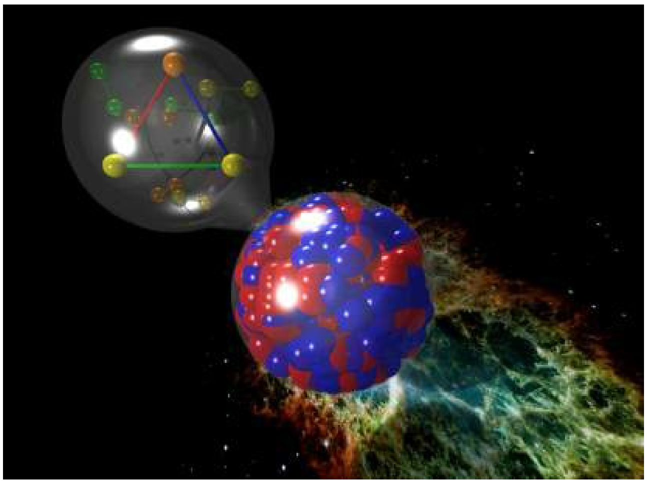
University of Birmingham

Nuclear Physics



The Nuclear Physics team is concerned with understanding the properties of nuclei over a range of scales, extending from nuclei in stable atoms, via exotic nuclei, to quarks. The main areas of capability include positron emission particle tracking, relativistic heavy ion collisions, exotic beams studies and laser spectroscopy of unstable isotopes.

MC40 Cyclotron and Positron Emission Tomography (PET)

Open all sections

The University of Birmingham has its own Cyclotron used for the production of medical isotopes for hospitals and to produce short-lived positron emitting isotopes for positron emission tomography (PET) and positron emission particle tracking (PEPT) studies within the Nuclear Physics Group. This machine also provides beams for undergraduate student projects, for detector testing, and for radiation damage studies. Beam energies of up to 40, 20, 53 and 40 MeV are available for 1H, 2H, 3He and 4He ions, with intensities ranging from a few nanoAmps up to tens of microamps with raster scanning and water cooled targets. Very low intensity beams (106s^{-1}) of protons can be produced for damage studies, using residual hydrogen in the machine.

At the University of Birmingham the Positron Imaging Centre **(http://www.np.ph.bham.ac.uk/pic/index)** allows the study of flow using positron emitting radioactive tracers. The techniques used are variants of the medical technique of positron emission tomography (PET), adapted by Birmingham for engineering applications.

The original positron camera, consisting of a pair of multiwire proportional chambers (MWPCs), has been operating since 1984. In 1999 a second, much more powerful positron camera was purchased, this camera is a commercially available gamma camera PET system (ADAC Forte).

Fluid tracers have been used for applications including imaging the lubricant distribution in engines and gearboxes, and dynamic studies of fluid flow through geological samples (relevant to underground nuclear waste storage).

The technique of positron emission particle tracking (PEPT), developed at Birmingham, allows a single positron-emitting tracer particle to be accurately tracked at high speed and has proved to be a very powerful tool for studying the behaviour of granular materials and viscous fluids in systems such as mixers and fluidised beds.

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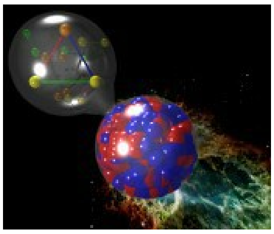
Relativistic Heavy Ion Collision



This programme focuses on the study of nuclear matter under extreme conditions of high temperature and high density. The important degrees of freedom are thought to be quarks and gluons, rather than hadrons. This state of matter, known as a quark-gluon plasma (or QGP), is described by Quantum Chromodynamics.

It is therefore expected that when nuclear matter is compressed and heated in a high energy collision, a phase transition may occur.

The transition marks the change of state from quark confined hadronic matter, to a plasma phase, where quarks and gluons have become liberated over a volume comparable with that of the colliding nuclei.

This novel state of matter must have existed during the first fraction of a second after the Big Bang and may exist today in the core of dense stellar objects such as neutron stars.

Work in this field is currently being performed at the Large Hadron Collider (LHC) at CERN using the **ALICE detector (http://aliceinfo.cern.ch/Public/Welcome.html)** .

Exotic Beams Studies - The CHARISSA collaboration

This area is primarily focused on the study of the structure of light nuclei. Here nuclear properties provide unique tests of state-of-the-art models of nuclei. The experimental programme explores the structure of nuclei with a particular emphasis on exploring the appearance of exotic nuclear structures and nuclei at the extremes of neutron-richness which are usually only formed in stars.

The experimental programme uses nuclear reactions to form the nuclei and their structure is probed via their decay properties.

Experiments use charged particle and neutron detection techniques and are performed at accelerator facilities around the world (from Europe and the USA to Japan and Australia).

See **www.scholarpedia.org/article/clusters_in_nuclei (http://www.scholarpedia.org/article/Clusters_in_nuclei)**

Laser Spectroscopy of Unstable Isotopes

The combination of high resolution laser spectroscopy with an on-line isotope separator is well-established as a powerful tool for investigating the charge radii, spins and moments of radioactive species. These studies yield direct information on nuclear features, such as shape isomerism, of crucial importance in testing nuclear models. They are particularly valuable in probing such properties at the limits of nuclear stability, where the predictions of current models are least certain.

As well as academic research into the structure of nuclei and nuclear matter, the group has considerable experience in applying its knowledge to industrial challenges.