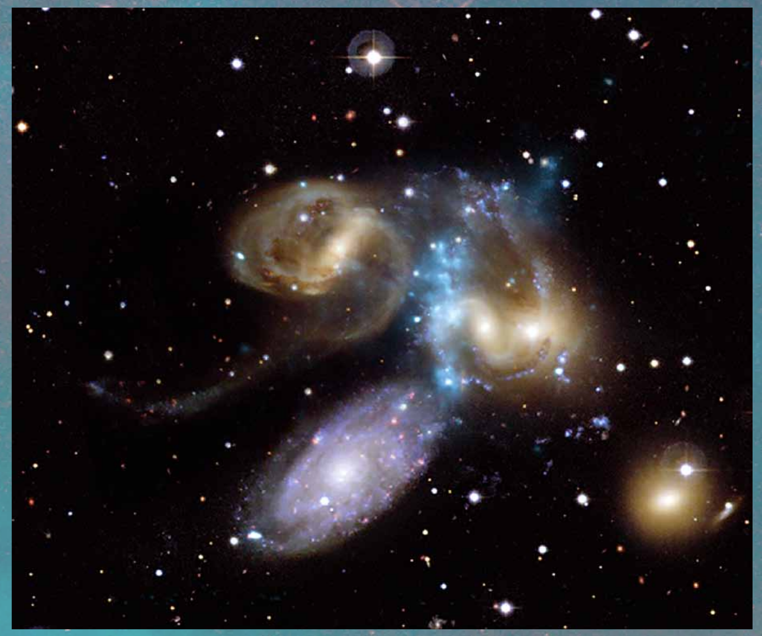
ASTROPHYSICS & SPACE RESEARCH GROUP

UNIVERSITY OF BIRMINGHAM

The ASR group contains over 50 staff and postgraduate students. Our research programme covers the study of galaxies and galaxy groups and clusters, the new science of gravitational wave astronomy, the measurement of ultra-weak forces which provide clues to the unification of gravity with quantum theory, and the study of stars and extrasolar planets. We also have excellent technical facilities, and a distinguished record of building instruments for space and ground-based astronomy. Some examples of our interests are shown below. Further details can be found on our Home Page at www.sr.bham.ac.uk.

Galaxy Groups



Credit: X-ray: NASA/CXC/CfA/E. O'Sullivan; Optical: Canada-France-Hawaii Telescope/Coelum

Most galaxies, including our own, are found in groups. The study of the group environment, its evolution, and its impact on galaxies, is a speciality of the ASR Group, and we study groups at wavelengths ranging from radio to X-rays.

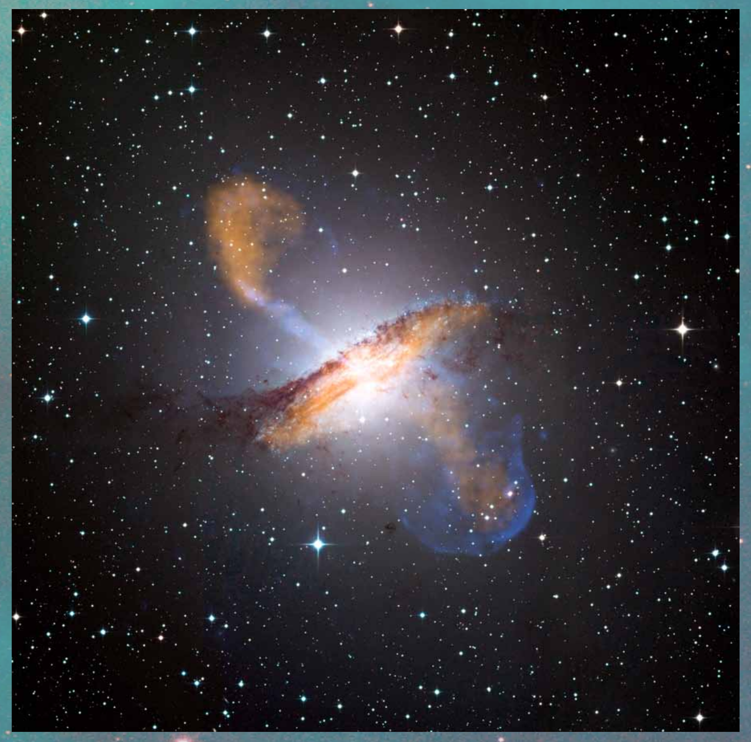
The compact group Stephan's Quintet is currently collapsing, and this optical/X-ray composite image, made using data from NASA's Chandra X-ray Observatory and the Canada-France-Hawaii Telescope on Mauna Kea, shows X-rays (blue) from 10^7K gas generated in a shock front arising from galaxy collisions.

Galaxy Clusters

Clusters of galaxies are the largest stable structures in the Universe. These huge mass concentrations can bend the light from background galaxies, producing spectacular lensed arcs, as in the Hubble Space Telescope image of Abell 1689 shown here. We use gravitational lensing and X-ray observations to study the mass of clusters, and multiwavelength observations spanning the full electromagnetic spectrum to study the properties of their galaxies.

Credit: NASA, N. Benitez (JHU), T. Broadhurst (The Hebrew University), H. Ford (JHU), M. Clampin (STScI), G. Hartig (STScI), G. Illingworth (UCO/Lick Observatory), the ACS Science Team and ESA

Cosmic Feedback



Credit: X-ray: NASA/CXC/CfA/R. Kraft et al.; Submillimetre: MPIfR/ESO/APEX/A. Weiss et al.; Optical: ESO/WFI

One of the major unsolved puzzles of astrophysics is the way in which the temperature of the matter which fills the Universe is controlled. This involves a balance between radiative cooling, and reheating of gas due to the energy pumped into it by supernova explosions and active galaxies.

This composite image of the nearby active elliptical galaxy Centaurus A shows an optical image of the galaxy, with submillimetre radio emission from the radio jets and lobes overlaid in orange, and in blue X-ray emission tracing the jets and the supersonic shock they are driving into the surrounding gas. The image combines data from the ESO 2.2m telescope and Atacama Pathfinder Experiment in Chile, and the Chandra X-ray Observatory.

Background image: A stellar jet in the Carina nebula. Credit: NSAS, ESA, and the Hubble SM4 ERO Team

Research Topics

Extragalactic Astrophysics
- Galaxy Groups
- Galaxy Clusters
- Cosmic Feedback

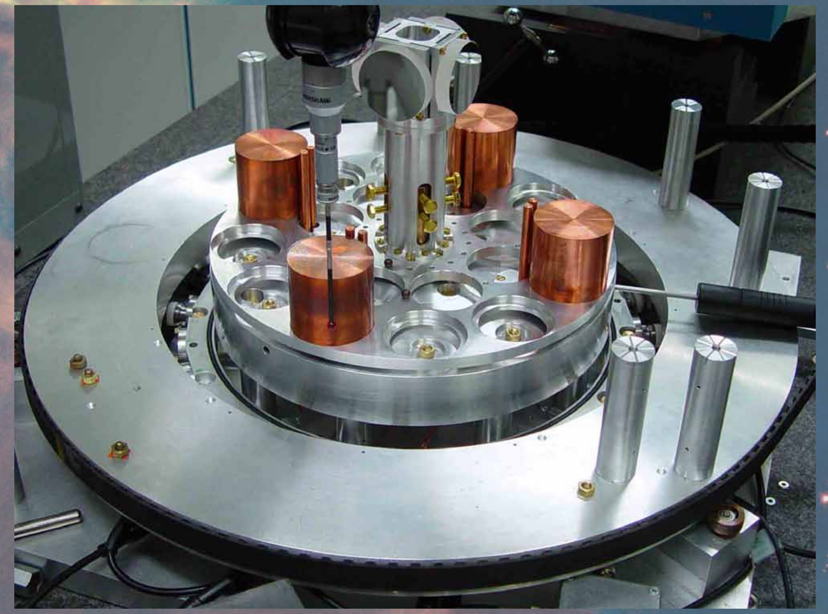
Gravitational Waves
- Detectors
- Astronomy

Experimental Gravitation

Extrasolar Planets

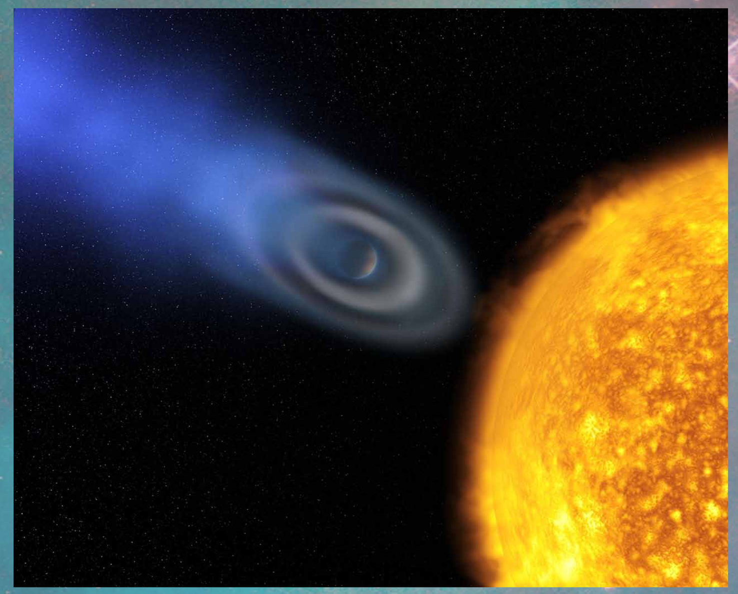
High-Precision Instrumentation

Experimental Gravitation



Our work is motivated by predictions of theories that seek to unify gravitation with the quantum forces. For example, possible solutions to the Cosmological Constant problem predict violations of the inverse square law of gravity at particle separations of 10's of micrometres. We are testing gravity on these scales using a cryogenic torsion balance. We are also searching for cosmological fields, predicted by quantum gravity schemes, that couple to intrinsic spin using the torsion-strip balance shown in the figure. The success of our work relies on our technical innovations, such as the superconducting magnetically levitated torsion balance and tilt-insensitive interferometers. These latter have been commercialised under the name EUCLID.

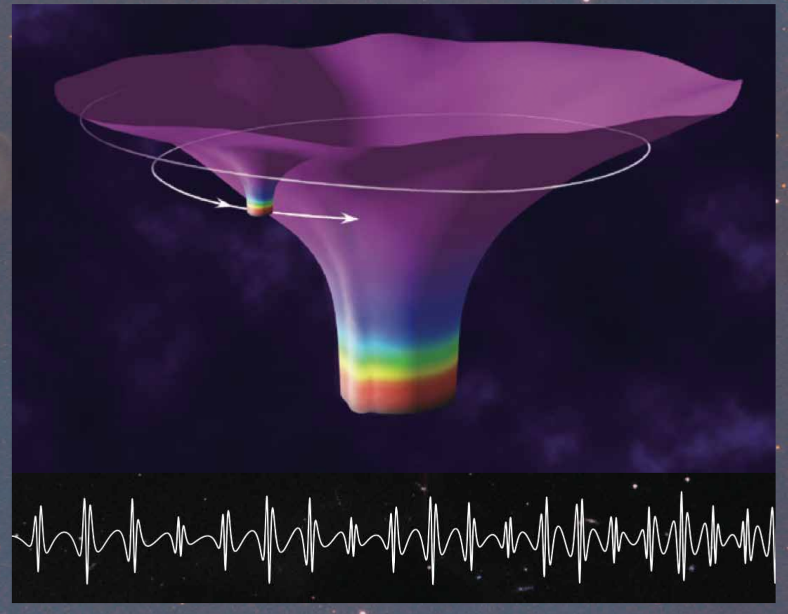
Extrasolar Planets



The first discovery of a planet around another normal star was only made in 1995, but improved instrumentation has since led to an explosion in our knowledge of extrasolar planetary systems. We are engaged in searches for transiting planets using high precision photometry to search for the small dip in brightness which occurs when a planet moves in front of a star. We are also searching for low frequency radio emission from extrasolar planets. In our own solar system, the magnetosphere of Jupiter is a powerful radio source.

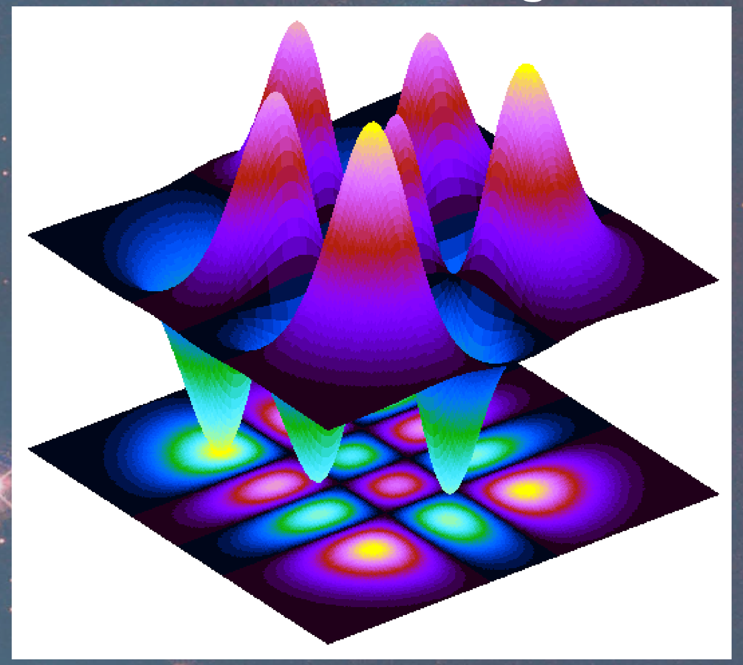
The image to the left shows an artist's impression of the transiting "hot Jupiter" HD209458b, which has been extensively studied by the Hubble Space Telescope.

Gravitational Wave Astronomy



The detection of gravitational waves involves the measurement of tiny changes in the separation of "test masses" (10 kg mirrors in fact), of the order of 1 part in 10^{21}. The most sensitive GW detectors are interferometers, in which laser beams are split and recombined after passing down two "arms" several kilometres in length. We are developing advanced analysis techniques to identify the signals from sources such as merging black holes and neutron stars – the picture to the right shows an artist's impression of space-time around such a binary system, whilst the trace below shows its predicted GW signal. We are searching for such signals in the best GW data available today, from detectors in the USA and Europe (LIGO, GEO 600, Virgo).

Advanced Technologies for GW Observatories



There is strong evidence for the existence of gravitational waves – ripples in spacetime predicted by Einstein's theory of General Relativity – but they have yet to be directly detected. We are involved in the construction of the next generation of GW detectors, which should make the breakthrough within the next few years, and in the design of future more powerful instruments which will firmly establish GW astronomy as a new probe of the Universe.

The image on the left shows a visualisation of the intensity distribution of a tailored laser beam. We are developing such beams in order to reduce the impact of thermal noise in GW interferometers.

Gravitational Wave Instrumentation

The ASR group has a long heritage in astronomical space instrumentation, and possesses state-of-the art facilities, including clean rooms, electronics fabrication and environmental test facilities. These are currently used primarily to support our experimental and project activities in the area of gravitational physics.

The images to the right show the integrated optical sensors and actuators, designed and built at Birmingham, which form a key part of the seismic isolation system for the new Advanced LIGO intruments (see insert).