

Centre for Astrophysics and Supercomputing

Overview

The Centre for Astrophysics and Supercomputing (CAS) is dedicated to inspiring a fascination in the universe through research and education. Now the largest astrophysics centre in Victoria, the centre has built an international reputation for research excellence. We operate a significant supercomputing facility and a virtual reality theatre; we have direct access to the world's largest optical and infrared telescopes – the 10 metre Keck telescopes in Hawaii; and we focus on problems in astrophysics that benefit from these resources. The centre delivers a strong public outreach and education program, and unique internet-based education initiatives.

Our radical approach of broadening our funding base through a combination of traditional research grants, commercial work, online teaching and university support, has led to spectacular growth since the centre's formation in 1998.

Our research focus

The centre's research spans across the electromagnetic spectrum, covering observational, theoretical and computational astronomy. Priority research areas include galaxy evolution and cosmology, globular clusters, pulsars, star and planet formation, the transient Universe, radio astronomy instrumentation simulations and astronomy visualisation.

A strong theoretical group uses the centre's supercomputer to produce world-class simulations, including simulating entire universes, exploring the nature of dark matter, and simulating star and planetary disk formation.

We are successful in attracting external research funding and in 2013 external research income from competitive grants was \$11M.

Facilities

The centre regularly secures time on the most advanced telescopes around the world, such as the Hubble Space Telescope, the Parkes Telescope and the Very Large Telescope in Chile. In 2008 the centre signed a landmark agreement with the California Institute of Technology (Caltech) that put Swinburne in the unique position of being the first Australian university to have guaranteed access to the 10 metre Keck optical telescopes in Hawaii which can be remotely operated from our campus.

The centre manages the supercomputing needs of Swinburne and is committed to providing an international-standard computing facility based on the latest technology, thus enabling Swinburne staff and students to meet their research goals while maintaining Swinburne as a premier supercomputing site.

Our facility includes gSTAR, a GPU-based supercomputer offering in excess of 100 Tflops of performance, we operate as a national facility as well as having our own guaranteed access.

CAS also has a virtual reality theatre, which supports its public outreach and school education programs with 3D technology.



Industry involvement

The centre has commercialised its intellectual property through the creation of a number of products. Using the latest in 3D virtual reality projection techniques and animation, these products help the centre inspire a fascination in the universe. The centre's 3D movies are sold to visitor centres and museums around the world and in 2013 we completed Australia's first 3D IMAX movie, *Hidden Universe*, which has been shown to acclaim around the world.

The skills developed in producing these products enable the centre to undertake consultancies to industry and universities for the creation of 3D animations. Stereo HD filming is a growing area of expertise, producing spectacular results.

We have a strong skill base in large-scale HPC numerical simulations and we lead our discipline in the development of GPU-supercomputing optimised data analysis and visualisation algorithms (scaling to the Petabyte regime). We also design, build and operate national large-scale data repositories for observational and theoretical astronomical datasets that have involved extensive database and web portal development.

Collaborations

CAS has wide-ranging collaborations in Australia and internationally. The centre is a member of the ARC Centre of Excellence for All-sky Astrophysics (CAASTRO). We have close ties with the CSIRO Astronomy and Space Science division (CASS), particularly in the area of new technology radio telescopes such as ASKAP and SKA. We also work with the Australian Astronomical Observatory, as well as having collaborators at most of the major universities in Australia. Internationally, the centre has links with Caltech, through our Keck collaborative agreement, and our researchers collaborate with astronomers in the United States, Canada, Europe, China and South America.

Recent projects

The centre's recent research projects include:

Theoretical Astrophysical Observatory – an online tool to build artificial universes from different cosmological simulations, and galaxy formation models to explore and interpret galaxy survey observations.

Molonglo Telescope – we are rebuilding this 1960's vintage radio telescope as a next generation facility for exploring the radio transient sky, including characterising the mysterious new population of 'fast radio bursts'.

The Universe's first 3 billion years – using a new panoramic near-infrared camera on the Magellan telescopes we are able to observe directly the early growth of mass and structure in the Universe. We have imaged early galaxy clusters and with the Keck telescopes obtained spectroscopic confirmations.

SKA Preconstruction – we are studying under a contract from the Australian Government the design of the pulsar timing engine for the next generation Square Kilometre Array radio telescope and are designing the next generation of multi-GPU visualisation systems for the SKA data avalanche.

Probing the Epoch of Reionisation – the era when the first stars and galaxies formed – using elements detected in absorption towards the most distant quasars with large telescopes such as Keck.

GERLUMPH – an online resource for exploring the properties of supermassive black holes in distant gravitationally-lensed quasars using data generated on Swinburne's GPU supercomputer

Building Planets – a project to explore the first dust grains that formed in our solar system and survey the dust content of planet-forming disks in the solar neighbourhood

The 2-degree Field Lensing Survey – uses the Anglo-Australian Telescope to test the laws of gravity on the scales of the Universe, by comparing the deflections of light rays through gravitational lensing with the velocities imparted to galaxies by gravitational pulls of matter.

Supernovae over Cosmic Time – CAS astronomers pioneered a method to detect supernovae in the early Universe, including the deaths of the very first stars to have formed after the Big Bang, and are using the Keck telescopes and the Dark Energy Survey camera to pursue their study over cosmic time.

The SAGES Legacy Unifying Globulars and Galaxies Survey – the Centre takes a leading role in this survey that combines Hubble imaging with spectra from the Keck telescopes to better understand how nearby galaxies formed and assembled their stars.

Education

The centre hosts a large number of postgraduate students who are undertaking a Doctor of Philosophy (PhD) degree, as well as operating the world's longest running online astronomy education program, Swinburne Astronomy Online. We teach astronomy, physics and computing units as part of Swinburne's new Bachelor of Science (Physics) degree. In addition, the centre provides education to school students and the general public via presentations and movies in virtual reality theatres in Australia and internationally.

Contact us

Swinburne University of Technology
Hawthorn, Melbourne, Australia

Key contact

Professor Karl Glazebrook
Director, Centre for Astrophysics
and Supercomputing
Telephone: +61 3 9214 4384
Email: kglazebrook@swin.edu.au

Further information

Telephone: +61 3 9214 5569
Facsimile: +61 3 9214 8797
Email: contact@astro.swin.edu.au
www.swinburne.edu.au/astronomy

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