Europe to build state of the art laboratory

March 11 2008

One of the great ongoing challenges of astrophysics, to find out how stars evolve and die, is to be tackled in an ambitious European research programme. This will involve studying in the laboratory over 25 critical nuclear reactions using low-energy stable beams of ions, in order to understand stellar evolution.

“This programme will enhance the ongoing effort to understand the lifecycle of stars, together with the structure and processes of stellar evolution,” said the workshop’s convenor Sotirios Harissopulos from the National Centre of Scientific Research “Demokritos”, Greece . “We also want to try and understand what happens when stars explode and how heavy elements are produced as a result.”

Although astrophysicists have been studying these questions for half a century, progress has been held back by the experimental difficulties involved. But now there is the opportunity to exploit new technology to build a major laboratory that would propel Europe to the head of the field of stellar evolution and nucleosynthesis. “We now want to build a state of the art facility to disentangle all these problems,” said Harissopulos.

The framework for this research programme was evaluated at a recent workshop, “The future of stable beams in Nuclear Astrophysics”, organised by the European Science Foundation (ESF). The workshop highlighted the urgent need to build a laboratory where state of the art instrumentation could be hosted, at a cost of less than 10 million Euros. “Unfortunately, leading nuclear astrophysics laboratories in Europe

fulfilling these requirements are already closed or will be closed in the near future, while others have been “transformed” into analytical laboratories or irradiation facilities in order to survive in a highly competitive environment, where the demand for industrial applications has washed out many basic research activities in the field of low-energy nuclear physics,” said Harissopulos. “As a result, a flagship facility providing intense stable beams for nuclear astrophysics studies in Europe is missing and, hence, there is an urgent need for Europe to create a new state-of-the art facility equipped with advanced detection techniques.”

Europe already has Radioactive Ion Beam (RIB) facilities to study various scenarios in which nucleosynthesis occurs in explosive stellar environments. The new planned facility based on stable ion beams would complement these existing sites and enable a much more complete picture of stellar evolution and nucleosynthesis to be built up.

Both stable and unstable ion beams are powerful tools to study the process of nucleosynthesis, in which chemical elements are created by thermonuclear reactions, or other nuclear processes involving beams of neutrons. “By studying these nuclear reactions, astrophysicists attempt to reconstruct the signatures of the various nucleosynthetic processes that take place throughout the universe, and what happens as stars are born, evolve and then die,” said Harissopulos.

There is a particular interest in what happens at the end of a star’s life, especially when this produces a supernova in a great expanding shock wave. All these processes taken together also shed light on the larger scale evolution of galaxies, including our own. The European project planned by the ESF workshop could make substantial contributions on all these fronts.

The importance of stable ion-beams in nuclear physics research was independently documented in the recent scientific report produced by

ECOS, the European Collaboration on Stable ion-beams (http://www.nupecc.org/ecos). ECOS has operated in the past two years as a working group of the Nuclear Physics European Collaboration Committee (NuPECC), which is the ESF's expert committee for nuclear science. According to the ECOS report, "a low-energy and high-intensity stable-ion beam facility dedicated to nuclear astrophysics is seen as vitally important to improvement of our current understanding of stellar evolution and nucleosynthesis. … Such a facility, built on the earth's surface, will have to meet demanding specifications if it is to resolve outstanding open questions in nuclear astrophysics…" The ESF Workshop came up with ideas about how these recommendations can be achieved in the near future.

As Harissopulos noted, the workshop has fulfilled all the preliminary planning objectives. "The framework of the research to be conducted in the new facility as well as the specifications of the facility was identified. The experimental set ups and detectors systems that need to be embedded in the facility have also been defined. An expert committee for follow-up activities was assigned with the aim of producing a physics-case report and a basic design study for the new facility, as well as identifying initiatives at a European level that will lead to creation of this facility. The expert committee has recognized the decisive role of the ESF in promoting and supporting science initiatives."

Source: European Science Foundation