18 April 2008

The Secretary,
Senate Standing Committee on Economics
PO Box 6100
Parliament House
CANBERRA ACT 2600

UNSW

PROFESSOR LES FIELD

DEPUTY VICE-CHANCELLOR
(RESEARCH)

RE: UNSW SUBMISSION TO THE INQUIRY INTO AUSTRALIA'S SPACE SCIENCE & INDUSTRY SECTOR

The University of New South Wales welcomes the opportunity to make a submission to the Inquiry into Australia's space science and industry Sector to the Standing Committee on Economics.

1. SUMMARY OF RECOMMENDATIONS

- To secure the next generation of space scientists we must ensure that there are world class research groups in Astronomy & Space Science in major research institutions in Australia. There should be a vibrant cohort of postgraduate and postdoctoral researchers supported by a range of targeted scholarships and fellowships.
- Australian Scientists who win peer reviewed access to international space missions need to have appropriate logistical support, research infrastructure, travel and project support, to capitalise on the research effort and to rapidly disseminate high impact results.
- The importance, and cost effectiveness, of ground-based follow-up facilities such as ROTSE needs to be recognised and supported by major research infrastructure programs.
- The 2.5 metre PILOT telescope in Antarctica needs to be supported as an enhancement to Australia's space observation capabilities.
- Australia could significantly enhance its return on investment in space science by focussing its efforts in ground based facilities.
- Australia needs to significantly ramp up resources and capacity for data analysis to maximise the usage of data from space missions.
- The management of critical research infrastructure in space science requires long-term strategic planning at all levels of Government, industry, and research organisations. There needs to be a whole-of-government response and the establishment of a central space organisation (maybe an analogue of NASA) for Australia.

2. UNSW IS A WORLD LEADER IN SPACE SCIENCE

The Department of Astrophysics and Optics, within the School of Physics at UNSW conducts a wide range of research programs in observational and theoretical astrophysics as well as instrumentation and site testing.

This includes investigation of fundamental phenomena in nature, such as the formation of stars, of galaxies, and of the Universe itself. Astrophysical observations are being used to test new ideas in fundamental physics and cosmology. Current research programs include variations in fundamental constants[1] and Hubble Space Telescope observations of quasars to measure the high redshift deuterium abundance[2] (a direct test of Big Bang theory).

THE UNIVERSITY OF NEW SOUTH WALES
UNSW SYDNEY NSW 2052 AUSTRALIA

Telephone: +61(2) 9385 2700
Facsimile: +61(2) 9385 8008

ABN 57 195 873 179
CRICOS Provider No. 00098G

[1] See http://www.phys.unsw.edu.au/astro/research/PWAPR03webb.pdf for further information
[2] See http://newt.phys.unsw.edu.au/astro/research/cosmology.html for further information

Researchers at UNSW collaborate closely with scientists at the Anglo-Australian Observatory, Australia Telescope National Facility, CSIRO, and other universities and research centres around the world.

Astrophysics at UNSW is one of the most successful research groups in the University – it has produced 32% of UNSW's publications in the journals Nature and Science in the decade to 2006, making it the University's leading department in those journals. Furthermore, UNSW's citation rate is ranked in the top 1% of institutes worldwide in space sciences.[3]

UNSW has about 30 researchers and has a range of recent Australian Research Council Projects across all aspects of space science **(See Attachment 1).**

UNSW is home to a range of major research projects and initiatives aimed at advancing research in the areas of space science including:

Design & construction of Astronomical Instrumentation

UNSW conducts major programs with instrumentation[4] and telescopes[5]. We are pioneering the development of astronomy in Antarctica[6]. We have built a range of instrumentation for large telescopes, particularly in the infrared.

UNSW, through the School of Physics, Faculty of Science, has one of the few Australian programmes that trains Honours and PhD students in the **design and construction of astronomical instrumentation.** UNSW Astrophysics graduates are in a strong position to contribute to future Australian space missions. Among UNSW Graduates in this field are: Professor Jamie Lloyd, now at Cornell University; Dr Jessica Dempsey, staff scientist, James Clerk Maxwell telescope, Hawaii; Maxime Boccas, Optical-Mechanical Engineer at the Gemini telescope; Dr Paolo Calisse, University of Cardiff; and Dr Tony Travouillon, Caltech.

To secure the next generation of space scientists we must ensure that there are world class research groups in Astronomy & Space Science in major research institutions in Australia. There should be a vibrant cohort of postgraduate and postdoctoral researchers supported by a range of targeted scholarships and fellowships.

Access to the Hubble Space Telescope

Our staff regularly win access to major international space missions through peer review. An example is the award of 75 orbits of **Hubble Space Telescope** time to Professor John Webb. The Hubble Space Telescope is the world's most prestigious and competitive astrophysical observatory. In the relevant allocation period, 192 proposals were submitted, of which only 12 were allocated more than 45 orbits. The allocation of 75 orbits to Professor Webb is one of the largest ever given to an Australian researcher.[7] Hubble Space Telescope time is estimated at $100,000 per hour, so this allocation translates to an $11 million investment by NASA.

While this is a tremendous achievement, there is a significant leveraging cost to UNSW to provide the necessary support underpinning this research program.

Australian Scientists who win peer reviewed access to international space missions need to have appropriate logistical support, research infrastructure, travel and project support, to capitalise on the research effort and to rapidly disseminate high impact results.

Robotic Optical Transient Search Experiment (ROTSE) telescope

UNSW operates several telescopes - the Automated Patrol Telescope[8], the ROTSE-IIIa telescope, and the Mopra millimetre-wave telescope[9].

Our **Robotic Optical Transient Search Experiment (ROTSE) telescope[10]** at Siding Springs Observatory is one of just four world-wide, which combine to make up the world's leading facility for rapid ground-based follow-up of discoveries from NASA and European gamma ray satellites. This greatly increases the scientific return of these missions. The ROTSE collaboration uses four small but powerful

[3] Thomson ISI Essential Science Indicators, 2004.
[4] See http://www.phys.unsw.edu.au/astro/research/instrumentation.html for further information
[5] See http://www.phys.unsw.edu.au/astro/research/telescopes.html for further information
[6] See http://www.phys.unsw.edu.au/astro/research/antarctica.html for further information
[7] See http://www.stsci.edu/hst/proposing/exp_abstract-catalogs/cy10-exposure-catalog for further information
[8] See http://newt.phys.unsw.edu.au/~mcba/apt.html for further information
[9] See http://www.phys.unsw.edu.au/astro/mopra/ for further information
[10] See http://www.rotse.net/information/world/australia.html for further information

telescopes at sites around the world to make optical observations of Gamma-Ray Bursts, which are massive deep-space explosions seen at gamma ray wavelengths.[11]

The importance, and cost effectiveness, of ground-based follow-up facilities such as ROTSE needs to be recognised and supported by government funded programs such as NCRIS.

PILOT Telescope

The 2.5-metre aperture optical/IR telescope (**PILOT telescope)** to be sited at Concordia Station, Dome C, Antarctica for Antarctica has unique capabilities to catalogue orbital debris. This would be a very important contribution by Australia to the world-wide space industry. UNSW was awarded $1m from the Australian Department of Education, Science and Training's NCRIS Program funds for a conceptual design study of PILOT; the study will be concluded in a few months. The technical component of this study is being conducted by the Anglo-Australian Observatory.

PILOT is proposed as a joint Australian-European project, with European coordination under the auspices of ARENA.[12]

The 2.5 metre PILOT telescope in Antarctica needs to be supported as an enhancement to Australia's space observation capabilities.

Search for Extrasolar Planets

A growing field at UNSW is the search for extrasolar planets[13]. We are involved in:

- The search for transiting exoplanets using the Automated Patrol Telescope[14].
- the design of a telescope that will search for exoplanets via direct detection from Antarctica.[15]
- the highly successful Anglo-Australian Planet Search seeks to find planets via Doppler Effect.[16]

UNSW hosts the headquarters of the Australian Centre for Astrobiology (ACA), one of only two centres in the world to be a formal Affiliate Member of NASA's Astrobiology Institute. The ACA is a distributed organization that includes members at other Australian universities and government research organizations. The ACA also has strong connections with the European Space Agency and through membership of the International Mars Exploration Working Group and informal links of ACA members is integrated into the global space exploration community.

Planetary exploration depends significantly on applying lessons learned from studying the Earth. Australia has unique advantages. Various environments here, both ancient and modern, have counterparts on other planets and moons. Examples are Shark Bay and the Pilbara region in WA. These and other Australian sites have been and continue to be the objects of many local and international space science projects. The World Heritage area of Shark Bay contains the best known modern analogues of microbial communities ("stromatolites") that existed on the ancient Earth and maybe elsewhere in the Solar System. The Pilbara has the oldest convincing evidence of life on Earth, 3.5 billion years old.

Space Science Communication

Astrobiology provides excellent opportunities for science communication to students and the general public. An example is the recently developed Pilbara Project, a hi-tech Virtual Field Trip developed in collaboration with NASA and others, and aimed primarily at providing an authentic science experience to Australian students in years 9-12. It was created by an education and outreach team from the ACA and NASA. The VFT allows students to explore three Pilbara locations and also Shark Bay. The Pilbara VFT DVD was launched on the cover of Cosmos magazine in April, 2007. Since then the associated wiki website – which contains a database of resources for students and their teachers – has had nearly 300,000 full-page visits (around three million hits). It has been adopted into the programs of the Victorian Space Science Education Centre in Melbourne.[17]

The ACA has the only SETI (Search for Extraterrestrial Intelligence) large radio-telescope project in the Southern Hemisphere, where more stars can be seen than in the Northern Hemisphere that is home to

---

[11] See http://www.rotse.net/ for further information
[12] See http://www.aao.gov.au/pilot/ for further information
[13] See http://www.phys.unsw.edu.au/astro/research/planetsearch.html for further information
[14] See http://www.phys.unsw.edu.au/~mcba/apt.html for further information
[15] See http://www.phys.unsw.edu.au/~mcba/pubs/storey06.pdf for further information
[16] See http://www.phys.unsw.edu.au/~mcba/pubs/storey06.pdf for further information
[17] See the wiki at http://pilbara.mq.edu.au and the NASA site is at http://quest.nasa.gov for further information

all the other professional projects. The Southern SERENDIP instrument piggy-backs onto normal radio astronomy research at the 64-metre Parkes radio telescope in New South Wales. The telescope has been upgraded to allow observers anywhere in the world to be able to access their data on a live basis. This move allows the public to also be engaged with the search. A new exhibit is to be installed at the Parkes Telescope Visitors' Centre, which receives 100,000 visitors per year. The exhibit will be able to be replicated in museums around the world at very low cost. A similar project for the Arecibo radio telescope in Puerto Rico, SETI@home, attracts 20 million users worldwide. Southern SERENDIP is a collaborative project between the ACA at UNSW, the University of Western Sydney and Arizona State University.

3. EXPANDED ACTIVITY IN SPACE SCIENCE

Australia could be in the position, through the PILOT telescope in Antarctica, of providing important and valuable data on orbital debris to the international space science community.

Since the launch of the first artificial satellite into orbit in 1957, vast numbers of objects have been placed in earth orbit. Over time there have been collisions and explosions of various rocket bodies and casings, ejected hatches, bolts, fuel and coolants virtually filling the orbital sphere with debris, ranging in sizes from metres to just a few microns. These objects now present a significant hazard to manned and unmanned space flight, yet the nature and distribution of the global debris population remains poorly quantified.

It is therefore of great interest to characterize debris objects, their sizes, heights and altitudes. PILOT is an excellent facility for this characterization. Observing satellite and debris from the Antarctic plateau provides a number of potential advantages to temperate locations in that a) the majority of satellites and debris of interest lie in polar orbits, so there is a natural concentration of objects at the highest latitudes; and b) the extended terminator period (twilight) at Antarctic latitudes means that satellites can be tracked every orbit for long periods of time.

Australia could obtain significant "bang for its buck" by strategic investment in ground-based facilities. Space missions themselves are extremely expensive, and there is a pattern internationally of large expenditures in space not having the necessary ground-based support that would increase the scientific return. A classic example of this is the gamma-ray satellites for which ground-based follow-up with telescopes such as UNSW's ROTSE is essential.

Australia could significantly enhance its return on investment in space science by focussing its efforts in ground based facilities.

4. NEED FOR SPACE SCIENCE DATA ANALYSIS

A major impediment to maximising Australia's usage of the data from space missions is the lack of resources and capacity for data analysis. When US researchers win access to the Hubble Space Telescope, through its very competitive peer review process, they are awarded funding to support their research in addition to Hubble Space Telescope time. Australian researchers are at a competitive disadvantage when applying for time, as the time allocation process rewards proposals that demonstrate the ability to produce results on short timescales.

Australia needs to significantly ramp up our resources and capacity for data analysis to maximise the usage of data from space missions.

5. CRITICAL RESEARCH INFRASTRUCTURE & PLANNING

Cutting–edge research areas such as Space Science rely on complex infrastructure. Such programs are not short-term – they take many years to establish and the benefits will flow over the space of decades rather than months. The infrastructure is typically expensive to purchase and install, and requires an on-going and long term commitment to properly maintain.

The necessity for long-term planning permits the government to position the Country for many international initiatives which require strong support from the Government. It is absolutely clear that major research initiatives must align strongly with National priorities before they will be considered seriously by Commonwealth and external agencies. As such there is a need to:

- Develop a long-term strategic plan (5-10 years and beyond) for space science and other areas of research which are a priority for Australia;

- Facilitate proactive engagements with industry and research organisations who are active in space science;
- Leverage support from the international agencies – with long term benefit to Australia; and
- Make Australia a desirable location to conduct space science through the investment in research infrastructure.

Furthermore, we have the ability and expertise to make substantial contributions to major space exploration missions, with concomitant benefits in terms of education and training, technology transfer and national prestige. The forthcoming Mars Sample Return joint mission by NASA and ESA is a good example.

The management of critical research infrastructure in space science requires long-term strategic planning at all levels of Government, industry, and research organisations. There needs to be a whole-of-government response and the establishment of a central space organisation (maybe an analogue of NASA) for Australia.

6. CONCLUSION

Australian scientists are recognised as leaders in the fields of space science, astronomy and astrobiology. These are fields that capture the interest of young people and have the power to attract them to the study of science, engineering and science communication. UNSW attracts PhD students from all over the world and runs popular undergraduate courses in space science.

Australia must attract researchers and grow industry investment in space science. This Inquiry provides a good opportunity for the Government to realise long-term benefits of space science for Australia. There needs to be a long-term strategic plan to address critical research infrastructure across and beyond space science.

The University of New South Wales is open to further discussions in this important area of research and industry development.

Yours sincerely,

Professor Les Field
Deputy Vice-Chancellor (Research)
The University of New South Wales

ATTACHMENT 1 – SAMPLE OF RECENT ARC PROJECTS AT THE UNIVERSITY OF NEW SOUTH WALES

Project Title	Investigators	Project Summary
The best astronomical site on earth?	Prof JW Storey Dr MG Burton A/Prof MC Ashley	A modern optical/infrared telescope is only as good as its site. We have previously shown that the infrared skies above the South Pole are up to 100 times darker than skies elsewhere, leading to enormous potential gains in sensitivity. We now seek to extend these measurements to Antarctic sites that are even higher, drier and colder than the South Pole. These are expected to be the best observing sites on Earth, paving the way for the deployment of telescopes of unprecedented sensitivity able to explore the origins of planets, stars and galaxies.
Fundamental physical parameters from Hubble Space Telescope and Keck Telescope observations	A/Prof JK Webb	A large allocation of Hubble Space Telescope time was awarded for new primordial baryonic density measurement, using luminous quasars (Webb et al, 75 orbits, cycle 10). Observations (begin after July 2001, spanning over a year) will yield unprecedented accuracy for the high redshift deuterium abundance, and a fundamental test of the homogeneous Big Bang. A parallel investigation, using the same techniques, uses higher redshift Keck Telescope spectra (85 quasars, collaboration with W. Sargent, Caltech) to constrain space-time variation of the fine-structure constant. Recent results suggest a weak time dependence. This new sample (3 times larger) will definitively check this.
Modelling a Complex System: In Search of an Observationally Consistent Universe	Ms LM Griffiths	This project aims to extract cosmological parameters from a synthesis of observational data and thereby significantly progress the understanding of our Universe. This will be achieved by mathematically modelling the theoretical predictions of the Big Bang Theory and statistically analysing a broad range of observational data.
Before Planets: The Mineralogy and Chemistry of Pre-Planetary Disks	Dr CM Wright Prof Dr EF van Dishoeck Dr A Glasse Dr R Siebenmorgen	Planets form within the circumstellar disks around young stars. Samples of the solid material composing our own primitive disk are found in meteorites and interplanetary dust particles. Using the powerful technique of astronomical mid-infrared spectropolarimetry, we will ascertain the composition of the material existing within the disks around young stars. By studying a range of disk ages we will determine how the composition evolves with time, and what physical processes affect it, in order to better understand how our own solar system formed. Further, we will image these disks in mm-wave molecular emission and constrain their chemistry and rotational properties.
Will Antarctic telescopes detect the first new habitable planets?	Prof JW Storey; Dr JS Lawrence	One of the most exciting questions in contemporary astronomy concerns the existence and nature of habitable planets in other star systems. A world-wide technological race is underway to develop the advanced techniques necessary to detect and study such planets. Our previous work has shown that Antarctic plateau sites offer major advantages for several of the planned techniques. We will now develop mathematical models and construct prototypes of the crucial optical sub-systems that will be needed for planet-detecting telescopes, and show how these can be optimised to take advantage of the conditions now known to exist in Antarctica.
Gamma-ray burst astronomy in the Swift era	A/Prof MC Ashley; Prof CW Akerlof; Prof WT Vestrand	Gamma-ray bursts are the most violent explosions known in the universe and are a testing ground for our understanding of physics in extreme environments. Later this year a new satellite, Swift, will increase by a factor of almost 10 the rate at which the bursts can be studied from the earth. Our ROTSE-III telescope is uniquely able to obtain optical data on these bursts during the first 60 seconds - a crucial period in understanding the interactions between the central engine of the burst, the fireball, and the interstellar medium. Our observations should also help explain the enigmatic short-period bursts that are believed to result from the direct formation of a black hole following a collision of two massive objects.
Star Formation at Millimetre Wavelengths with the CSIRO Australia Telescope	A/Prof MG BurtonProf RP NorrisDr TH Wong	The newly-upgraded CSIRO Australia Telescope Compact Array, together with the CSIRO Mopra Telescope, provide a unique and powerful combination for studying the millimetre-wave emission from molecules and cold dust in star formation regions. We propose to combine the astrophysical expertise of UNSW with the instrumental expertise of CSIRO to use these instruments to study the processes of star formation. There are two parallel themes to this research: to commission and develop optimal techniques for using the new instruments, and to make use of them to explore the poorly-understood processes that cause stars to form.
An ultra-wideband digital filterbank for the Mopra Radiotelescope	Prof JW Storey Dr MG Burton Dr RJ Sault Dr PD Godfrey Dr AJ Green	We seek funding to equip the Mopra radiotelescope with an ultra-wide-bandwidth digital filter bank. This will greatly improve the efficiency of the observatory, increasing the speed at which spectroscopic data is acquired by a factor of 8, and the speed of acquiring continuum data by a factor of 32. Once equipped in this way, Mopra, which is already the largest millimetre-wave radiotelescope in the southern hemisphere, will enjoy an unbeatable edge over all other competing observatories around the world through its combination of collecting area and bandpass.

36-megapixel CCD camera for wide-field astronomy	A/Prof MC Ashley; A/Prof JK Webb; Prof BP Schmidt; Dr M Colless; Prof BK Gibson	This project aims to design and build a state-of-the-art 36-megapixel charge-coupled device (CCD) camera for wide-field imaging on a robotic telescope at Siding Spring Observatory. The camera will employ a mosaic of two 18-megapixel CCDs, which are amongst the largest ever fabricated. This new facility will have an unprecedented ability to obtain precision photometry over a wide field, and will enable breakthroughs in research into areas as diverse as detection of extra-solar planets and nearby supernovae. The camera will also lead to collaborative research with ANU's newly-funded Skymapper telescope, as well as the Anglo-Australian Observatory's 6dF and 2dF instruments.
A ground station for the NANTEN2 sub-millimetre wave telescope	A/Prof MG Burton; Prof JW Storey; Dr MR Cunningham; A/Prof AJ Green; Dr PJ Barnes; A/Prof MJ Wardle; Prof Y Fukui; Prof Dr J Stutzki	We propose to provide a ground station for the NANTEN2 telescope, located on the high Atacama plateau of Chile, one of the world's finest astronomical sites. This will allow remote operation of the telescope from its base facility. It enables Australia to join the international university consortium from four countries (Japan, Germany, Korea, Chile) that run the facility, and provides us with access to the best site in the world for millimetre-wave astronomy. The telescope will conduct the first large-scale surveys of the southern galactic plane at sub-millimetre wavelengths, measuring the environment within molecular cloud complexes where star formation takes place, so allowing us to determine where and how this happens across the Galaxy.
International collaboration in millimetre and infrared astronomy to pursue the study of star formation	A/Prof MG Burton	Stars form in the cold cores of molecular clouds. Their formation can be studied at millimetre wavelengths, through the rotational line emission arising from the rich molecular chemistry taking place inside these clouds. They can also be studied at infrared wavelengths through their thermal emission. In a collaboration with UK astronomers a research program into this field will be advanced, making use of the new Australian facilities for millimetre-wave astronomy---the Mopra Telescope and the mm-interferometer of the Australia Telescope---as well as the ESO facilities for infrared astronomy. Funds are sought to facilitate this collaboration.
ARENA: Antarctic Research, a European Network for Astronomy	Prof JW Storey; A/Prof MC Ashley; A/Prof MG Burton; Dr NR Epchtein	The recent discovery that the world's best optical/infrared sites lie within the Australian Antarctic Territory creates a remarkable opportunity for Australia. The European Union is currently laying out a roadmap for the astronomical development of the Concordia Station, which opened earlier this year. Options include early deployment of the Australian-led PILOT 2.4 metre telescope, together with interferometer prototypes, followed by major telescopes of unparalleled capability. Creating this roadmap is the ARENA Network of 7 European nations plus Australia. A series of 17 meetings and workshops, fully funded by the EU, will be held over the next three years; this project will fund Australia's participation in this process.
The birth of massive stars	A/Prof MG Burton; Prof GA Garay; Prof KM Menten; Prof Y Fukui; Dr S Lizano	Massive stars are the most luminous objects in the Galaxy, the source for most of the elements. Yet their formation remains an enigma, hidden from view inside the coldest and darkest regions in space, the cores of molecular clouds. Here, stellar embryos can be seen in millimetre wavebands. Australia has completed a major enhancement to its astronomy facilities to operate in these bands. We now have the ability to peer into stellar nurseries in the southern sky, where the bulk of the Galaxy lies. We will exploit our competitive advantage, combining it with leading-edge facilities of our international partners, to conduct an unbiased survey of where massive stars form, what evolutionary stages they pass through, and how and why this happens.
The application of Markov Chain Monte Carlo methods to the search for space-time variations of fundamental constants	Prof JK Webb; Dr SJ Curran; Prof R Carswell; Dr D Mortlock; Prof A Lasenby; Dr A Jaffe	We shall search for cosmological variations of the fundamental laws of Nature (strength of electromagnetism, electron-proton mass ratio). The results will be the most stringent and will steer unified particle physics and cosmological theories. The dataset derives from >300 nights on the worlds largest observatories, VLT and Keck, costing A$24 million. No superior dataset is likely to exist for a decade. We pioneered crucial theoretical/numerical methods and will now develop and apply new statistical tools, to optimise and interpret the results and uncertainties. We are uniquely poised to make a fundamental step in the development of scientific knowledge.
Gamma-ray burst astronomy in the Swift era and beyond	Prof MC Ashley; Dr DK Galloway; Prof CW Akerlof; Prof WT Vestrand	Gamma-ray bursts are the most violent explosions known in the universe and are a testing ground for our understanding of physics in extreme environments. From 2008, two earth-orbiting satellites, Swift and GLAST, will provide an observational capability that will not be repeated for at least another 20 years. Our ROTSE-III telescope is uniquely able to obtain well-sampled optical data on gamma-ray bursts during the first 60 seconds - a crucial period in understanding interactions between the central engine of the burst, the fireball, and the interstellar medium.

Water vapour radiometers for millimetre-wave phase correction for the Australia Telescope	A/Prof MG Burton; Dr MR Cunningham; Prof JW Storey; A/Prof AJ Green; Dr A Walsh; Dr ST Maddison; Dr PG Edwards	We propose to provide a set of water vapour radiometers for the Australia Telescope. These will be used to improve the imaging capabilities of the telescope at millimetre wavelengths, by correcting for the phase changes caused by water vapour in the atmosphere. This will enable sharper images to be obtained by the telescope, as well as increasing its operating efficiency. It will benefit all observations made at millimetre wavelengths, so helping retain the international competitiveness of the facility. The enhancement will make possible the study of protoplanetary disks around infant stars, the examination of the natal dust cores in which stars form, and facilitate the search for biologically-relevant molecules in space.
Collaboration with The NANTEN2 International Star Formation Consortium	Dr MR Cunningham; A/Prof MG Burton; Prof Y Fukui	A major aim of the NANTEN2 consortium is to investigate star formation, a comprehensive understanding of which remains one of the major unsolved problems of astrophysics. The consortium will produce large-scale maps of the southern Milky Way galaxy and Magellanic Clouds, made using the new NANTEN2 sub-millimetre telescope in Chile, and Australia's Mopra Telescope. These maps will be used to determine the different types, and relative importance of, the large-scale processes that lead to star formation, such as disturbances to the interstellar medium by supernovae or collisions between molecular clouds.
The Science of Exoplanets - Finding & Understanding our Planetary Neighbours	Dr CG Tinney	I will build on my track record as Australia's leading exoplanetary astronomer and grow the nation's foremost research group in the detection, study and understanding of exoplanets. This field is now one of most important in all the physical sciences, as it critically addresses the search for habitable Earth-like planets, placing it at the very core of the strategic research plans for astronomical developments around the globe. We will undertake research at the international forefront of this field, by searching for solar systems orbiting stars like our own, by joining international teams in the quest to detect Earth-like habitable planets orbiting very cool stars, and by surveying clusters of stars for 'unbound' planets.
ARENA: Antarctic Research, a European Network for Astronomy	Prof JW Storey; A/Prof MC Ashley; A/Prof MG Burton; Dr NR EPCHTEIN	The recent discovery that the world's best sites for optical/IR astronomy lie within the Australian Antarctic Territory creates a remarkable opportunity for Australia. The European Union is currently laying out a roadmap for the astronomical development of the Concordia Station, which opened earlier this year. Options include early deployment of the Australian-led PILOT 2.4 metre telescope, together with interferometer prototypes, followed by major telescopes of unparalleled capability. Creating this roadmap is the ARENA Network of 7 European nations plus Australia. A series of 13 meetings and workshops, fully funded by the EU, will be held over the next two years; this project will fund Australia's participation in this process.
A transit search for extrasolar planets	Prof JK Webb; Prof MJ Irwin	The detection of planets around other stars is one of the most exciting recent scientific discoveries. Individual stellar spectroscopy reveals a Doppler wobble, as the star-planet maintains a common centre of gravity. Now, wide-field imaging surveys are poised to find large samples of planets eclipsing their host stars. An aligned orbital plane removes parameter uncertainties and allows the host star to spectroscopically probe any planetary atmosphere. A new CCD camera is being built (from 2004 LIEF funding, commissioning early 2006) for such a survey, using the Automated Patrol Telescope, providing a 15x efficiency gain. Post-doctoral support will be crucial to the success of the new, highly competitive survey.
Formation and evolution of galaxies in the Local Group	Dr K Bekki	Understanding the formation of galaxies in our Local Group, remains one of the key problems in extragalctic astronomy. State-of-the-art, high-resolution numerical simulations will be brought to bear on this problem, being used to interpret the latest observations and thus provide the first self-consistent theoretical explanations to the origin of the Local Group. Specific questions that will be addressed include: how did our galaxy form, how did the Magellanic Clouds form, and how, more generally, did the global group environment influence the formation of Local Group galaxies?
External influences on galaxy evolution	Dr ML Balogh	This project will undertake detailed observations to determine precisely where and when galaxies formed. This will be done by measuring the amount of star formation in clusters, groups, and isolated galaxies at different epochs. By comparing this evolution with the expected growth of dark matter structures from theory, I will be able to make the important distinction between the internal physics governing a galaxy's evolution and those forces imposed upon it by its surroundings. This will address one of the most important outstanding problems in extragalactic astronomy: understanding how galaxies like the Milky Way formed and evolve over time.