Spallation Neutron Source sends first neutrons to 'Big Bang' beam line

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While most of the instruments at the Spallation Neutron Source are dedicated to materials and condensed-matter studies, the Fundamental Neutron Physics Beam Line will explore questions in nuclear physics. Credit: ORNL photo

New analytical tools coming on line at the Spallation Neutron Source, the Department of Energy's state-of-the-art neutron science facility at Oak Ridge National Laboratory, include a beam line dedicated to nuclear physics studies.

The Fundamental Neutron Physics Beam Line (FNPB) has opened its shutter to receive neutrons for the first time. Among the nuclear physics studies planned for the new, intense beam line are experiments that probe the neutron-related mysteries associated with the "Big Bang."

"Completion of the Fundamental Neutron Physics Beam Line marks a significant step in the SNS's ramp up to full power, building up to its eventual suite of 25 instruments for neutron analysis," said ORNL Director Thom Mason, who led the SNS construction project to its completion. "The nuclear physics community is excited to have this new tool for exploring theories of the origins of the universe."

Although research at most of the current and future operating SNS beam lines is directed towards condensed matter and materials research, research at the FNPB is focused on basic studies in nuclear physics.

"While other beam lines use neutrons as a probe to study materials, the object for much of the work proposed at the FNPB is the study of the neutron itself," said University of Tennessee Professor Geoffrey Greene, who holds a Joint Faculty Appointment with ORNL and who leads the FNPB project. "Among the questions that will be addressed at the FNPB are the details of the internal structure of the neutron as well as a careful study of the way in which the free neutron decays. Such experiments have important implication for fundamental questions in particle physics and cosmology."

Greene explained that neutrons, which have no electric charge, may nevertheless have a slight displacement between internal positive and negative charges. The existence of such a "neutron electric dipole moment" could shed light on what happened in the early phases of the Big Bang. In particular it could help to explain why the universe appears to be made entirely of matter without any antimatter, he said.

While the neutron is stable in most nuclei, when it is liberated (for example in an SNS neutron beam) it lives for only about 10 minutes. "Precise measurements of the neutron lifetime help clarify the distribution of chemical elements generated in the first few minutes of the Big Bang and shed light on the amount of normal matter—as opposed to dark matter and dark energy—in the universe," Greene said.

"Another set of extremely precise studies at the FNPB will address the interaction between neutrons and simple nuclei and may help to explain universal 'parity' violation," Greene said. "Roughly speaking, parity is the symmetry that implies that the laws of physics are invariant when 'viewed in a mirror.' The surprising fact is, at a basic level, the universe appears to be 'left-handed.'

"The challenge remains to understand why this puzzling state of affairs exists," he said.

Greene noted that the theoretical basis for such symmetry violation --first outlined several decades ago--was recognized earlier this month with the 2008 Nobel Prize to Yoichiro Nambu.

Source: Oak Ridge National Laboratory