensing. (no math req)

Session #9
Where Does Energy Come From: Newton vs Einstein and Time

This sessions involves several thought experiments and the use of logic to discover something fascinating about the nature of time and space. You will leave with a better understanding of Einstein's theory of relativity

Session #10
Where Does Energy Come From: Special Relativity

Following the logical consequences of universal relativity, scientists have so far discovered time dilation, length contraction, and a universal speed limit. In this activity, you will conduct several thought experiments and use logic to discover something fascinating about energy.(Scientific Models: Time is suggested as a prerequisite)

Session #11
The Expanding Universe

This activity is designed to understand the nature of our expanding universe and how galaxies that are farther from us appear to be moving faster than galaxies that are nearby. (no math requirement)

Session #12
Signature of the Stars

Rainbows reveal a property of white light which is a combination of all the colors. In 1666, Isaac Newton showed that white light could be separated into its component colors using glass prisms. Soon scientists were using this new tool to analyze the light coming from several different light sources. This session will help you understand how astronomers learn about a star's motion, temperature, and composition by analyzing the starlight that reaches the Earth. (no math requirement)

Session #13
Particle Zoo

We have come a long way from Dalton and the indivisible atom. First, Thomson found the electron, Rutherford discovered the proton, and in 1932 Chadwick found the neutron. Then, the list expanded over the next 30 years to include over 90 different particles. Particle physics in the 50s and 60s was much like chemistry in the 1880s: a tremendous amount of data but no widely accepted theory to provide an organizing structure.
In this session you will examine some of these particles, identify a pattern, and explore a theory that will help us tame the particle zoo, just as Mendeleev did for the elements when he built the first Periodic Table. (no math requirement)

Session #14
Bubble Chamber Detective

Physicists discovered dozens of different 'elementary' particles using bubble chambers. Bubble chambers are large vessels of superheated liquids (usually hydrogen) in a uniform magnetic field. Identical charged particles are injected into the chamber where they collide inelastically with protons in the liquid to form new particles which may or may not decay. The following principles will allow you to analyze the events photographed in a bubble chamber:

Session #15
Finding Top Quark

In 1995, Fermilab discovered evidence for the sixth and final quark of the Standard Model. This was done by accelerating and colliding protons and antiprotons together to form a top quark and an antitop quark. The energy of the protons was converted into the mass of the quarks via E = mc2. The two quarks cannot be detected directly because they decay immediately into other particles. This session will demonstrate how momentum and energy of the decay particles can be used to determine the mass of the original pair. (completion of Algebra I preferred)

Session #16
Understanding the Photoelectric Effect and Phosphorescence

The photoelectric effect (where electromagnetic radiation ejects electrons) led to an understanding of the quantum nature of light and influenced the formation of the concept of wave-particle duality. This session will investigate how intensity of light and energy are related to the photoelectric effect and phosphorescence. (no math req.)

Session #17
The Challenge of Quantum Reality: Wave Particle Duality

One of the most important experiments in quantum physics is the double-slit experiment. In this experiment, individual quantum objects, such as electrons or photons, are fired at a barrier with two narrow slits. After passing through the slits, they produce an interference pattern on a detector screen on the other side of the barrier. This result leads to one of the deepest mysteries of quantum physics—wave–particle duality—the fact that electrons and other quantum objects behave like waves in some situations and like particles in others. This session will include investigating the nature of classical objects and classical waves and compare them to electrons. (no math requirement)

Session #18
Discovering Gravitational Waves

Recently, a global team of scientists announced that they had observed gravitational waves – ripples in the very fabric of space – for the first time ever. This session will help you understand some of the key concepts behind gravitational waves and answer questions including: 1) how does mass warp space, 2) how does a gravitational wave affect space, and 3) how does LIGO work? (no math requirement)

Session #19
Determining Planck's Constant

In the late 1800's, physicists were trying to model atomic vibrations, but they kept getting it wrong. Reality looked completely different from theory and no one knew why. Planck decided that atomic vibrations could be quantized and the resulting research opened a new field of physics called quantum mechanics. The discovery that atoms could only vibrate at certain frequencies of some base number (h) was the quantum in "quantum mechanics". Learn what this constant is and why it is important. (Alg I)