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2008 NOBEL PRIZE IN PHYSICS FOLLOWS EXPERIMENTAL CONFIRMATION BY HIGH ENERGY PHYSICISTS

UVic physicists' team made discovery predicted by Nobel Laureates

Half of the 2008 Nobel Prize in Physics was awarded this week to Makoto Kobayashi and Toshihide Maskawa for the 1972 explanation of a peculiar difference between matter and antimatter first detected in 1964. In a text-book example of the scientific method at work, Kobayashi and Maskawa not only explained the existing data but made bold new predictions, each of which has been experimentally verified. The final experimental confirmation cited by the Nobel committee was provided by two independent discoveries made by teams based at Stanford, California and Tsukuba, Japan. UVic high energy physicists on the Stanford-based team have been celebrating the awarding of the Nobel Prize and the role they played in validating the Kobayashi-Maskawa theory. UVic principal investigator Dr. Michael Roney, together with Drs. Robert Kowalewski, Randall Sobie, Justin Albert and Swagato Banerjee together with their team of graduate students are part of the BaBar collaboration based at the Stanford Linear Accelerator Center (SLAC) which published the discovery in 2002.

Despite claims in Dan Brown's popular novel *Angels and Demons*, antimatter has been studied extensively since the 1930's. In fact, antimatter, which can be created and occurs naturally in radioactive decay, provides the basis for the Positron Emission Tomography, or PET, medical imaging system. PET is a decades-old technology that detects particles produced in the annihilation of electrons and their antimatter counterparts, positrons.

Although antimatter is nothing new, a major puzzle for physicists has been the fact that both matter and antimatter were present in equal amounts at the birth of the universe, but that today we see a matter-dominated universe. To understand how the universe became matter-dominated requires the type of peculiar asymmetry between matter and antimatter discovered in the 1964 experiment of James Cronin and Val Fitch which won them the Nobel Prize for physics in 1980. This was the type of asymmetry Kobayashi and Maskawa were attempting to describe mathematically.

At the heart of the Kobayashi and Maskawa model is a prediction that there should be at least six quarks at a time when experimental physicists had only seen evidence for three quarks. The model's first success was the subsequent experimental discovery of the three additional quarks: in 1974 the 'charm' quark was discovered followed by the 'bottom' quark in 1979 and later, in 1994, the 'top' quark was discovered. But in addition to the six quarks, the model asserts that the interaction quantum state of a quark (i.e. those features of the quark that determine how it interacts with other particles) is different from the quark's quantum state associated with its mass. Kobayashi and Maskawa described a simple relationship between the quark mass and interaction quantum states which also provided an explanation for the type of matter and antimatter asymmetry discovered by Cronin and Fitch in 1964.

Participants in a meeting of the BaBar collaboration held at UVic in May, 2002.

But the reason they were awarded the 2008 Nobel was their unique and successful prediction of the matter and antimatter asymmetry seen in B meson and anti-B meson particles – subatomic particles containing the bottom quark and its antimatter counterpart. This prediction motivated the construction of the BaBar experiment at SLAC and Belle experiment at Tsukuba in the 1990’s. The facilities accelerated electrons and positrons to near the speed of light and brought them into collisions at high enough energy densities to create B mesons and anti-B mesons—these rare forms of matter and antimatter are very short-lived and decay quickly into lighter subatomic particles. But they live long enough to allow experimentalists to measure differences in the way they decay – differences that were precisely predicted by the Kobayashi-Maskawa model.

Roney and his group contributed to the construction of the device that tracked the particles produced in the collisions and subsequent decays. It was built at TRIUMF, Canada’s national laboratory for particle and nuclear physics, by a team from Canada, Italy and the U.S. UVic has also provided substantial computing resources for analysis and simulation of BaBar data.

The UVic team is among 500 PhD scientists and engineers from 75 institutions throughout the world working on the project which also includes physicists from McGill, U. Montreal and UBC. The Spokesperson for the BaBar Collaboration at the time of the discovery was Victoria-native Prof. Stewart Smith of Princeton University who will be receiving an Honorary Doctorate from the University of Victoria next year. SLAC is funded by the U.S. Department of Energy’s Office of Science. Canadian physicists are funded through Canada’s Natural Sciences and Engineering Research Council (NSERC).

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