

Development and Innovation

The development of new technologies for astronomical instrumentation has been, and will continue to be, essential to the AAO's success.

Darkening the sky

The sky glows brightly at infrared wavelengths, thanks to molecules in the upper atmosphere. To remove this unwanted infrared light, the AAO and the University of Sydney have developed optical fibres with tiny filters in them. Once the unwanted 'light pollution' from the atmosphere is gone, the astronomers can see faint infrared sources in the cosmos beyond. The scientific potential of this technology is immense: applications include observations of the Universe at the time the first stars and galaxies formed.

Miniature spectrographs

The AAO is working to develop an integrated photonic spectrograph, in which all the components of a normal astronomical spectrograph are miniaturised as a solid-state optical device – a 'spectrograph on a chip'. The AAO is collaborating with Australian and overseas institutions to develop this revolutionary technology.

Starbugs

Starbugs are tiny robots, about the size of a thimble, each attached to an optical fibre. They can "walk" autonomously about the focal plane of a telescope, each carrying its optical fibre to the right position to capture light from specific galaxy. Starbugs will be trialled on the UK Schmidt telescope and may then be used on the 25-m Giant Magellan Telescope in Chile.

The AAO today

The AAO has a reputation as one of the most productive observatories in the world. Its prodigious scientific output has made it a leader in many astronomical fields; it is the home of the Southern Hemisphere's most precise planet search program, and some of the world's most comprehensive galaxy and quasar surveys. The AAO's achievements include observing the spectacular explosion of the **Supernova 1987A**, the brightest supernova since the invention of the telescope four centuries earlier; discovering extremely small, "ultra-compact" **dwarf galaxies**; making the first detection of an isolated **brown dwarf star** in our Galaxy; measuring the **Hubble Constant** (the rate of expansion of the Universe) with unprecedented accuracy; discovering **streams of stars** in our Galaxy that are the remnants of dwarf galaxies that have been absorbed into our own; determining that "**dark matter**" (a nsion of the Universe) with unprecedented accuracy; discovering **streams of stars** in our Galaxy that are the remnants of dwarf galaxies that have been absorbed into our own; determining that "**dark matter**" (a material that we know of

only through its gravitational effects) can't be made of neutrinos – it must be made of something else; showing that "**dark energy**" is real and not a mistake in Einstein's equations.

In 2013 the AAO introduced '**remote observing**', enabling astronomers to use the AAT from their computers in Sydney or anywhere in the world.

Photos: Cover page: (top) Star-trails above the AAT by Ángel López-Sánchez, AAO; (upper middle) UK Schmidt Telescope; (lower middle) Anglo-Australian Telescope; Photos: Fred Kamphues (bottom) AAT dome and Milky Way, Photo: James Gilbert, AAO
Back page: AAT Dome, Photo: Fred Kamphues.
Inside left page: The 3.9 metre Anglo-Australian Telescope Photo: Fred Kamphues
Inside right page, top: AAO engineers Jeroen Heijmans and Ross Zhelm testing HERMES Photo: Fred Kamphues; middle left: Instrument Scientist James Gilbert with his "starbug" robotic positioners; middle right: USydney astronomer Julia Bryant with SAMI fibres, Photos: Tim Wheeler. bottom: Star Trails Star-trails above the AAT, Photo: Ángel López-Sánchez



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Australian Astronomical Observatory



The AAO's mission

The mission of the AAO is to provide world-class observing capabilities that enable its user community of optical astronomers to do outstanding science.

This involves three essential activities: first, ensuring access and high-quality support for existing front-rank telescopes; second, providing powerful and innovative instrumentation for those telescopes; and third, leading Australia's participation in the best facilities of the next generation. These activities underpin the AAO's future as Australia's national observatory for optical and infrared astronomy.

The AAO was established in 1971 and since 2010 it has been fully funded by the Australian Government. The Australian Astronomical Observatory operates the largest optical/infrared telescope in Australia, the 3.9-metre Anglo-Australian Telescope (AAT) at the ANU's Siding Spring Observatory near Coonabarabran in northwestern NSW, and the 1.2-metre UK Schmidt Telescope (UKST) also at Siding Spring Observatory. In addition the AAO provides support for Australian access to the twin Magellan 6.5-metre telescopes, located in northern Chile and is the host for the Australian Gemini Office, which supports Australia's involvement as a partner in the Gemini 8.1-metre telescopes, in Hawaii and Chile.

AAO Science

Some of the major science programs supported by the AAO are:

OzDES (Oz Dark Energy Survey)

A survey with the AAT to measure the redshifts of hundreds of thousands of galaxies, and to identify the host galaxies of distant supernovae, for improving our understanding of cosmology and dark energy.

WiggleZ

A dark energy survey with the AAT to map distant galaxies and understand the nature of the mysterious dark energy.

GAMA (Galaxy and Mass Assembly)

A redshift survey of 300 000 galaxies to study the assembly of mass and stars in nearby galaxies.

Planet Search

A program to discover planets around other stars using Doppler measurements.

GALAH (Galactic Archaeology with HERMES)

A new project to understand the chemical evolution of our own Galaxy by surveying a million stars using the new HERMES spectrograph. The elemental 'fingerprints' of these stars will reveal the history of the formation of the Milky Way.

Instrumentation

Telescopes are big "buckets" that collect starlight. Once light enters the telescope it can meet different fates. It can be directed to an imager, like a camera, and be turned into a picture. Or it can be fed into optical fibres and piped off to instruments that will analyse it.

The AAO designs and build instruments both for the two telescopes it operates (the AAT and the UK Schmidt) and, under contract, for other telescopes around the world. The AAO has built imagers (for making images) but now builds mainly optical-fibre positioners (for capturing the light) and spectrographs (for analyzing it). Spectrographs do what a prism does – spreads light out into its spectrum of component wavelengths (colours) – but provides much more detail. The features of a spectrum from a star or galaxy tell us how the object is moving (towards or away from us, and how fast) and its chemical composition.

Instruments the AAO has built for the Anglo-Australian Telescope include:

AAOmega

AAOmega is a spectrograph used with a robotic arm that positions optical fibres. It is the "workhorse" instrument for the AAT, being used for more than 50% of observing time.

UCLES

The UCL Echelle Spectrograph offers high resolution and good wavelength coverage. It is a versatile instrument that is used on the AAT 30% of the time. It is used with an optical-fibre system called CYCLOPS, particularly for studying stars to see if they have planets around them.

IRIS2

IRIS2 is a general-purpose infrared imager and spectrograph. It won the Bradfield Award for Outstanding Engineering of the Sydney Division of the Institution of Engineers Australia, and an Excellence Award at the national level.

SAMI

SAMI is a spectrograph and optical-fibre system. Using bundles of optical fibres, it can sample light from dozens of points in each galaxy, and do this for up to 13 galaxies at a time. This greatly speeds up survey work, making possible new kinds of projects. SAMI is one of the world's first instruments of this kind.

HERMES

HERMES is a high-resolution spectrograph that will be able to measure the chemical compositions of up to 400 stars at a time. It will be used to study how and when the different components of our Galaxy formed.

Instruments the AAO has built for other telescopes include:

OzPoz, a system for the Very Large Telescope in Chile that uses a robotic arm to pick up the fibres and place them, one at a time, at the desired locations for collecting light from specific galaxies; **Echidna**, a unique fibre-positioning system for Japan's Subaru telescope in Hawai'i, in which the optical fibres sit in spines like the bristles of a toothbrush, and move independently. The AAO is now preparing to build **MANIFEST**, an optical-fibre system for the next-generation 25-metre Giant Magellan Telescope (GMT) in Chile.

