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Faculty

JOSEPH FORMAGGIO

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Related Links:

- Sudbury Neutrino Observatory (SNO)
- KATRIN Experiment
- Project 8/CosmoNeut

Area of Physics:

High Energy Physics

Research Interests

An astonishing culmination of discoveries taking place over the last decade has led to a revolution in our understanding of neutrinos – one of nature ' s most elusive particles. Whereas just ten years ago it was commonly accepted that neutrinos were massless particles, a number of key experiments have shown that concept was incorrect. Experiments studying neutrinos from atmospheric, solar, and reactor sources have shown conclusively that neutrinos change flavor and, as a consequence, have a very small but finite mass. This serves to remind us that the standard model of nuclear and particle physics is incomplete. Knowledge of the neutrino mass can provide direction as how to extend that model.

Formaggio ' s research explores the nature of neutrinos and their deep connection between particle physics and cosmology. This exploration is conducted via three areas of experimental research:

- **SNO:** Located in a nickel mine deep underneath the Northern Ontario soil, the Sudbury Neutrino Observatory (SNO) has been studying neutrinos produced in the solar core. In 2001, SNO helped solve the so-called " solar neutrino problem, " by proving that neutrinos produced in the solar core undergo flavor transformation, a unique signature of neutrinos possessing a finite mass. The SNO experiment has also shed light on the mechanism by which the sun produces energy via nuclear burning.
- **KATRIN:** The scale of neutrino masses still remains an open question that is of great

importance for many areas of physics, including particle physics and cosmology. A direct measurement of the neutrino mass would therefore provide independent and valuable input to our understanding of the universe and how it evolves over time. Formaggio is currently involved in the construction of KATRIN, a next-generation tritium beta decay experiment geared at directly measuring the neutrino mass down to fractions of an electron volt.

- **Project 8 / CosmoNeut:** The standard model of cosmology predicts that the universe is populated with neutrinos that are remnants from the primordial Big Bang. This prediction is one of the cornerstones of cosmology, yet the direct detection of these neutrinos has not yet been achieved. To observe relic neutrinos directly, new levels of precision are necessary. Project 8 explores a novel technique by which to measure neutrino masses and, eventually, push toward the possible detection of relic neutrinos.

Biographical Sketch

Joseph Formaggio received his B. S. degree from Yale University in physics in 1996. Thereafter, he received his Ph.D. in physics from Columbia University, where he did his dissertation on neutrino physics by analyzing data taken at the NuTeV experiment located at the Fermi National Laboratory. His research focused on searches for exotic particles predicted by certain theoretical extensions of the standard model of particle physics. In 2001, he joined the Sudbury Neutrino Observatory as a postdoctoral fellow at the University of Washington, where he was later appointed as a research assistant professor. He has been at MIT as Associate Professor since 2010. Professor Formaggio lives with his wife, Jaymi, and his two children, Joshua and Coby.

Selected Publications

- " Relativistic Cyclotron Radiation Detection of Tritium Decay Electrons as a New Technique for Measuring the Neutrino Mass:, B. Monreal and J. A. Formaggio, *Phys. Rev. D* **80**:051301 (2009).
- " An Independent Measurement of the Total Active 8B Solar Neutrino Flux Using an Array of 3He Proportional Counters at the Sudbury Neutrino Observatory ", B. Aharmin et al., Phys. Rev. Lett. 101:111301 (2008).
- " Measurement of the Total Active 8B Solar Neutrino Flux at the Sudbury Neutrino Observatory with Enhanced Neutral Current Sensitivity, " Q. R. Ahmad *et al.*, *Phys. Rev. Lett.* **92**, 181301 (2004).
- " Direct Evidence for Neutrino Flavor Transformation from Neutral-Current Interactions in the Sudbury Neutrino Observatory, " Q. R. Ahmad *et al.*, *Phys. Rev. Lett.* **89**, 011301 (2002).
- " Measurement of the Day and Night Neutrino Energy Spectra at SNO and Constraints on Neutrino Mixing Parameters, " Q. R. Ahmad *et al.*, *Phys. Rev. Lett.* **89**, 011302 (2002).
- " A Precise Determination of Electroweak Parameters in Neutrino Nucleon Scattering, " G. P. Zeller *et al.*, *Phys. Rev. Lett.* **88**, 091802 (2002).

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