RESEARCH SCHOOL OF ASTRONOMY & ASTROPHYSICS

ANNUAL REPORT 2000

RSAA

The Institute of Advanced Studies
The Australian National University

Research School of Astronomy & Astrophysics
Institute of Advanced Studies
The Australian National University

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Front Cover:
A simulation of the collapsing phase of a thermally unstable interstellar medium shock with a speed of Mach 15, by Sutherland and Bicknell. The colours indicate temperature (green), cooling rates (red) and density (blue). The gas cools turbulently as density fluctuations are amplified by the thermal instability and by normal dynamical instabilities.

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STAFF

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Mr Michael C Begam, University of Virginia
Mme Gwendoline Blanchet, INSA Toulouse, France
Ms Gabriela Canalizo, Int. for Astronomy, Hawaii
Dr Andrew Drake, Lawrence Livermore National Laboratory
Dr Don Faulkner (retired)
Rev'd Dr Tom Frame, Bungendore (The History of MSO)
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	A Drake, BSc Auckland, MSc Auckland (to Sept)
	C Drake, BSc Monash
	L Germany, BSc UNE, Grad. Dip. Sc. Comm (to June)
	B Groves, BSc Monash
	S Gurovich, BSc UWS (Nepean)
	M Huynh, BSc UWA
	S Keller, BSc Syd (to Sept)
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	M Metchnik, BSc Comp.Sci, BSc Math, U.Qld
	R Moody, BSc
	J O'Brien, BSc U.Melb.
	R Olivier, BSc Western Cape, MSc Western Cape, S.Africa
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	I Price, BSc Newc. (to Sept)
	P Price, BSc U.Qld
	M Putman, BS Wisc-Mad.(to Nov)
	S Sankarankutty, BSc UFRN, MSc UFRN, Brazil
	H Sims, BSc
	G Wilson, BSc
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	S Sabine, BSc, Adel.
	J Smillie, BSc (Hons) U.Qld
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Observatories Secretary	G Kennedy (to March)

ADMINISTRATION:

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Assist.to Bus. Mgr.	I Sharpe
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Purchasing Officer	M Miller
Purchasing Clerk and Publications Officer	M O'Dowd
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	P Walshe (from Nov)
Gardener	B Mortlock (to Oct)
	H Coyle (from Nov)

MECHANICAL ENGINEERING

Chief Engineer	J Hart, BE (Mech) NSW

DESIGN OFFICE

Designers	P Barling, Ass. Dip. ME CTC (to July)
	P Conroy, CME CTC
	J Hu, Bach.Eng, Zhejiang (to Sept)

MECHANICAL WORKSHOP

Workshop Supervisor	C Vest
Technical Officers	R Commons
	H Gebauer, CME
	R Miles (Casual)
Contract Instrument Makers	
	A Cappuccio
	J de Smet
	R Tranter
Laboratory Technician	D Mitchell

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Programmers	W Roberts, BSc (LWOP Jan-Dec)
	K Sebo, BSc WA, PhD
	E Vassiliadis, BSc Melb, PhD (Jan-Feb)
	P de Silva, Dip IT North Sydney TAFE (Feb-Aug)
	A Lanzini, BSc Arg (Mar)
	I Price, BSc Newcastle (Jul-Dec)
	H Nyguen, BSc Griffith (Sep-Dec, 30% TNO)
	L Wilson, BSc UNSW (Oct-Dec)
	J Smillie, BSc (Hons) U.Qld (50% Nov-Dec)
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	D Pfitzner, BSc Adel (40% Jan-Oct)
	I Price, BSc Newcastle (25% Apr-Jun)
	M Buxton, BSc Tas (25% Apr-Dec)
	L Kewley, BSc Adel (25% Jul-Nov)
	G Wilson, BSc (25% Dec)

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Engineer in Charge, MSO Electronics	M Dawson, BEng MEng (from Aug)
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	G Hovey, BSc, PhD
	M Mulligan, BE (to June)
	M Jarnyk, BEng, MEng, PhD
	D Bishop, BEng (from Aug)
Technical Officers	W Goydych, BSc Syd
	B McLindin, Cat.C MIL-STD-2000, NASA (to May)
Laboratory Technicians	A de Gans

STROMLO EXPLORATORY

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Retail Supervisor	H Crawford
Marketing Officer	M McGregor
Information Officer	N Aked

SIDING SPRING OBSERVATORY STAFF

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Assistant Site Officer	T Houghton
Operations Officer	H Davenport
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	J Goodyear, HND E.Eng Edin.
	M Kanonczuk
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	R Shobbrook, BSc St Andrews, PhD

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SSO EXPLORATORY

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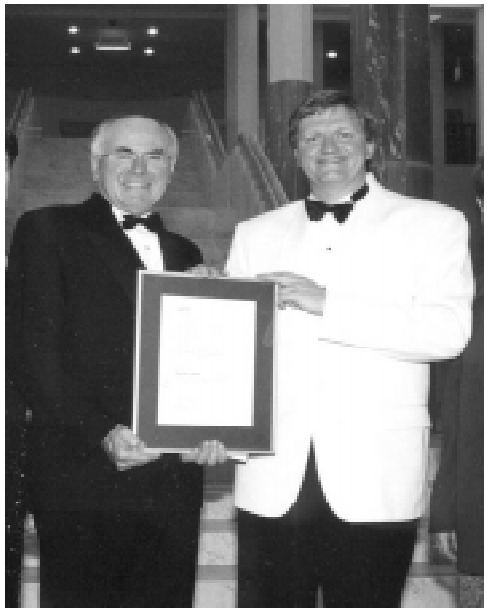
Casual Staff	J Atkin, H Goodyear, D Hynds, R Otrupcek, J Owen

SCIENTIFIC HIGHLIGHTS

Malcolm McIntosh Prize for Achievement in the Physical Sciences

In 2000, RSAA's Brian Schmidt was honoured as the inaugural winner of Australia's Malcolm McIntosh Award for Achievement in the Physical Sciences for his work on the accelerating Universe. He was presented with the award in a ceremony at Parliament House at the Prime Minister's Prize for Science Dinner by the Honourable Senator Nick Minchin.



At right, Brian displays his certificate of award with the Prime Minister, the Honourable John Howard.

It has been known for some time that we live in a Universe that is expanding around us; the farther an object is in distance, the faster it is receding from us. Work by Mould and collaborators, using the Hubble Space Telescope, has shown that the Universe is expanding at a rate of approximately 20 kms per second per million light years – a number which sets the scale on our Map of the Universe – much like the legend on a UBD Guide. But the Universe may be slowing down or speeding up over time. It is the measurement of this acceleration/deceleration that gives us clues to the nature of its birth in the Big Bang, and its ultimate fate. Since 1994 Schmidt has been leading a 20-member international team – the High-Z Supernova (SN) Search – that is using the world's most powerful telescopes to trace the expansion rate of the Universe back towards the Big Bang.

The High-Z SN Search uses type Ia supernovae to accurately measure distances. These rare explosions of the burned out embers of normal stars outshine an entire galaxy of 10 billion stars, but with a power that is predictable to 10%. By measuring how bright these objects appear, Schmidt's team is able to accurately measure distances to distant galaxies – the fainter an object appears, the more distant the object. Schmidt's group discovered their first object in 1995, at some 5 billion light years in distance. The light from this object had been travelling

since before the Earth was formed, and provided a rough measurement of how fast the Universe was expanding at that time. Over the past 5 years the High-Z SN Search team has followed up that discovery with a hundred more.

In 1998 when Schmidt plotted these objects' distances against their velocity of recession, a surprised emerged: The Universe was not slowing down at the rate expected due to gravity. Rather it had accelerated over the past 5 billion years. This discovery was named 'Science' magazine's Breakthrough of the Year for 1998. Over the past two years Schmidt's team has worked hard to verify this discovery, and to take observations of even more distant objects to better understand what is causing the Universe to speed up. The new data, soon to be released, includes the most distant supernova yet discovered, at nearly 10 billion light years in distance, and will help identify the nature of the material causing the acceleration.

Mapping the Universe with the 2dF Galaxy Redshift

Since 1997, a group of 30 astronomers, led by Matthew Colless (RSAA) and John Peacock (Edinburgh), have been making one of the largest-ever maps of the Universe. They have used a remarkable instrument, the Two-Degree Field (2dF) spectrograph at the Anglo-Australian Observatory (AAO), to measure the positions in space of over 150,000 galaxies. Using this map they have been able to make the most precise measurement to date of the total mass density in the Universe, and to place strong limits on other fundamental cosmological parameters.

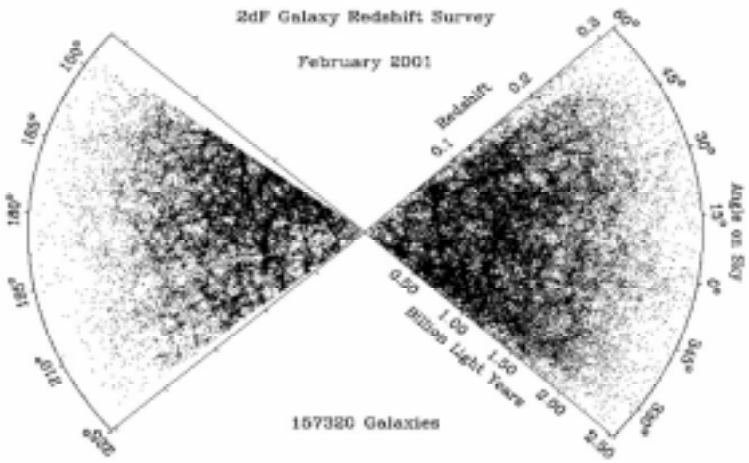
Cosmography, the making of maps of the Universe, is an ancient science. Recent advances in physics and technology have deepened our understanding of how the Universe came to be the way it is and opened up vast new tracts of space and time to quantitative observation. We now have directly-observed maps of the Universe at epochs ranging from 100,000 years after the Big Bang (from observations of the cosmic microwave background radiation) down to the present, some 10 billion years later. The level of detail and precision of these maps allows us to learn much about the origins, contents and fate of the Universe.

The 2dF Galaxy Redshift Survey (2dFGRS) aims to extend maps of the relatively nearby Universe by an order of magnitude or more in both the number of galaxies mapped and the volume covered. Galaxies are the most easily-observed tracers of the mass in the Universe, acting as beacons showing the peaks of the mass distribution. Their three-dimensional positions in space can be measured from their redshifts, which are the velocities at which they are receding from us due to the overall expansion of the Universe. This is because the recession velocity of a galaxy is simply related to its distance – for nearby

galaxies the distance is directly proportional to the recession velocity, although there is also a small additional 'peculiar' velocity which is due to the gravitational attraction of the mass concentrations around the galaxy.

The previous largest redshift surveys mapped the positions of as many as 25,000 galaxies and took many years to complete. In order to map ten times as many galaxies in a reasonable time span, a more powerful instrument was needed. The AAO's 2dF spectrograph was built with precisely this sort of survey in mind. It is capable of observing the spectra of 400 galaxies simultaneously over a 2-degree diameter field of view (roughly 16 times the area of the full moon). It uses fibre optics to feed the light from these 400 galaxies from the focal plane of the telescope to the spectrographs. The fibres themselves are positioned over the target galaxies using a fast and precise robot. This system allows the survey team to measure a few thousand redshifts on a clear night.

The 2dFGRS is mapping some 2000 square degrees of sky and 250,000 galaxies. Survey observations began in 1997 and by January 2001 redshifts had been measured for over 150,000 galaxies. The distribution of the galaxies mapped to date is shown in the accompanying figure as a function of redshift and angle on the sky along the strips. There are two main points worth noting in this figure: first, the very large number of galaxies in the survey means that the large-scale structure of the galaxy distribution is revealed with high spatial resolution; second, the volume covered by the survey is much larger than any single structure apparent in the map, so that the survey does represent a statistically fair sample of the Universe.



The galaxy distribution projected onto two slices in Right Ascension (angle on the sky) and redshift. There are 150,000 galaxies shown as dots in this figure. The Milky Way is at the centre of the figure, which reaches out to a distance over 2.5 billion light years.

The 2dFGRS team, including RSAA staff members Colless, Peterson and Jackson, is now analysing these maps in order to extract quantitative information on the large-scale structure in the galaxy distribution. Such information provides powerful constraints on cosmological models, because the formation of this structure depends on a relatively small number of fundamental parameters (the energy density in ordinary baryonic matter, in non-baryonic dark matter, and in the vacuum itself, as well as the initial distribution of quantum mass fluctuations emerging from the Big Bang), plus the simple (and testable) assumptions that structure grows due to gravitational instability (i.e. that mass concentrations grow by the gravitational attraction of more mass), and that clusters of galaxies correspond to mass concentrations.

The survey team have been able to use the map of the galaxy distribution to measure the total mass density of the Universe in two complementary ways. One way compares the measured strength of galaxy clustering on different scales with models for the formation of large-scale structure in cosmologies with different fundamental parameters. The other method is a direct measure of the mass density based on the gravitationally-induced motions of the galaxies.

Using the first of these two methods, the survey team found strong evidence supporting a cosmological model in which the Universe has a 'flat' geometry (without spatial curvature), with about 30% of the energy density in matter and about 70% in vacuum energy. The ordinary baryonic matter of which stars and galaxies are made comprises only about 15% of the total amount of matter in the Universe, with the rest being non-baryonic dark matter, whose constitution is presently unknown. This model, which is also favoured by observations of the cosmic microwave background and distant supernovae, is becoming the new standard cosmological model.

The second method uses statistical analysis of the galaxy motions and finds that on small scales the galaxies are typically orbiting each other very rapidly in dense groups and clusters, but that at larger scales there is coherent infall of galaxies towards mass concentrations. This latter effect permits a very direct measure of the mass density, since the amplitude of the infall is directly related to the amount of matter in the Universe, up to a constant factor (the bias parameter) that scales the fluctuations in the galaxy distribution to those in the mass distribution. This method yields an estimate of the mass density which again is in excellent agreement with the standard cosmological model. It also provides the first direct confirmation of the gravitational instability paradigm for the formation of large-scale structure.

The 2dF Galaxy Redshift Survey will finish measuring redshifts for all 250,000 galaxies in the survey volume by the end of 2001. Many other exciting issues remain to be explored with the full sample, including tests of the linear biasing model relating the distributions of mass and galaxies, and tests of one of the

main predictions of inflationary cosmologies. The survey will also provide a magnificent database for studying the properties of the galaxy population and exploring models for the formation and evolution of galaxies.

Building Gemini's Near-Infrared Integral Field Spectrograph

The Australian National University signed a $4.5M contract in 2000 to design, construct, and commission a complex near-infrared spectrograph for the 8 metre Gemini North telescope in Hawaii. The Near-infrared Integral Field Spectrograph (NIFS) will be Australia's first Gemini instrument. (Australia is a 5% partner with the USA, the UK, Canada, Chile, Brazil, and Argentina in the International Gemini Telescopes Project to build two 8 m diameter astronomical telescopes in Hawaii and Chile.) The award of the NIFS construction contract to the RSAA recognises the high level of technical skills in the School that has been built up over four decades of designing, constructing, maintaining, instrumenting, and operating ANU telescopes at Siding Spring Observatory. The NIFS construction contract also guarantees six nights of time on the Gemini North telescope using NIFS to the instrument building team during the first year of operation of the instrument. At RSAA the Project Scientist is Peter McGregor, while Jan van Harmelen is the Project Manager.

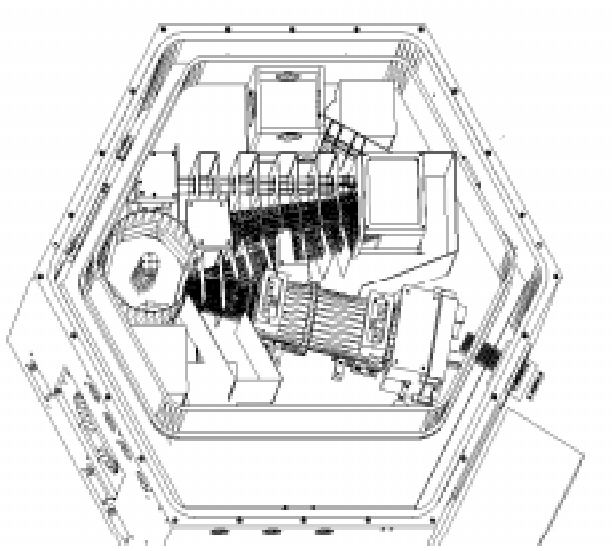
NIFS was proposed to the Gemini Instrument Forum in March 1999. It was conceived as a fast-tracked, specialised instrument which would be made available to the Gemini community on the shortest possible timescale. RSAA was awarded a contract to perform the NIFS Conceptual Design Study in August 1999. The Conceptual Design Review was successfully completed in March 2000 at Mount Stromlo Observatory. The construction contract was signed by ANU in August 2000 and by the Association of Universities for Research in Astronomy (AURA) who manage the International Gemini Project Office in November 2000. The NIFS Critical Design Review will be held at Mount Stromlo in April 2001. NIFS is scheduled for commissioning on the Gemini North telescope in mid-2003 and will be available to the Gemini community later in that year.

The signing of the NIFS construction contract was announced at a press release in December 2000 at the Mount Stromlo Visitors' Centre. The event was attended by the Deputy Chief Minister of the Australian Capital Territory, Mr. Brendan Smyth, the Deputy Vice-Chancellor of the ANU, Prof. John Richards, representatives from local industry who are assisting the RSAA in constructing NIFS, and a large number of television and newspaper representatives. This, and subsequent radio interviews, were used to emphasise the importance of the Gemini telescopes to Australian astronomy, the internationally competitive high-tech capabilities of Australian universities and industry, the high level of technical expertise at the RSAA and the extra employment opportunities in

high-tech fields that the NIFS project has generated. Visitors were shown NIFS components being constructed in the Mount Stromlo Observatory workshops and examples of the complex optical system at the heart of the instrument.

NIFS will use a state-of-the-art 2048 x 2048 pixel HgCdTe HAWAII-2 near-infrared detector array manufactured by the Rockwell Science Centre in California. These devices have been designed in collaboration with the University of Hawaii and have become available to other groups only recently. The local company AUSPACE has assisted in the design of the key grating drive mechanism. AUSPACE has had a long association with RSAA from its creation as a spin-off company from the then Mount Stromlo and Siding Spring Observatories.

NIFS will simultaneously record near-infrared spectra at each location in a 3 arcsecond by 3 arcsecond field on the sky at nearly the full spatial resolution achieved by Gemini's ALTAIR adaptive optics system, which corrects for atmospheric distortion in the incoming optical wavefronts. This combination of Gemini's 8 m diameter collecting area, an advanced adaptive optics system, and a near-infrared integral field spectrograph is unprecedented. It will allow NIFS to record data at near-infrared wavelengths with the same spatial resolution that is achieved at optical wavelengths with the Hubble Space Telescope.



Schematic outline of the open NIFS showing the integral field unit (top), grating turret (left), and detector housing (lower right).

The primary purpose of NIFS is to study moderate surface brightness structures around discrete objects which are revealed at high spatial resolution by ALTAIR. The main science goals are to characterise the masses of black holes in the nuclei of spiral galaxies and to study the interactions of the radio jets from Seyfert galaxies with the interstellar medium of the host galaxies. The nuclei of many nearby elliptical galaxies contain massive (10^6-10^9 $M_\odot$) black holes which appear to have formed along with these galaxies at early times in the Universe. Early-type spiral galaxies also contain massive nuclear black holes, but it is less clear that all spiral galaxies underwent the process (perhaps a major galaxy merger) which led to the formation of a massive nuclear black hole. NIFS will measure the masses of nuclear black holes in nearby spiral galaxies by recording the integrated velocities of stars orbiting close to the black hole. Galaxies in which material is currently accreting onto the massive nuclear black hole are classified as Seyfert galaxies. The active nucleus powers a luminous region of the surrounding interstellar medium, called the Narrow Line Region, by both irradiating it with X-rays and blasting ejected material through it. NIFS will study the details of this interaction to distinguish which of these processes is the dominant excitation mechanism in the inner Narrow Line Regions of nearby Seyfert galaxies. Other projects include studies of the star formation history in massive star clusters in the nucleus of the Milky Way galaxy, the nature of outflows and circumstellar disks around forming stars, interactions occurring in ultra-luminous infrared galaxies, and the dynamical evolution of high redshift disk galaxies.

OTHER HIGHLIGHTS

Duffield Chair of Astronomy

On 20 June, Professor Ken Freeman was installed as the inaugural Duffield Professor at RSAA. The Chair was endowed in Mt Stromlo's 75th Anniversary year with the generous support of Ms Joan Duffield to honour her father, W.G. Duffield, who was the founding Director. Professor Freeman has made significant contributions in astrophysics and fundamental physics, notably properties of galaxies and dark matter.

Ms Joan Duffield congratulating Prof Ken Freeman

Ms Duffield was present for the ceremony and remarked that in its first 75 years, the site has expanded far beyond the hopes and expectations of her father when as a young man he first began to dream. She hoped many more young people will take up the challenge of this fascinating science and that the next 75 years will be as exciting as the first 75 years.

Charlene Heisler Workshop 2000

On December 7 and 8 the RSAA organised its fifth annual AGN Workshop, an event that serves as forum for interaction between Australian astronomers working in the area of Active Galactic Nuclei (AGN). This year the workshop was named after Charlene Heisler to honour her contributions in this field.

The workshop was well attended, with 46 registered participants from Australia, USA and Japan. An outstanding characteristic of the meeting was the excellent balance between observations and theory in the presentations, and the high level of interactions between these two disciplines. Many new results on radio observations of AGN were presented. Conclusive evidence was shown that the intra-day variability of radio sources is almost entirely due to scintillation effects in the local interstellar medium. A second focus of the meeting was provided by several presentations showing a range of evidence for the importance of outflows in the AGN environment on scales of tens to hundreds of light years from the central black hole. Other talks showed how significant progress is being made in the development of theoretical tools to interpret these dynamical effects, in the form of hydrodynamical simulations including radiative processes. The remaining part of the meeting was largely devoted to the use of AGNs to probe the evolution and structure of the Universe, one of the highlights being the presentation of the impressive results that are now coming out of the 2dF Quasi Stellar Object redshift survey.

The success of this meeting demonstrated the strength and vitality of Australian AGN research, and a continuation of the AGN workshop series on an annual basis is planned.

Mount Stromlo Visitors' Centre

The Visitors' Centre welcomed some 27000 visitors in 2000, including over 370 schools and public groups. Special events included the very successful Total Lunar Eclipse on 16 July, as well as Open Day and the week of the National Science Festival, which together attracted some 5500 participants.

The Mount Stromlo Observatory Heritage walk was launched in January, with the valued assistance of Australian Geographic. The walk was designed to complement Canberra's other cultural heritage sites, and presents the Observatory's scientific heritage to the public as part of an active research institution, and to meet the public's desire for knowledge about astronomical features, events and discoveries, both historical and current. July saw the launch by the then Deputy Chief Minister Mr Gary Humphries, of Capital Astronomy Nights, an initiative aimed at broadening public access to the largest telescope on site, the 1.9 metre, and making it available for public viewing.

In October the National Australia Bank presented the Visitors' Centre with $5000 as winner of an ACT National Community Link award. The prize acknowledged the valuable contribution of Mount Stromlo's volunteer explainers, who play an essential role in the life of the centre.

Year 10 Astronomy Summer School

Normally in December, most year 10 students look forward to several weeks of sun, surf and sand. However, from December 10 to 16, 2000, Astronomy, for the second year in a row, showed its capacity for inspiring young minds. Fifteen extremely bright students were selected from a national competition for the Mount Stromlo Astronomy Summer School that was financed by a grant from Perpetual Trustees. In 2000 this grant was supplemented by a scholarship for one of the students from Newton magazine. The students arrived in Canberra on December 10 for a week filled with astrophysics projects, visits to local facilities, lectures from RSAA astronomers, role playing exercises and fun social occasions. The highlight for the students was the project (led by Paul Francis) that they each carried out using Mount Stromlo's 74 inch telescope. This project involved using skills on colour imaging in astronomy taught to the students by Ralph Sutherland. As always, the role-playing exercises, also led by Paul Francis, were very successful and the students greatly appreciated the fact that the lectures by Jeremy Mould, Carole Jackson and Geoff Bicknell represented the cutting edge of their particular fields of interest.

Year 10 Astronomy Summer School students

FROM THE DIRECTOR'S OFFICE

2000 was the seventh and final year of the directorship of Professor Jeremy Mould. He resigned in January 2001 to take up the directorship of the United States' National Optical Astronomy Observatory (NOAO) in Tucson, Arizona. Jeremy played a pivotal role in Australian astronomy both within the ANU and in the wider Australian community. He was instrumental in strengthening existing international ties and in establishing others. Some highlights of his tenure were:

Prof. Jeremy Mould

- Fostering, early in his term, the application of Australia to join the European Southern Observatory. While unsuccessful, the recent midterm review of Australian astronomy "Beyond 2000 - The Way Forward" identifies this as a move still strongly favoured by Australian astronomers.

- Successfully working towards Australia becoming a partner, at the 5% level, of the Gemini consortium to establish twin 8 m optical telescopes in Hawaii and Chile. Mount Stromlo hosted the Gemini Project Office for the first year of Australia's participation.

- Membership and Chairmanship of the Anglo-Australian Telescope Board, and of the National Committee of Astronomy.

- Mount Stromlo and Siding Spring Observatories had been a centre of the Institute of Advanced studies. During his tenure it became the Institute's ninth school – the Research School of Astronomy and Astrophysics.

- His directorship coincided with a period of reduced funding which led to a leaner operation of the Observatories. While painful, this was achieved in a manner which maintained the effective good operation of the School.

- As part of the restructuring, the School looked to develop a larger role in the construction of instrumentation for the world's 8 m class telescopes, in particular the Very Large Telescope and Gemini. Of particular importance was the award of a large contract for RSAA to design and construct the Near-infrared Integral Field Spectrograph for the Gemini project.

- Expansion of the outreach role of the School. Strong links were established with the ANU's Faculties in both teaching and research, and the number of Honours students supervised from Stromlo dramatically increased. The Mount Stromlo Exploratory (Visitors' Centre) was established to reach out to Canberra and its schools, and to the wider Australian community.

- His directorship witnessed the strategic decision to strengthen the School's role in cosmological studies by building on synergies within the school and targeted recruitment. Evidence of his success in this endeavour may be found in the highlights of this report.

- Finally, but definitely not least, he completed his work as leader of the Hubble Space Telescope Key Project to measure the Hubble Constant – the rate of expansion of the Universe. Before the project began there were strongly divergent views in the community favouring a range in values between 40 and 100 km/sec/Mpc. As reported in the previous Annual Report the value determined by the Key Project team – $H_0 = 68 \pm 6$ km/sec/Mpc – now strongly constrains the situation.

At his farewell dinner in Canberra, Jeremy spoke to the proposition that all Directors of Mount Stromlo and Siding Spring Observatories had been crazy. By this he meant they all possessed the temerity to dream (and act upon) impossible dreams. He certainly belonged to the group. We wish him well in his new challenge at NOAO.

SOURCES OF REVENUE

Source of revenue	1998	1999	2000
	$000	$000	$000
IAS block grant	5276	5210	5273
External funds	676	806	2788
Ancillary activities	796	1027	967

NATIONAL FACILITIES

Number of Nights Allocated for External or Collaborative Use on RSAA Telescopes During 2000

	2.3m		74″		40″		24″	
Overseas users	26	153	224	3	193	26	55	
UNS universities	52	8	32		18			
AAO/CSIRO	17	6			28			
Other							11	45
Total nights external /collab. use	**262**		**259**		**265**		**111**	

The first entry of each pair is the number of nights allocated entirely for external use; the second is the number of nights allocated for collaborative projects involving RSAA and external researchers.
AAO = Anglo-Australian Observatory.
The 24" is scheduled less regularly than the larger telescopes.

PERSONNEL INFORMATION

Dr Jianke Li, Dr Robert Smith and Dr Griet Van de Steene left us for the Department of Education, Training and Youth Affairs, for England and for Belgium respectively. Dr Curtis Saxton joined us as ARC Fellow, and Dr Helmut Jerjen accepted a position as Research Fellow. Two offers of academic positions were outstanding at the end of the year.

At the end of 2000, RSAA had 15 doctoral students (6 men, 9 women), and three postdoctoral fellows (2 men, 1 woman). The academic staff comprised 19.5 men and 2 women, while the non-academic staff comprised 39 men and 12 women. The ratio of academic to non-academic staff was 0.42.

EQUAL OPPORTUNITY

The RSAA Equity and Diversity Committee reported a deterioration in the gender balance of the staff: the number of men increased by 4 while that of women decreased by 2.

The committee recommends that the Appointments Committee should actively recruit women and that the agency employed to find general staff members should be made aware of the University's desire to improve gender balance by recruiting female engineers and IT workers.

As targets for 2001 the committee recommends that the RSAA Strategic Plan should set a target of comparability in gender balance with institutions such as AAO, JILA and the Observatories of the Carnegie Institution of Washington, and the gender balance of academic hires at Level A should resemble that of our graduating class. The Appointments Committee should consider joint appointments of women RSAA-Mathematics and RSAA-Physics.

John Norris, Interim Director

17 February 2001

RESEARCH

- * not a member of the University

STELLAR ASTROPHYSICS

Formation of the Very Heavy Elements in the First Intermediate-mass Stars

Norris, with Aoki*, Ryan*, Beers*, and Ando*, analysed the abundances of the very heavy elements in the carbon-rich, very metal-poor star LP 625-44 (which has an iron abundance some 500 times less than that of the sun, and formed some 12 billion years ago). They detected lead in this object. The abundance pattern of some 13 elements between barium and lead agrees well with a scaled solar system s-process component (nucleosynthesis involving the slow addition of neutrons), and is interpreted as a result of mass transfer in a binary system from a previous intermediate-mass companion (some 5-10 times the mass of the sun) - an interpretation strongly supported by radial velocity variations of this system. The very heavy elements observed in LP 624-44 were formed in the more massive (and now no longer visible) star and transferred to the object now being observed.

The detection of lead makes it possible, for the first time, to compare model predictions of s-process nucleosynthesis in intermediate-mass stars with observations of elements between Sr and Pb. The lead abundance is significantly lower than the prediction of the recent models of Gallino and co-workers. This suggests the need to either (a) reconsider the underlying assumptions of those models (which involve a postulated pocket of ^{13}C-rich material), or (b) investigate alternative sites for the formation of the very heavy elements in very metal-poor intermediate-mass stars.

Chemical Abundances of the Most Metal-poor Stars

Norris, with Beers* and Ryan*, obtained high-resolution, high-signal-to-noise spectra with the Anglo-Australian Telescope (AAT) for the five most metal-poor stars known (objects having less than 1/3000 the heavy-element abundance of the sun and which were among the first to form some 12 billion years ago). They derived chemical abundances for some 18 elements in these stars, and were able to constrain the early enrichment history of the Milky Way Galaxy more tightly than was possible in previous analyses. Results from this work include:

The existence of large supersolar values (larger than found in the sun) of C/Fe and N/Fe at lowest abundance, not predicted by canonical theoretical models. For carbon at least, the result is difficult to attribute to internal mixing effects following element production within the stars themselves.

Detection of no upward trend in alpha-element/Fe, (where alpha = Mg, Si, Ca, Ti) at the lowest values of Fe/H, in contradistinction to some reports of the behaviour of O/Fe - a result at odds with existing models of the chemical enrichment of the Galaxy.

Confirmation of earlier results concerning the Fe-peak elements, that Cr/Fe and Mn/Fe decrease at lowest abundance, while Co/Fe increases (relative to their values in the sun) - behaviours that had not been predicted. The authors found, however, that Ni/Fe does not vary, a result which appears inconsistent with the supernova models of Nakamura and co-workers that seek to understand the observed behaviour of the Fe-peak elements by varying the position of the model mass above which the outer layers are expelled during the explosion of massive supernovae.

The existence of a large scatter in the abundance of the heavy neutron-capture elements Sr and Ba, with the effect being larger for Sr than Ba. The disparate behaviour of these two elements has been attributed to the existence of (at least) two different mechanisms for their production, neither of which is currently well-understood.

For the remarkable object CS 22949-037, which has only ~1/10000 the iron abundance of the sun, the authors confirmed the result of McWilliam and co-workers that C/Fe, Mg/Fe, and Si/Fe are larger by a factor 10 than found in the sun. Further, they found N/Fe has 500 times its value in the sun - an extremely surprising result. None of these abundances is understandable within the framework of standard models. The authors discuss them in terms of partial ejection of supernova mantles and massive (200-500 times the mass of the sun) zero-heavy-element hypernovae, as have been described by Woosley & Weaver. The hypernovae models actually predicted overproduction of nitrogen and underproduction of Fe-peak elements.

An Unusual Main Sequence Star in the Globular Cluster M55

Globular clusters, clusters of up to a million or more old stars, are usually thought to be chemically homogeneous - i.e. the chemical composition of any one cluster star is identical to that of any other. However, observations obtained over the past two decades have indicated that this picture may be too simple. While abundances of heavier elements such as Fe and Ca do seem to be constant from star-to-star, elements such as O, C and N, and Na, Al and Mg show star-

to-star abundance variations, particularly among the cluster red giant stars. The origin of these abundance anomalies is not understood - the competing hypotheses ascribe the anomalies either to variable internal mixing processes within the stars themselves or to variable enrichment processes occurring during the formation of the cluster. These hypotheses can be distinguished by observing stars on the cluster main sequence since such stars cannot possess mixing driven abundance anomalies. For this reason Da Costa, Norris, Cannon* and others have been using the 2dF multi-object spectrograph system at the AAT to observe large samples (~130 to 300 or more) of main sequence stars in a number of nearby globular clusters. At this stage the analysis of these data is not yet complete but the observations have resulted in the discovery of an unusual main sequence star in the globular cluster M55. This star, which is a definite cluster member, shows a very strong enhancement of carbon in its atmosphere - the carbon abundance exceeds that of other cluster stars by a factor of between 6 and 20. The most likely explanation for the origin of this anomalous star is that it is (or was) a member of a binary system and that its atmosphere was polluted by mass transferred from the original more massive primary star during the carbon star phase of its asymptotic giant branch evolution. No other abundance anomalies are apparent in the observed spectrum of the star.

The Final Stages of Stellar Evolution Revealed

Wood and Cohen* have made a study of 504 infrared point sources discovered in the Large Magellanic Cloud (LMC) by the MSX satellite in 1996-1997. Near-infrared magnitudes were obtained with the ANU's 2.3 m telescope at Siding Spring Observatory. The K magnitude (brightness) of the sources is plotted against the J-K colour (temperature) in Figure 1. The results show that: 125 of the MSX sources are bright red supergiants (masses of 10 or more solar masses); 230 are AGB stars, highly evolved versions of stars like our sun which are enshrouded in the dust produced by a copious stellar wind which is removing the outer layers of the star; and 25 appear to be post-AGB stars which have lost essentially all their outer layers via the stellar wind. This is the first time that a complete sequence of stars covering all the late evolutionary stages of solar-like stars has been seen in a single galaxy at known distance. By studying the numbers and properties of the stars along the sequences seen in Figure 1, it will be possible to unravel the processes by which solar-like stars eject their envelopes, turn into planetary nebulae, and die as white dwarfs.

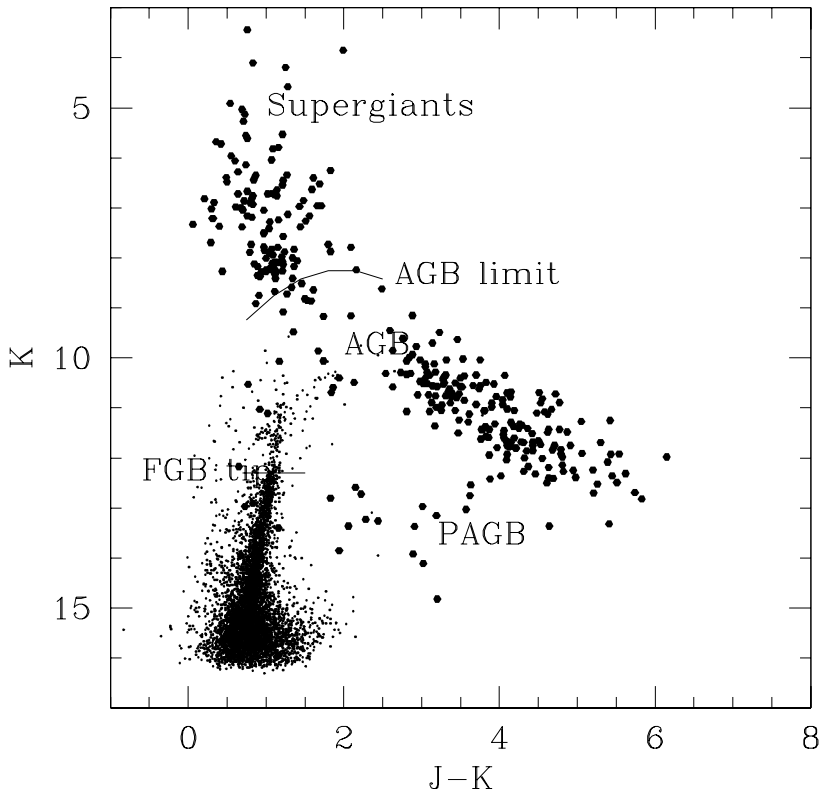


Figure 1: The K magnitude plotted against J-K colour for ordinary giant stars (small dots) and infrared MSX sources (large dots) in the LMC. The massive supergiant stars lie above the line labelled "AGB limit". Solar-like stars evolve up the giant branch delineated by the small dots, then evolve down and to the right on the AGB as the stellar wind they produce become stronger and dustier, then they run out of gas to fuel the stellar wind and move back to the left (hotter region) through the sequence labelled "PAGB" where they turn into planetary nebulae and fade away to become white dwarfs.

Detection of Objects in the Outer Solar System

Schmidt, Axelrod, Moody, Alcock* and Cook* have commenced the Southern Trans-Neptunian Object Survey, which uses the Mount Stromlo 50 inch telescope and MACHO camera system to look for objects like Pluto in the outer solar system. These objects, called Trans Neptunian Objects (TNOs), are thought to be remnants of the formation of our solar system. The goal of this survey is to perform a complete census of bright objects in the outer solar system located in a 20 degree wide band centred on the ecliptic. The team has automated the 50 inch telescope, which now routinely takes data without human intervention.

The survey has been accumulating data for a year. The data processing pipeline is now detecting moving solar system objects, which are being reported to the Minor Planet Center. This program expects to find more than 50 objects over 3 years and to determine their orbits.

Axelrod is also a member of the closely related TAOS Project, an effort to detect Kuiper belt (outer solar system) objects by observing their occultation of background stars. The first of three telescopes has been installed on Lu Lin Mountain in Taiwan, with the second going to Lawrence Livermore Lab in California for integration work. Software and hardware integration work will be completed on two coupled telescopes at Livermore during 2001, which then will be moved to Lu Lin to begin the experiment.

THE GALAXY

Probing the Galactic Potential

Unbound star or gas clouds dissolve in the tidal field of the Galaxy. As time goes by the tidal debris is stretched out along an arc which remains close to the orbit that would be described by the centre of mass of the cloud.

The shape of the tidal arc is sensitive to the tidal potential. An orbit in a spherical potential is characterised by two periods: the radial period is associated with the in-and-out motion, and the angular period with the mean drift in azimuth. These two periods are different in general and produce distinct tidal arcs.

In the Kepler case where all the mass is interior to the orbit, the two periods are equal, and therefore during half a radial period, or the time it takes to move from the closest to the furthest point from the centre, the drift in azimuth will be 180 degrees. The left upper panel in Figure 2 shows a tidal arc in the Kepler case. The panel below shows the variation of the radial velocity as a function of the azimuth. In this case the velocity is a sinusoid with a period of 360 degrees.

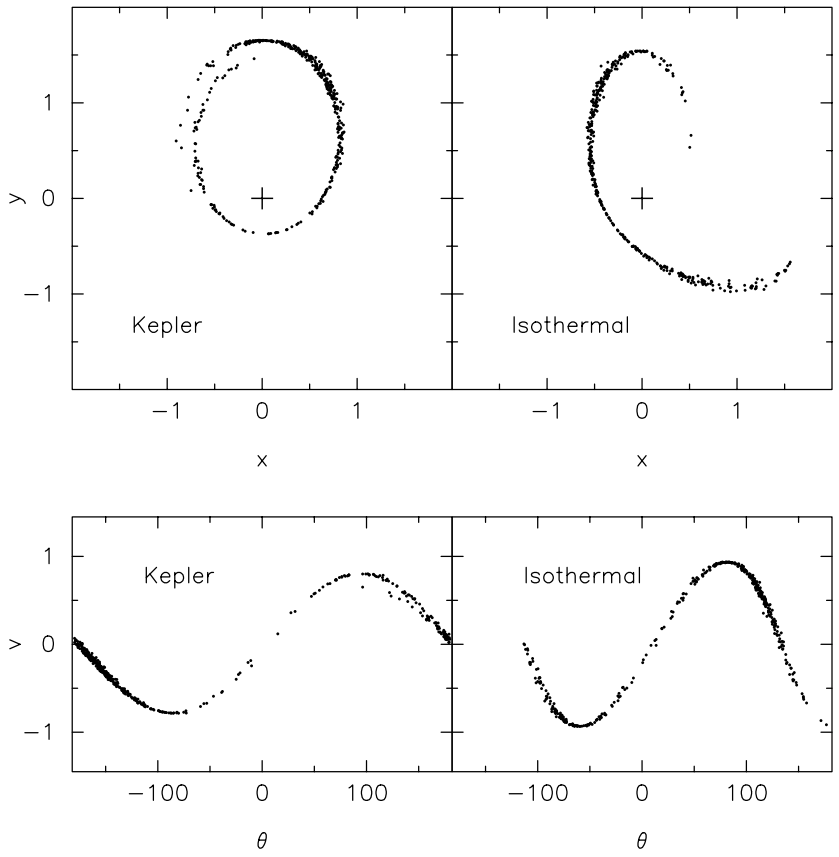


Figure 2. Tidal arcs in two galactic potentials (top panels), and the respective radial velocities measured clockwise from the peri-galactica (bottom panels). The particles are orbiting in a clockwise sense.

In the Isothermal case, associated with dark halos, the radial period is shorter than the azimuthal. Now the azimuthal drift in half a radial period will be about 123 degrees, as can seen in the upper right panel of Figure 2. The radial velocity, shown in the panel below, will not be strictly sinusoidal, but it will have a period which is close to 123 degrees.

Kalnajs points out that the period of the radial velocity variation along the tidal arcs determines the ratio of the two orbital periods which is a distinguishing characteristic of spherical potentials.

The Magellanic Stream is a long tail of gas trailing behind the Magellanic Clouds. This tail is a likely tidal arc which can be used to probe the Galactic mass distribution.

The Effects of the Galactic Bar on the Local Stellar Kinematics

The Milky Way is a barred galaxy. The length of the semi-major axis of the bar is about half the galactocentric distance of the Sun. Fux has conducted a study of orbits in a simple rotating bar potential in order to see how a bar would affect the observed velocity distribution of stars passing through the Solar neighbourhood. The results show that the local velocity distribution contains both regions of regular as well as chaotic orbits, which breaks the traditional belief that the bar has little or no influence on the Solar circle stellar kinematics.

The chaotic behaviour may provide a new and efficient mechanism for the heating of galactic discs.

Search for Old Halo White Dwarfs

The MACHO Project detected a previously unknown population of compact objects in the Milky Way through their gravitational lensing effect on the light of distant stars. These objects may make up part of the dark matter that dominates the dynamics of the galactic halo. If so, they are probably ancient, cold white dwarfs left over from a first epoch of star formation. There are now intriguing hints that such objects have also been detected as faint moving objects in the Hubble Deep Field. Additionally, several nearby examples have been fortuitously discovered, and their spectra measured, confirming the theoretical expectations of their colors and brightnesses.

In 2000 a team led by Mould, and including Freeman, Da Costa, and Axelrod started a new observational program to conclusively determine how many ancient white dwarfs are present in the halo. This program has two components. The first reobserves with the Hubble Space Telescope (HST) an area of sky known as the Groth strip that was previously observed in 1994. The timespan is sufficient that moving white dwarfs should be reliably detected. The first of these observations have now been taken, and data reduction has begun. The remainder of the observations will be taken in 2001. The second component uses the Wide Field Imager on the 40 inch telescope at Siding Springs. This will allow a much larger region of sky to be observed than is possible with HST, though of course not as deeply. These observations will form a useful complement to the Groth strip. First epoch observations were taken in 2000.

The Kinematics within ω Centauri

Freeman, with van Leeuwen*, Le Poole*, Reijns*, de Zeeuw* and Seitzer*, has completed a very large proper motion and radial velocity study of internal motions in the globular cluster ω Centauri. The proper motion study was started in 1978, using about 50 plate pairs taken by W.C. Martin with the Yale Columbia 26-inch refractor when it was in Johannesburg in the early 1930s and by Freeman and others with the same telescope at Mount Stromlo about 50 years later. This study produced precise internal proper motions for about 8000 stars and radial velocities (and therefore all three components of the internal space motion) for about 1700 stars. The main results are: (1) the velocity dispersion within the cluster is close to being isotropic over a wide range in radius, (2) the cluster shows differential rotation in both the proper motions and radial velocities, so the angular momentum vector lies at some intermediate angle to the line of sight, (3) with tight kinematic criteria for stellar membership, the colour-magnitude diagram for the member stars is very well defined, (4) the radial velocities show evidence for a kinematically independent core in ω Centauri.

GALAXIES AND GALAXY EVOLUTION

Hubble Space Telescope/WFPC2 Observations of M31 Dwarf Spheroidal Companion Galaxies

The dwarf spheroidal (dSph) galaxy companions of the Milky Way are the nearest and best studied examples of what is probably the most common type of galaxy in the Universe. In the past decade or so, observations of these local companions have revealed a surprising diversity in some properties, while at the same time establishing that there are relations, e.g. between the total luminosity of the dSph and the mean metal abundance of its stars, which all the galaxies follow. What is not clear, however, is the extent to which these results can be generalised. In other words are the Milky Way's companions "typical" examples of the dSph class, or have they been influenced by the particular environment in which they are found? In order to begin to answer this question, Da Costa, Armandroff*, Caldwell* and Seitzer* have been carrying out a program with the Hubble Space Telescope WFPC2 camera to study the dwarf spheroidal companions of M31, the nearest examples of dSph galaxies other than those of the Milky Way.

During this year observations of And III, one of the least luminous and most metal-poor of the M31 dSph companions, were analysed. It was found that like the previously studied systems And I and And II, and like most of the Galaxy's dSph companions, the distribution of horizontal branch stars in the colour-magnitude diagram of And III is predominantly red. In this respect, And III is very similar to the Draco dSph companion to the Milky Way.

There is a high velocity HI gas cloud at almost exactly the same position on the sky as And III which, within measurement error, has the same radial velocity as the dwarf galaxy. If the cloud is truly associated with And III (the distance of the cloud is not known), then the presence of the gas should give rise to star formation. However the And III colour-magnitude diagram shows no evidence of a significant number of blue (young) main sequence stars, which leads to the conclusion that either no significant star formation has occurred in the gas cloud over the past billion years or so - which would be unusual, or the gas cloud is not physically associated with And III.

The HST observations consist of two data sets taken approximately 4.5 days apart, allowing a search for variable stars. As for And I and II, a number of RR Lyrae variable stars have been found, but And III differs from And I and II by containing at least two examples of a class of variable stars known as Anomalous Cepheids. These And III Anomalous Cepheids are the first examples of such stars to be discovered outside the Milky Way Galaxy and its companions. Their occurrence in And III, but not in And I or II, confirms the trend from Galactic dSphs that such stars occur relatively more frequently in lower luminosity dSphs. Lower luminosity dSphs also have lower mean abundances and so this trend reinforces the result that, regardless of the mechanism that generates anomalous cepheids (e.g. mass transfer binaries or single younger stars), a low metallicity stellar population is a necessary prerequisite for the existence of such stars.

Unveiling the Secret of a Virgo Dwarf Galaxy

Dwarf galaxies may not be as impressive in appearance as their larger brethren, but they are at least as interesting from a scientific point of view. Sometimes they have hidden properties, such as a well developed spiral structure within an otherwise featureless galaxy, that can only be found by probing the light at the faintest levels.

This was the surprise result of a recent study by Jerjen, Kalnajs and Binggeli* who obtained detailed observations with the ESO Very Large Telescope of the dwarf galaxy IC 3328 in the Virgo Cluster of Galaxies, some 50 million light-years away.

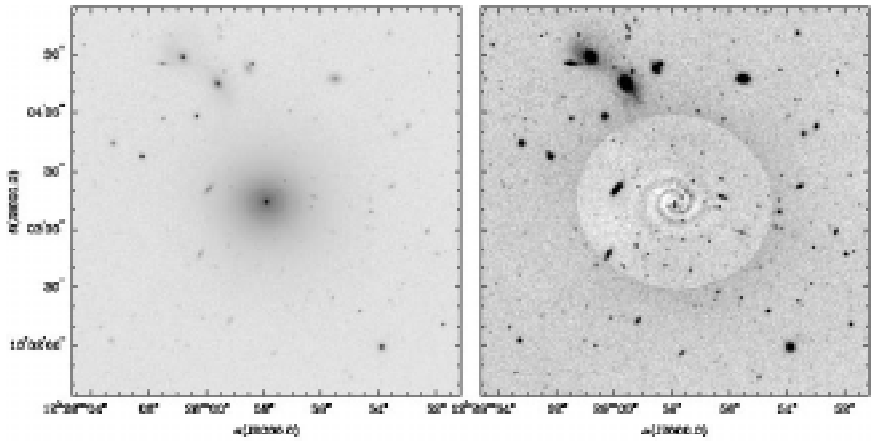


Figure 3: A deep R-band image of IC3328 (left panel) shows a normal, featureless dwarf elliptical galaxy. After the subtraction of the axially symmetric component of the light, a regular well developed spiral can be seen (right panel).

Galaxies with smooth light distributions are of special interest because it is possible to measure their approximate distance by means of the so-called Surface Brightness Fluctuation method. The central task of this method is to determine the pixel-to-pixel fluctuations in the light distribution of the galaxy that is due to the finite number of unresolved stars. The fluctuations are obtained by subtracting a suitably smoothed galaxy model from the CCD image. In the case of the seemingly inconspicuous dwarf galaxy IC3382 the astronomers made an amazing discovery. When the best fitting model was removed from the observed image, a neat and regular spiral structure appeared in the residual image. Nothing like this has ever been seen before in a dwarf elliptical galaxy. The light associated with the spiral constitutes a 3% modulation of the surface brightness.

The Most Distant Elliptical Galaxies

Francis, Woodgate*, Williger*, Collins*, Palunas* and Malumuth* used the Hubble Space Telescope to discover a pair of elliptical galaxies more than ten billion light-years away (redshift 2.38). These are the most distant elliptical galaxies yet discovered: we are seeing them as they were when the universe was only about 20% of its current age. They emit nearly ten times as much light per unit area as modern elliptical galaxies, and show strong colour gradients, with blue cores. Their properties may help us understand how elliptical galaxies form.

INTERSTELLAR MEDIUM

Solving the Mystery of the Warm Ionised Medium

The Warm Ionised Medium (WIM) in our galaxy has long presented an observational mystery. This medium is a warm (~10000K), tenuous zone of ionised gas, about a kiloparsec thick on either side of the mid-plane of our Galaxy. The observational mystery is the enormous power requirement to keep this material hot - about equal to that put out by all of the supernova explosions in the Galaxy! It had been usually supposed that the energy source is ionising photons from the young hot stars in the Galaxy, but this cannot explain the spectral characteristics of the emitting gas, nor does it explain how these photons can seep out of the dense interstellar gas which is located close to the mid-plane. Yeshe Fenner, an Honours student in 2000 has tackled this problem with the assistance of Dopita. She has been able to show that the ionising photons may come not from the hot, young stars, but from the dying embers of stars like our sun as they fade to become White Dwarfs. These stars, being old, are distributed in a much thicker layer about the mid-plane of the Galaxy, and are very hot (~100000K). They therefore produce the photons in the same region of space in which the WIM is located.

A second clue to the mystery is the heating effect due to photoelectron ejection by the smallest dust-grains, which turns out to be considerable, and capable of being the major heat source at low density. These dust grains are called Polycyclic Aromatic Hydrocarbons, and are similar in chemical nature to the finest soot spewed out by overworked diesel engines.

Fenner has built radiative transfer models including both of these effects to predict the spectrum and temperature of the WIM. These new models do a much better job of describing the observations, and so it appears that the mystery of the WIM is well on the road to solution.

Oxygen-Rich Supernova Remnants

When a massive star explodes as a supernova, its interior is blown out at thousands of kilometers per second, leaving only a small dense remnant core, either a neutron star or a black hole. In a few cases, the expanding ejecta are seen at the moment they start to interact with the surrounding gas, when they produce a rich emission spectrum. Through this interaction, we can directly study the material which has been nuclear processed in the parent star, with hydrogen having been burn mostly to oxygen and neon.

A team led by Blair* and Morse*, and which includes Dopita and Sutherland has taken advantage of the spatial and spectral resolution offered by the Hubble Space Telescope (HST) to make a detailed imaging and spectroscopy study of two such young supernova remnants in the Magellanic Clouds, N132D (LMC) and 1E 0102.2-7219 (SMC). The spectra cover essentially the entire UV/optical range available to HST and provide the first true comparison of UV/optical line intensities from astrophysical shocks that do not depend on scalings from different aperture sizes or instruments. From the spectra, they isolated specific knots and filaments that contain fast-moving debris of nuclear-processed material that are devoid of hydrogen and appear to have originated from the cores of the progenitor stars. In N132D they also observed a knot on the outer rim of the remnant that represents a shocked interstellar cloud. In the debris from both remnants, only the elements O, Ne, C, and Mg are detected. They find no evidence for oxygen-burning products, such as S, Ca, Ar, etc., which are seen in Cas A and are expected from models of Type II supernovae.

It appears that the progenitor stars of N132D and 1E 0102.2-7219 had large, oxygen-rich mantles (perhaps Wolf-Rayet stars) and may be the products of so-called Type Ib supernovae. Shock modeling demonstrates systematic differences in the relative abundances in the O-rich debris, possibly pointing to different progenitor masses for these two objects. The shocked interstellar knot in N132D shows that we are probably seeing a range of conditions within the ~1" aperture and that no evidence is present for enrichment by a precursor star wind.

The Intra-Cluster Medium at High Redshift

Francis, Wilson and Woodgate* carried out the first study of the intra-cluster medium of a galaxy cluster in the early Universe, using quasar absorption lines and deep narrow-band imaging. Galaxy clusters today are dominated by vast pools of hot gas, but this had never been seen in a galaxy cluster further than redshift 1.2. Francis and his co-workers were able to detect the gas in a cluster of galaxies at redshift 2.38, and showed that it is shock ionised, fast moving, lumpy and predominantly neutral. In all respects it is very different from gas in present-day clusters.

ACTIVE GALACTIC NUCLEI

Luminous Infrared Galaxies

Luminous infrared galaxies were discovered by the IRAS satellite in 1983, and emit the bulk of their radiation in the infrared. Much work has been carried out to determine the infrared source, and it is still a current issue of debate. Some have been found to contain Active Galactic Nuclei (AGN), while in others the infrared source is intense star formation. It is unknown whether there is an evolutionary connection between starburst and AGN in these galaxies.

In order to study this issue, Kewley, Heisler, Dopita and R. Norris* have completed a large optical spectroscopic survey of their sample of 285 IRAS galaxies in order to obtain accurate optical classification of these galaxies. Theoretical modeling has been completed and involves the use of stellar population synthesis models (Starburst 99 and Pegase) to produce the ionising radiation field which is then utilised by the shock and photoionisation modeling code MAPPINGS vIII. The authors also carried out supernova remnant (SNR) shock modeling, showing that the contribution by mechanical energy from SNRs to the photoionisation models is <20%.

They have used their models to define a new classification scheme for the optical diagnostic diagrams. This new scheme has been used to classify the galaxies into AGN, starburst and LINER types. The theory-based classification scheme compares favourably against the previous semi-empirical scheme of Veilleux & Osterbrock, producing only 6% ambiguity in classifications between the different diagnostic diagrams compared with 16% ambiguity using the traditional method. They find that 70% of the galaxies in their sample are classified optically as starburst, 17% are Sy2, 4% are Sy1, and 0.4% are LINERs.

Many galaxies in the sample lie on a mixing line between starburst and AGN, most likely containing both phenomena. The authors used their models to define theoretical mixing lines on the diagnostic diagrams to determine the AGN contribution to the optical emission for these galaxies. They found that the optical AGN contribution agrees well with that determined from infrared studies, and concluded that dust extinction is relatively unimportant for the majority of the objects in the sample.

To test whether an evolutionary scenario exists for the galaxies in their sample, they selected a subsample of galaxies which are currently undergoing interactions, as traced by tidal features (tails, plumes and bridges). For these galaxies, the AGN fraction was compared with three indicators of merger progress; morphological interaction class, age of the old stellar population, and projected separation. They found that there is a lack of optical AGN activity

in the more evolved mergers. This may tentatively be explained in terms of a combination of increased dust extinction and circumnuclear star formation as gas and dust is funnelled towards the centre of the merger. They are undertaking a more detailed study into these objects to test this hypothesis.

Winds from Quasars

A quasar is a special type of galaxy that shows evidence of very energetic processes in its central regions. The most likely cause of this activity is a supermassive black hole that draws in matter from the galaxy surrounding it. Surprisingly, there is no direct evidence that matter is flowing towards the black hole, but there is much evidence that matter is expelled from the nuclei of quasars at very high speeds. These outflows can take two forms: very tightly collimated jets that move at relativistic speeds, and less collimated outflows in the form of winds moving at speeds ranging from a few thousand to 30,000 kilometres per second. These quasar winds are studied mainly using the ultraviolet absorption lines that they produce in the spectrum of the host quasar.

De Kool has been involved in several projects studying quasar winds using measurements of their ultraviolet absorption lines. A forty orbit Hubble Space Telescope observation (in collaboration with Korista* and Arav*) of the quasar PG 0946+301 was an outstanding success. These observations have provided the best quality far-ultraviolet (500 - 1550 Angstrom) spectrum of a quasar in existence. Preliminary analysis of absorption lines from excited states of OIII (doubly ionised oxygen) and SIV (triply ionised sulphur) in this spectrum shows that the wind in this particular quasar has a relatively low density. This in turn implies that the wind extends over a large scale, and is not located as close to the black hole as previously believed. This finding reinforces a similar result obtained by this group in 1999 for the large scale of the lower velocity, lower ionisation wind in the quasar FBQS 1044+3656. De Kool and his colleagues believe that these results provide a strong indication that quasar winds are, in general, large scale phenomena and are not confined to regions near the black hole.

Jet induced star formation in Centaurus A

Centaurus A (NGC 5128) is the closest radio galaxy. As such, it offers the best opportunity to observe the effects of the transfer of energy from the active nucleus of a galaxy into the intergalactic medium by means of the jet phenomenon. One can also see in graphic detail what fuels the activity, in this case the intrusion into an elliptical galaxy's potential of a low mass galaxy, rich in gas and dust. The radio emission is the site of complex interactions. This area contains a large hydrogen cloud as well as filaments of ionised gas and associated blue knots, several of which exist along the edge of the radio-emitting zones.

Mould and ANU Summer Research Scholar Ridgewell studied WFPC2 observations of the filaments and blue knots with the Hubble Space Telescope. Calzetti* observed the ionised gas from Las Campanas Observatory. The sensitive, high angular resolution WFPC2 images reveal the presence of young stars, many concentrated in what appear to be stellar associations, superimposed on a background sheet of older stars that is typical of the Centaurus A halo. The ages of the associations are estimated to be less than 15 million years from a comparison of their photometry with that of the Large Magellanic Cloud star cluster NGC 2004. Younger stellar groups may be nearer regions of Balmer line emission.

Four years ago Mould and graduate student Soria observed a field in the southern stellar halo of NGC 5128. They found nothing unusual about the stellar population, simply the old metal rich population one expects to see in a luminous elliptical. They concluded that the bulk of the stars formed at least half of the age of the Universe ago. That field served as the control sample for the investigation reported here.

Mould and Ridgewell propose the following plausible explanation for the existence of young stars in these numbers and at this location: gas was deposited in the giant elliptical's potential by the dynamical interaction whose aftermath defines today's NGC 5128. The radio jet from the active nucleus then triggered star formation in this gas some 10 million years ago.

The Middle Lobe of Centaurus A

A group at the Australia Telescope National Facility (Morganti*, Killeen*, Ekers* and Oosterloo*) imaged the middle lobe of the nearby radio galaxy Centaurus A revealing fascinating radio emitting structures adjacent to emission line filaments and star formation regions. These have been the subjects of important past and current RSAA research. (See Jet induced star formation in Centaurus A, above.) A group from RSAA and the Dept. of Physics and Theoretical Physics (Saxton, Sutherland and Bicknell) has been conducting numerical simulations of buoyant bubbles with a view to understanding the radio and related optical morphology. The physical idea is that the Centaurus A jet is intermittent. When the inflow of radio-emitting plasma into the inner radio lobe ceases, the buoyant radio-emitting plasma drifts upward in the gravitational field. Saxton et al. have been successful in reproducing the morphology of the Centaurus A middle lobe using ray-traced images of supercomputer output from hydrodynamic simulations. Moreover, the velocity field induced in the local interstellar medium reaches transonic values and is likely to be sufficient to explain the neighbouring emission line filaments and newly formed stars (through shocks driven into dense gas). The details of the bubble's location and shape depend upon the parameters of the hot atmosphere of Centaurus A, in particular the logarithmic slope of the atmosphere, and a grid of models is currently being calculated to address this issue.

Figure 4 shows ray-traced snapshots of the radio surface brightness obtained from simulations of bubbles rising through a galactic atmosphere, for different initial density ratios **(η)** of bubble density to interstellar medium density. The early phase of the $\eta = 10^{-3}$ simulation comes closest to representing the appearance of the Centaurus A middle lobe.

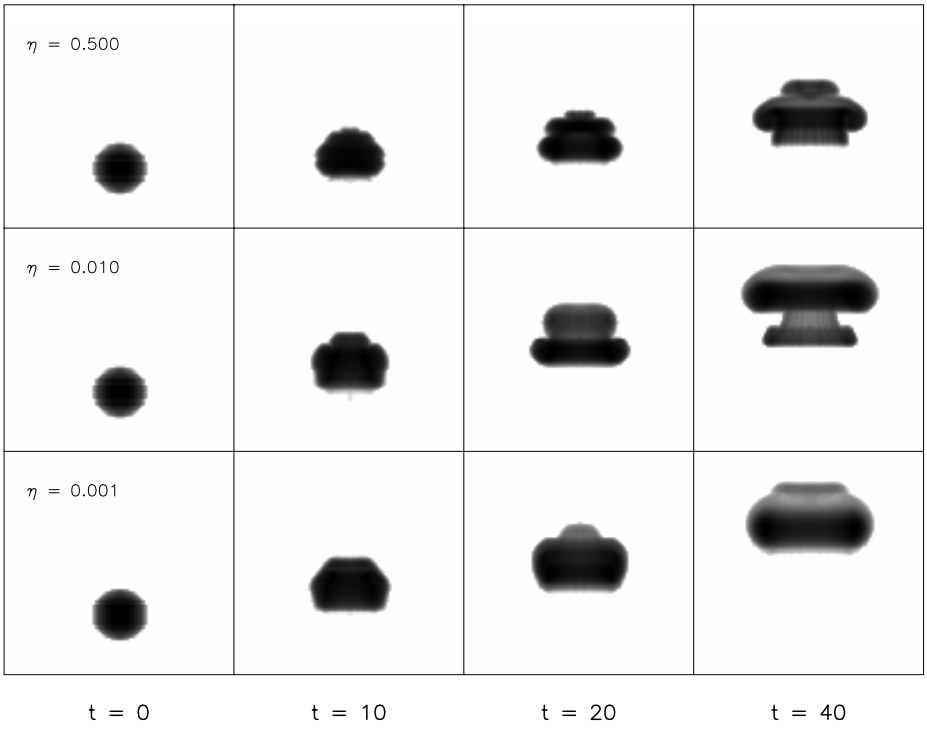


Figure 4: Simulations by Saxton, Sutherland and Bicknell of rising radio emitting bubbles in a galaxy atmosphere for various values of the ratio of the bubble density to the density of the surrounding medium, η . The unit of time is one million years.

Numerical simulation of radiative shocks

ARC research associate Bisset (Dept. of Physics and Theoretical Physics), Sutherland and Bicknell have incorporated cooling via atomic processes into the formerly adiabatic PPM and Zeus hydrodynamic codes. This exacerbated an instability, always present in these codes, which is produced when shocks propagate parallel to the coordinate grid. The instability manifests itself in the form of the faint parallel stripes seen in the left panel of Figure 5. This numerical artefact is removed by the use of a novel oscillation filter developed by Bisset, Sutherland and Bicknell, as shown in the right panel.

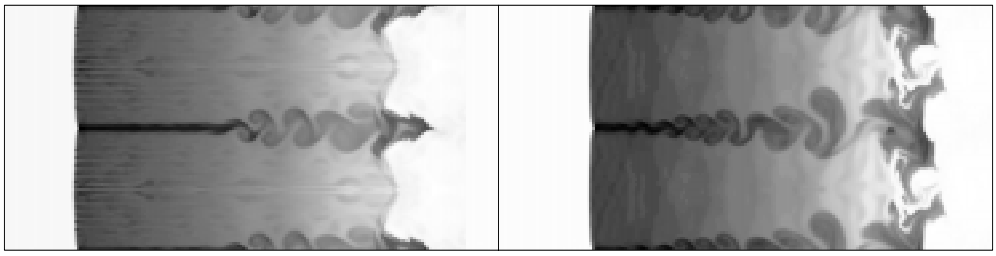


Figure 5: Two simulations of the same cooling shock, showing the effect of the oscillation filter. The flow is periodic in the vertical direction, with a slight shear along each periodic boundary. The disappearance of the stripes highlights standing waves in the post-shock flow and allows the unstable shear layer to develop more rapidly.

Sutherland and Bicknell have used the new numerically robust hydrodynamic code to investigate very high resolution, two-dimensional shocks, such as one might encounter in the interstellar medium (ISM). They have shown that thermal instabilities in such ISM shocks produce unusual turbulent structures such as those shown in Figure 6 below.

The turbulence has strong dissipation at intermediate scales which produces a break in the energy power spectrum, and thus cannot be described by a single powerlaw.

The turbulent cooling regions that form at later stages of the simulation do not depend on the initial fluctuations and can also be described by a fractal dimension. The turbulent cooling is also much more efficient than that found in a steady model, by factors of 5 - 10 in some cases.

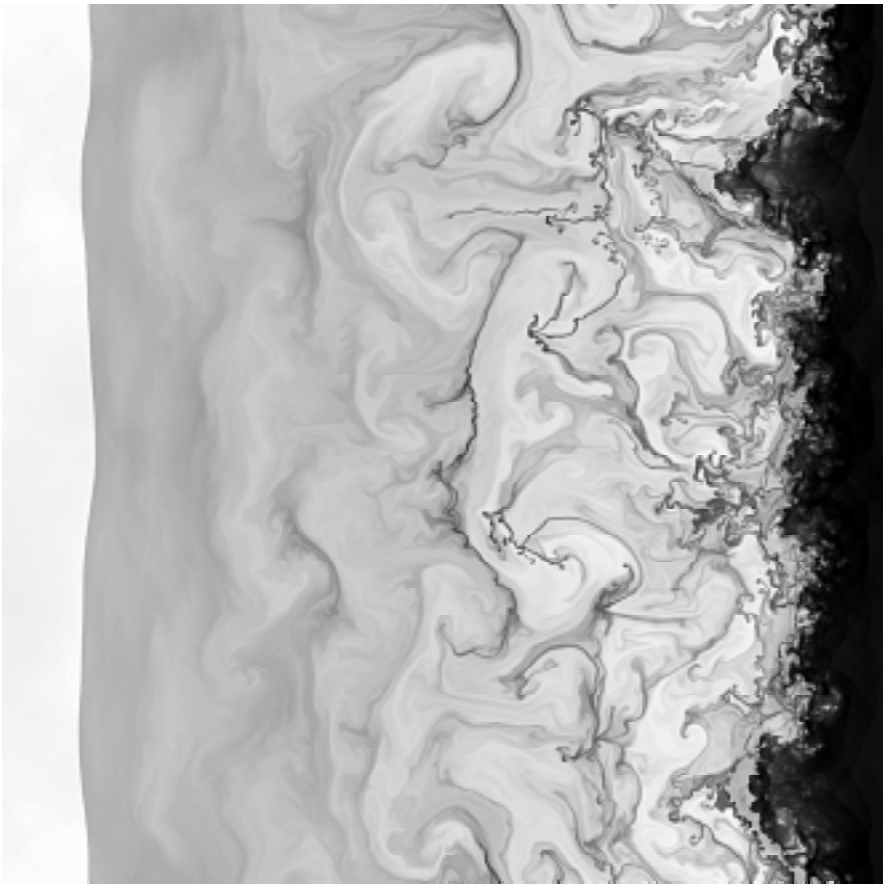


Figure 6: The density in the collapsing phase of a thermally unstable Mach 15 ISM shock.

In Figure 6 cool (7500 K) low density gas enters at about 150 km/s from the left and a shock forms which then travels back upstream, compressing and heating the gas to 600000 K. The shock grows until the onset of thermal collapse, as dense filamentary cooled gas forms at 10000K. The gas cools turbulently as density fluctuations are amplified by the thermal and normal dynamical instabilities. The cooling occurs so quickly that pressure support is completely lost at the base and the whole shock collapses, forming the dense layer of cooled gas at the right. Over time the shock reforms and collapses continuously.

COSMOLOGY

Supernovae in the Distant Universe

Schmidt is leading a team of more than 20 astronomers on 4 continents who discover supernovae (SNe) stars which explode at the end of their lives with the energy output of an entire galaxy. This team, known as the High-Z SN Search, discovered over 70 objects in two nights, with simultaneous observations scheduled in November using telescopes in Chile and Hawaii. Positions of seven of these objects were immediately sent to the Space Telescope Science Institute and the Hubble Space Telescope observed them in November and December.

In 1998 the High-Z SN Search discovered that the universe was accelerating in its expansion - a discovery named the "Breakthrough of the Year" by Science Magazine. However this result left some lingering doubts because it is so difficult to show that distant supernovae are the same as their nearby siblings. The data obtained with the Hubble Telescope of the SNe, located 5 billion years in distance, will be as good as that taken of objects 50 times closer, and should reveal any differences between the distant and nearby SNe.

In addition, in 2000, the High-Z SN Search published the spectrum of the most distant SN yet discovered, some 9.5 billion light years away, as well as the first infrared study of distant explosions. These observations cut through the dust surrounding supernovae and provide even stronger evidence that the universe is accelerating.

Large-scale Motions in the Universe

Colless, with collaborators from Germany, the UK and the USA, has measured the bulk motions of two large, distant volumes of the universe in order to test the predictions of cosmological models. This 'EFAR' project used detailed observations of 700 elliptical galaxies in 85 clusters to determine the clusters' distances and their peculiar velocities (their motions after accounting for the expansion of the universe). Careful analysis reveals that the bulk motions (the average of the clusters' peculiar velocities) are relatively small in both regions. The observed motions are completely consistent with standard cosmological models, and do not support claims for large bulk motions on similar scales by some other researchers.

The Populations and Evolution of Extragalactic Radio Sources

Radio-loud active galaxies are enigmatic, highly energetic, and, for the most part, very distant objects. Throughout cosmic history they are rare - being vastly outnumbered by normal galaxies at all epochs. Although sparsely distributed throughout the universe, their enormous radio power means that they can be used to trace the mass distribution right back to the earliest epoch of AGN (and possibly galaxy) activity.

Jackson and Wall* are developing evolutionary scenarios for radio-loud AGN, including constraints on source lifetimes. The availability of complete, relatively faint samples from the 6C and 7C radio surveys, the local luminosity function from the 2dFGRS-NVSS galaxies, and the flat-spectrum quasar luminosity function at redshifts up to 4 obtained by Shaver*, Jackson, Wall* and Hook*, together now greatly constrain tenable evolution models.

Jackson, Sadler* and Cannon* have determined the local space density of radio galaxies (i.e. the luminosity function) using galaxies common to the 2dFGRS (Colless, Jackson, Peterson et al.) and VLA NVSS surveys. This work is continuing and will include refining the luminosity function to much lower radio power via deep radio imaging of a selected area of the 2dFGRS survey with the Australia Telescope Compact Array (ATCA.) In addition, Jackson continues to investigate the radio source populations, radio morphologies and evolution of the 'local' radio AGN.

The Nature of Gamma Ray Bursts

Gamma Ray Bursts (GRBs) are enigmatic events, and despite the tremendous advances in recent years, their cause remains unknown. The fading afterglows of GRBs, observed in optical and radio and interpreted in the context of the "fireball" model, allow us to determine the physical parameters of the explosion, as well as determining whether or not the radiation is beamed, all of which are important for constraining progenitor models.

Schmidt, Price, Axelrod, Mould, Harrison*, Kulkarni*, and Bloom* monitored GRBs with the MSO 50 inch telescope. GRB afterglows are expected to be bright on timescales of minutes after the detection of the GRB by satellites. Combined with the newly-launched High Energy Transient Explorer II (HETE-2) satellite which will provide real-time localisations of GRBs, the MSO 50 inch is automatically observing the GRB error-box on these timescales and identifying an afterglow, enabling rapid spectroscopic observations by the 2.3 m telescope at Siding Spring Observatory while the afterglow is bright. These observations will allow us to determine the redshift (distance) and search for variable spectral features predicted by models. Two optical identifications of GRBs this year were based on 50 inch observations.

INSTRUMENTATION

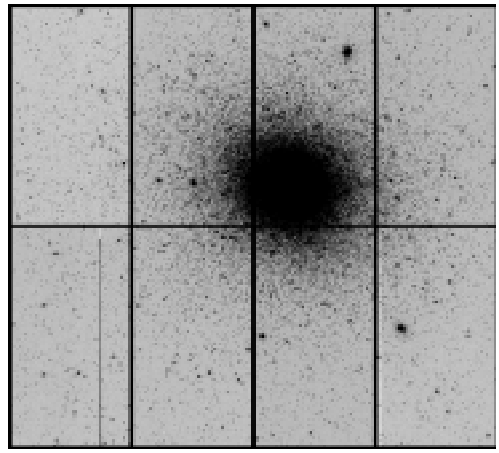
Near-infrared Integral Field Spectrograph (NIFS)

NIFS has been RSAA's major instrument development project in 2000. Progress is described in detail in the *Scientific Highlights* section of this report.

The Wide Field Imager (WFI)

The Wide Field Imager has been successfully brought into operation on both the SSO 1 m and the 3.9 m Anglo-Australian telescopes. This outcome represents the culmination of some years of effort by RSAA staff and their collaborators at the Anglo-Australian Observatory, the University of Melbourne, AUSPACE and GL Scientific in Hawaii. The RSAA project scientist for WFI is Gary Da Costa. The heart of the WFI is a mosaic of eight 4096 x 2048 pixel CCDs, arranged to produce images 8192 x 8192 pixels in size. On the SSO 1 m telescope this allows an area of sky to be imaged that is six times larger than is possible with the best currently available single CCD. This increase in efficiency permits large survey work to be undertaken that was not previously possible.

During the report year the complete WFI system consisting of the filter wheel and shutter mechanisms, corrector lens assemblies, support structure, the WFI dewar, CCD Controllers and control and user-interface software was integrated and tested. Then after a successful commissioning run on the 1m telescope in early September, WFI was made available for general use and since that time it has been in constant use. A successful commissioning run for WFI on the AAT occurred in late December.



The southern globular cluster 47 Tucanae taken during commissioning with the 1m telescope, Wide Field Imager combination, by Gary Da Costa.

On 9 January 2001 the Honourable Dr. David Kemp, the Federal Minister for Education, Training and Youth Affairs visited Siding Spring Observatory to open WFI at the Anglo-Australian Telescope. He also visited RSAA's 1m telescope where the instrument was being used for night-time operation.

Robotic Telescopes

The Southern Trans-Neptunian Object Survey was funded by Lawrence Livermore Laboratory at a level that precluded the use of paid observers to operate the telescope system. During 2000, Tim Axelrod, assisted by members of the Computer Section, upgraded the 50 inch telescope system to fully robotic operation. A weather station, including an infrared cloud detector, was installed and connected to the computer network. This allows the telescope dome to be opened and closed in response to weather conditions. A fully automatic scheduling system was implemented that allows prioritised observation requests to be fed into the system from several sources, including gamma ray burst (GRB) alerts received from satellite observatories. Software was written that focuses the telescope automatically, and a number of reliability improvements were made. The result of this effort is that the telescope operates unattended in a reliable and efficient manner.

In addition to its importance to the projects that utilise the 50 inch telescope, the robotic technology developed in the project will be of importance for other telescopes at the Observatory. RSAA expects to automate the 40 inch telescope and Wide Field Imager at Siding Spring as the next step.

CICADA

RSAA's data acquistion software package CICADA was enhanced during 2000 to serve WFI and the Anglo-Australian Observatory's 6dF system. The WFI upgrade was commissioned at the AAT during August and then at the 1 m telescope in September. After a large effort the system was functioning to a satisfactory level with some debugging remaining by end of year. The AAO 6dF camera system was delivered and installed in December with considerable enhancements made to CICADA.

Co-operation with the Anglo-Australian Observatory

Ties with the Anglo-Australian Observatory have been strengthened this year with the commissioning of WFI, built by the RSAA to be used on both the AAT and the ANU's 1 m telescope, and through the School's work on an AAO subcontract for a turn-key CCD detector system for 6dF on the AAO Schmidt telescope.

GRADUATE PROGRAM IN ASTRONOMY AND ASTROPHYSICS
RESEARCH SCHOOL OF ASTRONOMY AND ASTROPHYSICS
Mount Stromlo and Siding Spring Observatories

REPORT OF THE GRADUATE PROGRAM FOR THE YEAR TO 15 DECEMBER 2000

Enrolments and Submissions

In the leadup to the 2000 academic year, 6 offers of APA/GSS scholarships were made, of which 3 were accepted, one with ANU top up and one with RSAA top up (Brent Groves, Catherine Drake, Paul Price). Ricky Olivier from Cape Town was offered and accepted an IPRS and ANU scholarship. Minh Huynh and Shobha Sankarankutty were offered and accepted ANU scholarships. All 6 of these students commenced in 2000.

Six students submitted theses during the period 15.12.1999 to 15.12.2000. Their destinations are given here:

David Pfitzner	Industry, USA
Raven Kaldare	Cambridge University
Lisa Germany	European Southern Observatory, Chile
Andrew Drake	Lawrence Livermore National Laboratory
Mary Putman	Hubble Fellow, University of Colorado
Stefan Keller	Lawrence Livermore National Laboratory

Currently, there are 15 students in the program (* denotes an international student):

1996	Oak-Kyoung Park*, Lisa Kewley
1997	Michelle Buxton
1998	Greg Wilson
1999	Sebastian Gurovich, Marc Metchnik, Rachel Moody, Jess O'Brien, Holly Sims
2000	Catherine Drake, Brent Groves, Minh Huynh, Ricky Olivier*, Paul Price, Shobha Sankarankutty*

Lecture Courses

The Astrophysics Honours program in the Faculties continued into its second year. Although this program is not formally part of the Astronomy and Astrophysics Graduate Program, it is convened by Paul Francis who holds a joint appointment in the Physics Department of the Faculties and at the RSAA,

in collaboration with SMS staff, and most of the lectures and honours project supervision were provided by RSAA staff. This year there were seven very good honours students, all from outside the ANU.

As in previous years, RSAA and SMS staff gave a series of lectures on core astrophysics subjects, which our graduate students must take if they have not already done so as ANU undergraduates. Most of these courses double as third year undergraduate courses in mathematics and physics, and fourth year courses for the Astrophysics Honours program. RSAA staff also give undergraduate astrophysics courses at first and second year level in the Physics department.

Summer Research Scholar Program

Another very successful Summer Research Scholarship program, convened by Dr Robert Smith, was run during the 1999-00 summer vacation. Seven undergraduates from Australian universities participated for about 8 weeks working on projects supervised by MSO staff. Also included in the program were a series of lectures and a tour of the major observatory sites in NSW. Several of the 1999-00 summer scholars decided to stay on for the Astrophysics Honours program. The 2000-01 Summer Research Scholar program has commenced, convened by Dr Carole Jackson and Dr Peter Wood, with 9 scholars taking part.

RSAA Summer Research Scholars 2000-2001.
Back l-r: John Patten, Jonathan Good, Laura Stanford, Gareth Kennedy
Front l–r: Leslie Woerner, Andrew Roberts, Gayandhi de Silva,
Susanne Hartl, Jiufu Lim

The Harley Wood School of Astronomy and the ASA Annual Meeting

The Harley Wood School and the annual scientific meeting of the Astronomical Society of Australia were held in Tasmania this year, in early July. These are important occasions for our students, and each year we send as many as we possibly can. It gives the students the opportunity to meet with graduate students and astronomers from other universities, and to take part in a focussed series of graduate-level lectures.

The Alex Rodgers Travelling Scholarship

Funds for this scholarship come from an endowment made in 1998 to the ANU's Endowment for Excellence by Mrs Ruth Rodgers, in memory of her husband the late Professor Rodgers, Director of MSSSO from 1987-92. The scholarship is to assist a currently enrolled student in the Graduate Program in Astronomy and Astrophysics to travel abroad to attend scientific meetings and/or to work with astronomers at another institution on some chosen research project of direct relevance to the thesis work being undertaken. Greg Wilson was this year's recipient of the Alex Rodgers Travelling Scholarship. He worked at Leiden Observatory with Prof Tim de Zeeuw, on problems of galactic dynamics.

Recruitment Activities

For 2001, we had 11 strong Australian applicants, 4 of whom were ranked above the first round cutoff for APAs, plus three overseas applicants, one of whom is on the IPRS award list.

2000 Board of Studies

The current Graduate Program Convenor, Ken Freeman, operates the program together with the Co-Convenor, Brian Schmidt.

Membership of the Board of Studies now comprises:

* four ex officio members (the Director, the Graduate Program Convenor and Co-Convenor, and the Convenor of the RSAA Summer Research Scholar Program),
* four elected RSAA staff including one position for an RSAA postdoc
* one staff member external to the School, and
* four student members.

The membership for the Board for 2000 was:

Director, RSAA: Jeremy Mould
Convenor, Graduate Program in Astronomy & Astrophysics: Ken Freeman
Co-Convenor, Graduate Program in Astronomy & Astrophysics: Brian Schmidt
Convenor, RSAA Summer Research Scholar Program: Robert Smith.

Elected Staff members: Tim Axelrod RSAA, Lilia Ferrario SMS, Paul Francis RSAA/Physics, Maartje Sevenster (postdoc RSAA), Geoff Bicknell.

Student members: Catherine Drake, Rachel Moody, Paul Price, Jess O'Brien.

Concluding Comments

I would again like to put on record the contributions of Dr Paul Francis to the Astrophysics Honours program. Although this program is not formally part of the Astronomy and Astrophysics Graduate Program, it makes a substantial impact on the graduate program in several ways: a large and lively body of students in the advanced lecture courses, a significant increase in the number of students doing research projects at RSAA, and a group of enthusiastic and well-qualified applicants for the PhD program in 2001.

It was again a pleasure to work with co-convenor Brian Schmidt.

I must close on a negative note. The RSAA School Secretary, Gay Kennedy, was made redundant in March. This has greatly increased the load on all involved in the RSAA Graduate Program. The resulting fragmentation of the administration of the program has adversely affected almost every aspect of our program, from recruiting to monitoring the status of our students. I am very grateful to Gay for all that she did in keeping our Graduate Program functioning and in making the job of the convenor and co-convenor so much easier. She is greatly missed.

Kenneth Freeman
Convenor
Graduate Program in Astronomy and Astrophysics
14 December, 2000

VISITORS TO THE OBSERVATORIES AND COLLOQUIA

Visitors to Mount Stromlo Observatory

Mr Brendan Smyth, Deputy Chief Minister, ACT

Colloquium Speakers

Arnold Dekker	CSIRO Remote Sensing Research Group
Martin Asplund	Uppsala
Paula Benaglia	Institute Argentino de Radioastronomia
Brian Boyle	Anglo-Australian Observatory (AAO)
Frank Briggs	Groningen/ATNF
Roger Brissenden	Chandra X-ray Observatory
Paolo Calisse	Embassy of Italy
Mun-Suk Chun	Yonsei University
Peter Cottrell	University of Canterbury
Tim de Zeeuw	University of Leiden
Jean Dupuis	University of California Berkeley
Trish Henning	Univ. New Mexico/ATNF
Swetlana Hubrig	Astrophysikalisches Inst der Sternwarte
Dave James	University of St Andrews
Ray Jayawardhana	University of California Berkeley
Paul Jones	University of Western Sydney (Nepean)
Adela Kawka	Murdoch University
Ariane Lancon	Strasbourg
Chris Lidman	European Southern Observatory (ESO)
Geraint Lewis	AAO
Jim Lovell	ATNF
Naomi McClure-Griffiths	University of Minnesota
Phil Nicholson	Cornell University
Kevin Pimbblet	Durham University
Onno Pols	Monash University
Boud Roukema	Inter-Univ Ctr for Astron/Astrophysics
Stuart Ryder	AAO
Gary Schmidt	Steward Observatory
Michael Scholz	University of Heidelberg
Graham P. Smith	University of Durham
Nicholas Suntzeff	Cerro Tololo Inter-American Observ.
Jesper Sommer-Larsen	TAC Denmark
Lister Staveley-Smith	ATNF
Alan Stockton	University of Hawaii
Steven Tingay	ATNF Narrabri
Kaspar von Braun	University of Michigan

Visiting Observers on ANU Telescopes

Abbott, J	University College London
Allan, A	Keele University
Appleton, P	Iowa State University
Baade, D	European Southern Observatory
Beaulieu, S	University of Cambridge
Begam, M	University of Virginia
Bennett, D	Notre Dame University
Bland-Hawthorn, J	Anglo-Australian Observatory (AAO)
Bleach, J	Keele University
Bridges, T	AAO
Burston, A	University of Leicester
Burton, M	University of New South Wales (UNSW)
Carswell, R	University of Cambridge
Carter, B	University of Southern Queensland
Charles, P	University of Southampton
Cheng, K-P	California State University, Fullerton
Hua, C-T	Lab. Astrophys. Spatiale (CNRS)
Christlieb, N	Hamburger Sternwarte
Chun, M-Y	BOAO, Korea
Collier Cameron, A	University of St Andrews
Corbett, E	AAO
Crawford, I	University College London
Croom, S	ICMTS
Crowther, P	University College London
Dalton, G	Oxford University
Davies, R	University of Durham
Deeley, K	UNSW
Deguchi, S	Nobeyama Radio Observatory
Doyle, L	SETI Institute
Feigelson, E	Penn State University
Ferrara, E	Georgia State University
Filipovic, M	University of Western Sydney (Nepean)
Geha, M	Lick Observatory
Glazebrook, K	AAO
Guenther, E	Thueringer Landessternwarte
Hartley, M	AAO
Hubrig, S	Astrophysikalisches Institut Potsdam
Ianna, P	University of Virginia
Irwin, M	University of Cambridge
James, D	University of St Andrews
Johnston, H	AAO
Kregel, M	Kapteyn Astronomical Institute

Kuntschner, H	University of Durham
Larson, S	University of Arizona
Lattanzio, J	Monash University
Lawson, W	UNSW
Lazendic, J	UNSW
Lee, J-K	UNSW
Lewis, G	AAO
Liske, J	UNSW
Londish, D	University of Sydney
Lucy, P	University of Hawaii
Mamajek, E	University of Arizona
Marsden, S	University of Southern Queensland
McIntyre, V	University of Sydney
Medici, A	Astrophysikalisches Institut Potsdam
Meurer, G	Johns Hopkins University
Meyer, M	University of Arizona
Miller, H	Georgia State University
Miller, S	University of Maryland
Neff, J	College of Charleston
Norris, R	Australia Telescope National Facility
Oshlack, A	University of Melbourne
Parker, Q	Royal Observatory Edinburgh
Phillipps, S	University of Bristol
Price, R	University College London
Rafanelli, P	Padua University
Rathborne, J	UNSW
Richter, H	Berlin
Rifatto, A	OAC, Italy
Rodler, F	Vienna Astronomy Institute
Sackett, P	Kapteyn Astronomical Institute
Schmidt, G	University of Arizona
Schultz, A	UNSW
Shobbrook, R	Retired
Smalley, B	Keele University
Smith, R	University of Wales Cardiff
Soria, R	MSSL, UK
Stankov, A	Vienna Astronomy Institute
Stefl, S	Acad. Sciences of the Czech Republic
Sung, H	BOAO, Korea
Theissen, A	Armagh Observatory
Van der Kruit, P	Kapteyn Astronomical Institute
Veilleux, S	University of Maryland

Walker, M	University of Sydney
Walsh, A	UNSW
Ward, M	University of Leicester
Webb, J	UNSW
Webb, N	Keele University
Webster, R	University of Melbourne
Wu, K	University of Sydney
Zezas, A	University of Leicester

STAFF ACTIVITIES

HONOURS, AWARDS AND GRANTS

Dr G Bicknell
•ARC Large Grant, 1999-2001.

Dr M Colless
•Access to Major Research Facilities program, $2,700 for observing run at the Keck Observatory, Hawaii with Prof. R.S. Ellis (Caltech).
•IAU, $2,120 for attending the IAU General Assembly XXIV in Manchester, UK.
• IREX Fellowship (Dr R Saglia), $81,641.

Dr G Da Costa
• $10,000 from the ARC/USydney Gemini Travel Fund, for three International Gemini Project meetings during 2000.
•Travel grant of £600 UK from the IAU for the 2000 IAU General Assembly XXIV in Manchester, UK, as President of IAU Commission 37 "Star Clusters and Associations".

Dr P Francis
•Winner, Vice Chancellor's Award for Excellence in Teaching.
•Recipient, ANU Flexibile Learning Fellowship, $9,500.

Prof K Freeman
•Duffield Professorship, RSAA.
•Dannie Heineman Prize, American Institute of Physics and American Astronomical Society.
•Tinsley Visiting Professorship, University of Texas.
•IREX Fellowship (Dr E-C Sung), $61,773.
•Access to Major Research Facilities program, $4,200 for observing run at the VLT, Paranal.

Dr R Fux
•Research Fellow of the Swiss National Science Foundation.
•Swiss Society of Astronomy and Astrophysics travel grant, 1,500 CHF.
•IAU travel grant, £1,000.

Dr C Jackson
•STScI visitor grant (US$500) to attend STScI Blazar workshop in July.
•University of Oxford visitor grant for accomodation ($1,100) June.
•Appointed Honorary Fellow, ATNF, CSIRO.
•Elected member of IAU (Commission 40), August.

Dr H Jerjen
- Research Fellow of the Swiss National Science Foundation (Aug 1997 – July 2000).

Ms L Kewley
- Australian Academy of Science Young Researcher Award for Travel to the USA, $4,500.

Prof J Mould
- DISR Industrial Research Alliances, The Australia Large Telescope, $50,000.
- Honorable Visitor, Academia Sinica, Republic of China, September 2000.
- ACT Government, Capital Astronomy Nights, $45,000 / year for 3 years.
- J. Kirby Foundation, Visitor Centre Navigation Exhibit, $9,000 over 2 years.

Prof J Norris
- Travel grant of £500 from the IAU to attend IAU General Assembly XXIV in Manchester, UK.
- ARC RIEF grant for Fast Link to Siding Spring Observatory, $150,000.

Dr B Schmidt
- Bok Prize, US$3,000 award for outstanding thesis in Astronomy at Harvard University.
- The Malcolm McIntosh award for achievement in the physical sciences, $35,000.
- ANSTO Access to Major Facilities: Award of $3,000 for travel to San Francisco in July.
- ANSTO Access to Major Facilities: Award of $2,113 for travel to Hawaii in October.

EXTERNAL COLLABORATIONS

Dr T Axelrod

MACHO Project by T Axelrod, K Freeman, B Peterson, A Drake with R Allsman ANUSF, C Alcock, K Cook, M Geha, S Marshall, D Minniti, P Popowski, C Nelson, A Tomaney Lawrence Livermore National Lab, P Quinn, ESO, C Stubbs, A Becker University of Washington, W Sutherland Oxford, D Welch McMaster, D Alves STScI, D Bennett Notre Dame, K Griest, T Vandehei UCSD, M Lehner Sheffield.

TAOS Project by T Axelrod with C Alcock, K Cook, S Marshall Lawrence Livermore National Lab, T Lee, C-Y Wen, SK King Academia Sinica, Taiwan, WP Chen, C Lemme, A Wang National Central University, Taiwan, I de Pater UC Berkeley, J Lissauer NASA Ames.

Southern Trans-Neptunian Object Survey by T Axelrod, B Schmidt, C Jackson, R Moody, with C Alcock, K Cook, S Marshall Lawrence Livermore National Lab, I de Pater UC Berkeley, J Lissauer NASA Ames.

REACT by T Axelrod, J Mould, B Schmidt, P Price with S Kulkarni, F Harrison, A Diercks, T Galama Caltech.

Prof M Bessell

Echelle Spectroscopy of Solar-type Stars by MS Bessell with J O'Mara, University of Queensland.

Model Atmospheres of Metal-deficient Stars by MS Bessell with Fiorella Castelli, Trieste Observatory.

Follow-up Spectroscopy of Hamburg-ESO Objective Prism by MS Bessell and JE Norris with Norbert Christlieb of Hamburg University.

SUBARU Observations of Extreme Metal Deficient Stars by MS Bessell, JE Norris with Hiroyasa Ando.

Search for Nearby Young Stars by MS Bessell with B Zuckerman, I Song and R Webb, UCLA .

UBVRI Photometry of Subdwarfs by MS Bessell with R Shobbrook RSAA visitor

Dr G Bicknell

Magnetised Accretion Discs, by G Bicknell with Z Kuncic,
University of Sydney.

High Energy Emission from Blazars by G Bicknell with S Wagner,
Landessternwarte, Heidelberg.

Dr M Colless

The 2dF Galaxy Redshift Survey, by Dr MM Colless, Dr BA Peterson and Dr CA Jackson with Drs K Taylor, J Bland-Hawthorn, IR Lewis, TJ Bridges and RD Cannon AAO, Drs WJ Couch and R De Propris UNSW and UK collaborators.

The EFAR Project: The Peculiar Motions of Early-Type Galaxies in Two Distant Regions, by Dr MM Colless with Prof RL Davies Durham, Prof D Burstein Arizona State, Prof G Wegner Dartmouth, Dr R Saglia Munich, Dr R McMahan UNC.

OzPoz: Design and Construction of a Fibre Positioner Unit for the FLAMES Spectrograph on the European Southern Observatory's Very Large Telescope, by Dr MM Colless with Dr K Taylor AAO, AProf W C Couch UNSW.

The 6dF Galaxy Survey: a Survey of the Mass and Motions in the Local Universe using a New Fibre Spectrograph on the AAO Schmidt Telescope, by Dr MM Colless with Dr QA Parker, Dr W Saunders, Dr FG Watson AAO and other collaborators in Australia, USA, UK and France.

Dr M de Kool

Spectral Properties of Radio-selected Broad Absorption Line QSOs, by Dr M de Kool with Prof R Becker, Lawrence Livermore National Laboratories.

Analysis and Interpretation of HST-STIS Broad Absorption Line QSO spectra, by Dr M de Kool with Dr N Arav, University of California Davis and Dr KT Korista, University of Western Michigan.

Dr G Da Costa

The Dwarf Spheroidal Companions to M31 by Dr G Da Costa with Dr T Armardroff, KPNO, Dr N Caldwell, Whipple Obs, and Dr P Seitzer, Univ of Michigan.

The Chemical Histories of the Fornax and Carina Dwarf Spheroidal Galaxies by Dr G Da Costa with Dr T Smecker-Hane, UC Irvine, Dr J Hesser and Dr P Stetson, DAO, and Dr D Hatzidimitriou, Univ of Crete.

The Origin of Globular Cluster Abundance Anomalies - Clues from the Main Sequence by Dr G Da Costa with Prof J Norris, Dr B Gibson, Swinburne Univ, Dr R Cannon, AAO and Dr B Croke, ANU.

Magnesium Isotope Ratios in Globular Cluster Red Giants by Dr G Da Costa with Prof J Norris and Dr J Lattanzio, Monash Univ.

Prof M Dopita

The COLA Project: Compact Objects in Low-powered AGN by Prof M Dopita and Lisa S Kewley with Dr PN Appleton Iowa State U, Dr AP Marston Caltech, Dr R Norris ATNF & Dr A Zezas CFA.

Calibration of Nebular Emission-Line Diagnostics, by Prof M Dopita with Dr S Oey STScI, Prof JC Shields Ohio U, & Dr RC Smith CTIO.

Photoionisation and Shock Modelling of the HII region Abundance Sequence and of Luminous Infrared Galaxies, by Prof MA Dopita, LK Kewley, Dr CA Heisler and Dr RS Sutherland RSAA, Prof B Rocca-Volmerange, and E Moy Institut d'Astrophysique, France.

Southern Planetary Nebulae, by Prof MA Dopita, and Prof CT Hua Laboratoire Astrophysique Spatiale, Marseilles, France, & Prof RE Williams STScI.

The Joint Australian Centre for Astrophysical Research in the Antarctic by Prof JR Mould, Prof MA Dopita, Dr P McGregor, Dr R Sutherland and Dr P Wood with Prof J Storey, Dr M Ashley, and Dr M Burton University of New South Wales.

The Physical Conditions in the Extended Emission-Line Regions of Nearby Seyfert Galaxies by M Allen, Prof MA Dopita and Dr GV Bicknell with Z Tsetanov Johns Hopkins University.

Astronomical Site Testing at Dome C in the Antarctic by Prof JR Mould, Prof MA Dopita, and Dr RS Sutherland with Prof J Storey, Dr M Ashley, and Dr M Burton University of New South Wales, Prof J Vernin, Dr Coulman, and Dr M Azouit, Université de Nice Prof P Maffei and Dr L Valenziano Universa di Perugia, and Prof R Viotti Instituto di Astrofisica Spaziale, Frascati.

Determination of the Emission Mechanism in LINERS and Seyferts by Prof MA Dopita Dr R Sutherland and Dr GV Bicknell with Dr AP Koratkar and Dr M Allen of the Space Telescope Science Institute.

HST Observations of the O-Rich Supernova Remnant in the Magellanic Clouds by Prof MA Dopita and Dr R Sutherland with Dr WP Blair Johns Hopkins University, Baltimore Dr PF Winkler, Middelebury College, Dr R Kirshner, and Dr JC Raymond, Center for Astrophysics, Harvard, Dr K Long and Dr J Morse, Space Telescope Science Institute.

The Helical Jet/ISM Interaction in NGC 4258 by Dr GN Cecil Univ of N Carolina, USA with Prof MA Dopita MSSSO, Dr LJ Greenhill CFA, USA Dr Moran CFA, USA and Dr CG De Pree, NRAO, USA.

Dr P Francis

A Galaxy Cluster at Redshift 2.38, by Dr PJ Francis, with Dr BE Woodgate, Dr GM Williger, Dr E Malumuth, Dr N Collins, and Dr P Palunas, NASA GSFC.

The Parkes Half-Jansky Quasar Sample, by Dr PJ Francis, with Dr RL Webster, Mr M Whiting and Dr MJ Drinkwater, University of Melbourne.

Red Quasars from the Two Micron All Sky Survey, Dr PJ Francis with Dr RL Cutri, NASA, IPAC.

Prof K Freeman

Studies of Ionized Gas in High Velocity Clouds, by M Putman and Prof K Freeman, with Dr B Gibson University of Colorada and Dr J Bland-Hawthorn, AAO.

Studies of Neutral Hydrogen in Dwarf Elliptical Galaxies of the Centaurus A Group, by Prof K Freeman and Dr H Jerjen, with Dr S Beaulieu University of Cambridge and Prof C Carignan University of Montreal.

Internal Proper Motions and Radial Velocities in the Globular Cluster Omega Centauri, by Prof K Freeman with Ms R Reijns, Prof T de Zeeuw and Drs R Le Poole, University of Leiden, Dr P Seitzer, University of Michigan, and Dr F van Leeuwen, Cambridge University.

The MACHO Project, by Dr T Axelrod, Dr B Peterson and Prof K Freeman, with the MACHO Team Lawrence Livermore National Laboratory, University of California, University of Washington, McMaster University.

HST Studies of The Post-Starburst Galaxy NGC 5102, by Prof K Freeman, with Dr S Beaulieu, Cambridge University, Prof C Norman, Johns Hopkins University, Prof N Scoville, Caltech, and Dr P Quinn, ESO.

Kinematics of Planetary Nebulae in Nearby Galaxies and in the Intracluster Medium of the Virgo Cluster, by Prof K Freeman, with Dr M Arnaboldi and Prof M Capaccioli, Osservatorio di Capodimonte, Naples, Prof R Kudritzki and Dr R Mendez, University of Muenchen, Prof H Ford, Johns Hopkins University, Prof R Ciardullo and Dr J Feldmeier, Penn State University, and Dr G Jacoby, NOAO.

HST Studies of the Inner Regions of Barred Galaxies, by Prof K Freeman with Dr M Carollo JHU and Prof T de Zeeuw Leiden.

HST Studies of Lyman-alpha Absorption of QSOs by the Outer Regions of Spiral Galaxies, by Prof K Freeman with Dr S Cote, ESO and Prof C Carignan, Montreal.

Wide-Field HI Synthesis Mosaic of the Spiral Galaxy M83, by O-K Park and Prof K Freeman, with Dr B Koribalski ATNF and Dr D Malin AAO.

Dr R Fux
Structure of the Galactic Bulge from the MACHO Red Clump Stars, by R Fux, T Axelrod, with P Popowski Lawrence Livermore National Laboratory, USA.

Dr C Jackson
Evolution and Unified Schemes of Radio-loud AGN by Dr C Jackson with Prof JV Wall, University of Oxford.

Local Radio Source Populations and the LRLF by Dr C Jackson with Dr EM Sadler & Mr VJ McIntyre, University of Sydney and Prof RD Cannon, AAO.

The Space Density of Flat Spectrum Radio Quasars by Dr C Jackson with Prof JV Wall, University of Oxford, Dr PA Shaver, European Southern Observatory Garching and Dr IM Hook, European Southern Observatory Garching.

Optically-faint, Radio-bright Radio Galaxies at High Redshift by Dr C Jackson with Prof R Norris and Prof R Ekers ATNF.

Dr H Jerjen
Distance and Depth of the Virgo Cluster by Dr H Jerjen, Prof KC Freeman, with Dr B Binggeli, Astronomical Institute of the University of Basel, Switzerland.

Empirical Calibration of the SBF Method for dEs by Dr H Jerjen with Mrs M Rejkuba, European Southern Observatory, Germany.

SBF and Spectroscopic Survey of Dwarf Elliptical Galaxies in the Supergalactic Plane by Dr H Jerjen, with Prof M Valtonen, Tuorla Observatory, Finland, Mr M Hanski, Tuorla Observatory, Finland, Mr R Rekola, Tuorla Observatory, Finland, and Dr L Takalo, Tuorla Observatory, Finland .

The All-Sky 21cm Survey at the Parkes Radio Telescope by Dr H Jerjen, Prof KC Freeman and Prof JR Mould, with Prof R Webster, University of Melbourne

and Dr G Banks University of Wales, Dr D G Barnes ATNF, Prof R Bhathal UWS, Prof M J Disney University of Wales, Prof R D Ekers ATNF Dr B Gibson University of Colorado, Dr P Henning New Mexico, Mrs V Kilborn University of Melbourne, Dr B Koribalski ATNF, Dr P Knezek STScI, Dr D Malin AAO, Dr T Osterloo ATNF, Dr R M Price ATNF, Dr SD Ryder AAO, Prof E M Sadler University of Sydney, Dr L Staveley-Smith ATNF, Dr AE Wright ATNF.

Dr A Kalnajs

Dynamics of the Shearing Sheet, by Dr AJ Kalnajs with Prof A Toomre MIT.
Probing the Galactic Potential, Dr AJ Kalnajs with Dr L Staveley-Smith ATNF.

Ms L Kewley

Theoretical Starburst Modelling by L Kewley, Prof M Dopita and Dr R Sutherland, with Dr C Leitherer, Space Telescope Science Institute.

Compact Objects in Low Power AGN COLA project by L Kewley and Prof M Dopita, with Dr P Appleton Iowa State Univ, Dr E Corbett ATNF, Dr T Marston Caltech, Prof R Norris ATNF, Prof C Struck Iowa State Univ, Dr A Zezas CfA.

X-Ray Luminous Starburst Galaxies by L Kewley, with Dr A Zezas CfA, Prof M Ward U Leceister.

Interference Excision for Radio Arrays by L Kewley with Prof R Ekers ATNF, Dr B Sault ATNF.

Compact Radio Sources: Obscured AGN or Compact Radio Supernovae? by L Kewley with Prof M Dopita, Dr R Sutherland, Prof R Norris ATNF.

Prof J Mould

The Extragalactic Distance Scale by Prof J Mould and Dr K Sebo with JP Huchra Harvard Smithsonian CfA, L Ferrarese UCLA, HC Ford Johns Hopkins University, WL Freedman Observatories of the Carnegie Institution of Washington, J Graham & D Kelson Carnegie Institution of Washington, B Gibson Swinburne University, JG Hoessel University of Wisconsin, GD Illingworth UCSC, RC Kennicutt Jr University of Arizona, BF Madore, Nancy Silbermann IPAC, Caltech, A Saha NOAO, & PB Stetson DAO.

The Multiband Photometric Imager for SIRTF by Prof J Mould with E Arens UC Berkeley, C Beichman Caltech, T Gautier JPL, E Haller LBL, C Lada Harvard Smithsonian, G Rieke & F Low U Arizona, G Neugebauer Caltech, P Richards UC Berkeley, M Rieke & P Strittmatter U Arizona, and M Werner JPL.

NICMOS Observations of Extragalactic Cepheids by Prof J Mould with L Macri Harvard University, D Calzetti Space Telescope Science Institute, W Freedman

Carnegie Observatories, B Gibson Swinburne University, J Graham Carnegie Institution of Washington, J Huchra Harvard Smithsonian Center for Astrophysics, S Hughes, B Madore IPAC Caltech, E Persson Carnegie Observatories, and P Stetson Herzberg Institute for Astrophysics.

Identification of the Galaxy's Missing Mass, by Prof J Mould, Prof K Freeman Dr G Da Costa and Dr T Axelrod, with K Cook & C Alcock Lawrence Livermore National Lab.

Prof J Norris

The Most Metal Deficient Stars by Prof JE Norris, with Prof TC Beers, Michigan State University, and Dr SG Ryan, Open University, United Kingdom.

Lithium Abundances of Halo Stars by Prof JE Norris, with Prof TC Beers, Michigan State University, Dr SG Ryan, Open University.

Carbon-Rich Metal-Poor Stars by Prof JE Norris and Prof MS Bessell, with Dr H Ando, National Astronomical Observatory, Japan, Dr W Aoki, National Astronomical Observatory, Japan, Prof TC Beers, Michigan State University, and Dr SG Ryan, Open University.

The Origin of Globular Cluster Abundance Anomalies: Clues from the Main Sequence by Dr GS Da Costa and Prof JE Norris, with Dr D Cannon, Anglo-Australian Observatory, and Dr B F Croke, University of Crete.

The Origin of Globular Cluster Abundance Anomalies: Magnesium Isotope Ratios in Omega Centauri and other clusters by Prof J E Norris and Dr GS Da Costa, with Dr J Lattanzio, Monash University and Ms I Ivans, University of Texas at Austin.

In Situ Studies of the Old Populations of the Galaxy by Prof JE Norris and Prof KC Freeman, with Prof G Gilmore, Cambridge University, and Prof RFG Wyse, Johns Hopkins University.

Studies of Structure in the Galactic Halo by Prof JE Norris and Prof KC Freeman, with Dr HL Morrison, Case Western Reserve University, Prof M Mateo, University of Michigan, Dr E Olszewski and Mr P Harding, University of Arizona.

Blue Horizontal Branch Stars and the Mass of the Galaxy by Prof JE Norris, with Dr P Hewett, University of Cambridge and Dr S J Warren, Imperial College London.

Dr B Schmidt

The High-Z SN Search by B P Schmidt with N Suntzeff, C Smith, R Schommer, CTIO, A Clocchiatti, U Catolica, R Kirshner, P Challis, P Garnavich, Harvard, B Leibundgut, J Spyromilio, P Woudt, ESO, M Phillips, Carnegie, M Hamuy, Arizona, C Stubbs, C Hogan, D Reiss, A Diercks, UW, A Filippenko, A Riess, Berkeley, J Tonry, Hawaii, R Gilliland, STScI.

Supernova Intensive Study with HST by B P Schmidt with R Kirshner, Harvard, D Branch, Oklahoma, R Chevalier, Virginia, A Filippenko, Berkeley, C Fransson, Stockholm, B Leibundgut, ESO, N Panagia, STScI, M Phillips and N Suntzeff, CTIO, C Wheeler, Texas.

The Trans Neptunian Search by B P Schmidt and T Axelrod, with C Alcock, U Penn, K Cook, LLNL.

The REACT Gamma Ray Burst Study by B P Schmidt, T Axelrod and P Price, with S Kulkarni and F Harrison, CalTech, and D Frail, NRAO.

Dr M Sevenster

Global Properties of Inner-ring Galaxies by Dr M Sevenster and Prof K Freeman with Dr B Koribalski, ATNF, CSIRO, Dr A Lancon, Obs de Strasbourg, Dr P van der Werf, Sterrewacht Leiden.

Unusual OH-maser Point Sources by Dr M Sevenster with Dr J Chapman, ATNF, CSIRO.

Dynamical Behaviour of Infrared Carbon Stars by Dr M Sevenster with Dr M Groenewegen, MPA, Garching, Prof A Omont and Mr E Josselin, IAP, France, Prof H Habing, Sterrewacht Leiden.

Dr P Wood

Stellar Evolution and Nucleosynthesis on the AGB by Dr PR Wood with Dr J Lattanzio, Monash University.

Theoretical Models of Mira Variables by Dr PR Wood with Prof M Scholz, University of Heidelberg and Dr T Bedding, University of Sydney.

Observational Studies and Theoretical Models of Mira Variables by Dr PR Wood with H Richter, Technical University of Berlin.

Optical/Near-IR Spectra of AGB stars by Dr PR Wood with Dr A Lançon, University of Strasbourg.

Infrared and SiO Observations of Stars Near the Galactic Center by Dr PR Wood with Dr S Deguchi, Nobeyama Radio Observatory.

Infrared Observations of ISO Sources in the Magellanic Clouds by Dr PR Wood with Dr T Tanabe and Dr Y Nakada, University of Tokyo.

Infrared Observations of Cepheids in M33 by Dr PR Wood with Dr D Bersier, Harvard.

Velocity Monitoring of LMC Red Giants by Dr PR Wood and Dr T Axelrod with Dr D Welch, McMaster University.

Studies of MSX Sources in the Magellanic Clouds by Dr PR Wood with Dr M Cohen, Berkeley.

Studies of the Variability of AGB Stars in the Magellanic Clouds and Near the Galactic Centre by Dr PR Wood with Prof H Habing and M Cioni, Leiden and Dr A Omont, IAP Paris.

CONFERENCES ATTENDED, PAPERS AND LECTURES PRESENTED

Dr T Axelrod

NOAO "Science with LSST" Workshop, 17-18 November, Tucson.

Prof M Bessell

AGM of the Astronomical Society of Australia , 3-7 July, Hobart.

IAU General Assembly Meeting XXIV, 7-18 August, Manchester.

Invited review: "The Oxygen problem in cool stars" at Joint Discussion 8 "Oxygen Abundances in Old Stars and Implications to Nucleosynthesis and Cosmology"

Dr G Bicknell

High Energy Gamma-Ray Meeting, 25-30 June, Heidelberg.

Oxford Radio Galaxy Workshop, 3-5 August, Oxford.

CANGAROO project meeting, 28 November-2 December, Institute for Cosmic Ray Research, University of Tokyo, Kashiwa.

Festschrift in honour of Don Melrose, 10 November, University of Sydney.
Presentation: "The Snake – A Reconnecting Coil in a Twisted Magnetic Flux Tube"

Dr M Colless

AAO/ATNF Symposium, 16-17 March, Hunter Valley, Australia.
Talk: "Progress with the 2dF Galaxy Redshift Survey"

Astronomical Society of Australia, 3-7 July, Hobart.
Talk: "Progress with the 2dF Galaxy Redshift Survey"

International Astronomical Union, Symposium 201, 7-11 August, Manchester, UK. Invited talk: "Cosmological Parameters from the 2dF Galaxy Redshift Survey"

Workshop on the Environments of Galaxies, 11-12 August, Birmingham, UK.
Talk: "Galaxy Properties from the 2dF Galaxy Redshift Survey"

Royal Observatory, 1 August, Edinburgh, UK
Talk: "Bulk Motions from EFAR (and 6dF)"

Dr M de Kool
5th Annual Stromlo AGN Workshop, 8-10 December, Canberra.
Presentation: "Probing Active Galactic Nuclei with Absorption Lines"

Dr G Da Costa
International Astronomical Union General Assembly, 8-16 August, Manchester.
Joint Discussion Session 5, Poster presentation: "A Main Sequence CH-Star in the Globular Cluster M55 (NGC 6809)"
Division VII Science Meeting, Oral presentation: "The Dwarf Spheriodal Galaxy And. III - M31's Draco or Ursa Minor?"

One-day Workshop, "Australian Optical Astronomy Beyond 2000", 17 May, Sydney.

Australian Institute of Physics meeting, 13 June, University of New South Wales.
Invited presentation: "The International Gemini Project: Australia's New View on the Universe"

"Mid-Term Review of Australian Astronomy: Beyond 2000", 8 November, Sydney.
Invited presentation: "Australia and the International Gemini Observatory"

International Gemini Observatory: NIFS Concept Design Review, 15-16 March, Mount Stromlo Observatory. IRIS2-g and Flamingos-II Concept Design Reviews, 27-28 April, Gemini Northern Operations Center, Hilo, Hawaii. Committee of Gemini Offices, Instrument and Operations Forum, and Telescope Readiness Review, 1-4 May, Gemini Northern Operations Center, Hilo, Hawaii. International Gemini Project Board meeting, 15 May, Sydney. Multi-Conjugate Adaptive Optics Concept Design Review, 30-31 May, Gemini Northern Operations Center, Hilo, Hawaii. Joint Gemini Science Committee and Instrument Forum meeting, 1-2 June, Gemini Northern Operations Center, Hilo, Hawaii. Multi-Conjugate Adaptive Optics Science Workshop, 23-26 October, University of California, Santa Cruz.

Prof M Dopita
24th IAU General Assembly, 5-13 August, Manchester.
Paper given in Joint Discussion 1 : Atomic and Molecular Data for Astrophysics: New Developments, Case Studies and Future Needs, "HI Shells in the Large Magellanic Cloud" (Kim, S, Dopita, M A, Staveley-Smith, L and Bessell, M).

Conference "Starbursts, Near and Far", 9-15 September, Germany.
Invited contribution: "Chemical Abundances and Evolution in Nearby Starbursts" (Dopita, M A, Kewley, L S, Heisler, C & Sutherland, R S)

Conference "Emission Lines from Jet Flows", 13-17 November, Isla Mujeres Mexico.
Invited paper: "Spectral Signatures of Jet-Driven Shocks in AGN"

Conference "Ionised Gaseous Nebulae", 3-17 November Mexico City, Mexico.
Invited paper: "Emission Regions in Galactic Nuclei: Photoionisation, Shocks or Starbursts?"
Poster paper: "New calibrations of nebular diagnostics for stellar effective temperature and metallicity" (Oey, MS, Shields, JC, Dopita, MA & Smith, RC)

Dr P Francis
Ozlens, 4-6 December, Melbourne.
Invited Review: "What do Quasars Look Like?"

Charlene Heisler Workshop, 7-8 December, Canberra.
Talk: "The Spectra of Pink Quasars" (Francis, PJ, Webster, RL, Whiting, M & Drinkwater, MJ)

Optical Astronomy Beyond 2000, 17 May, Sydney.

Mid Term Review Meeting, 8 November, Sydney.

Colloquium: "The Mystery of the Red Quasars", 3 December, Swinburne University.

ANU Teaching Forum, 25 August, Canberra.
Seminar: "Classroom Role-playing Games"

Outreach Lectures and Activities:
"Galaxy Formation and the Early Universe", 17 January, Talk to Summer Scholars.
"Twilight Talk", 20 January, Mount Stromlo Visitors' Centre.
"Dark Ages of the Universe", 4 April, talk to Australian Institute of Physics.
"Introduction to Astronomy", 30 April, talk for general public given five times during the Mount Stromlo Open Day.
"Pink Black Holes", 23 May, radio interview, 2CN.
"Introduction to Astronomy", 23 May, two talks to school groups.
"Dining at the Dome", 15 July, public talk at Mt Stromlo Visitors' Centre.
"Introduction to Astronomy", 9 August, talk for general public, Visitors' Centre.
"Planets and Nebulae", 22 August, talk to CSIRO Double Helix Club, Waniassa Hills Primary School.
Present "Red Rover Goes to Mars" prize, Marist College.
"Life in Space", 10 October, Marist Primary School.
"The Solar System", 16 October, CCE course lecture.
"Life in Space", 14 November, CCE course lecture.

Prof K Freeman
Conference "Dynamics of Star Clusters and the Milky Way", 20-24 March, Heidelberg.
Invited talk: "Proper Motion and Radial Velocity Study of Internal Motions in omega Centauri"

Oort Centenary Symposium "Looking Ahead in Wonder: from Comets to the Universe", 25-27 April, Leiden.
Invited talk: "Galactic Structure"

Conference "Gas and Galaxy Evolution", 21-24 May, Socorro.
Invited talk: "Dark Halos: an HI Perspective"

Visit to Space Telescope Science Institute, 1 May -1 June.

Conference "Galaxy Disks and Disk Galaxies", 12-16 June, Rome.
Invited talk: "Disk Galaxies"

Dr R Fux
International spring meeting of the Astronomische Gesellschaft, "Star 2000 - Dynamics of Star Clusters and the Milky Way", 20-24 March, Heidelberg.

IAU Symposium 205, "Galaxies and their Constituents at the Highest Angular Resolution", 15-18 August, Manchester.

Ogorodnikov meeting, "Stellar Dynamics: from Classical to Modern", 21-27 August, Saint Petersburg.

Dr C Jackson
AAO-ATNF Joint Symposium, 16-17 March, Hunter Valley.
Paper : "The local radio luminosity function and its evolution to z 0.3"

"Particles and Fields in Radio Galaxies", August, University of Oxford.

The VLA summer school, June, NRAO, Socorro.

"Blazar Demographics and Physics" workshop, July, Space Telescope Science Institute,
Invited review paper.

National Innovation Summit, February, Melbourne. Invited delegate.

ANU CEDAM: "Supervising Research Students", 11 May.

"What makes a Champion", 3-4 September, University of Sydney. Delegate.

5th Stromlo AGN workshop, 7-8 December, Canberra.

Dr H Jerjen
Vatican Observatory, Conference "Galaxy disks and disk galaxies", 12-16 June, Rome.

ATNF, Sydney.
Invited Talk: "Cluster, Group, or Cloud? How the Surface Brightness Fluctuations can tell the Difference" (Jerjen, H, Freeman, K C, Binggeli, B)

University of Canterbury, Christchurch.
Invited Talk: "Cluster, Group, or Cloud? How the Surface Brightness Fluctuations can tell the Difference" (Jerjen, H, Freeman, K C, Binggeli, B)

Ms L Kewley
5th Stromlo AGN Workshop, 7-8 December, Canberra.
Contributed talk: "The Starburst-AGN Connection: The Sequel" (Kewley, L, Dopita, M, Sutherland, R & Norris, R)

Prof J Mould
University of Hawaii, Institute of Astronomy Colloquium, 8 March.
Talk: "Future Directions in Observational Cosmology"

Osservatore di Capodimonte, 30 June.
Talk: "The Hubble Constant"

9th Marcel Grossman Meeting, 6 July, University of Rome
Talk: "The Hubble Constant from Cepheid distances measured with HST"

Sydney University Astronomy Colloquium, 31 July.
Talk: "The Hubble Constant"

Academia Sinica Institute of Astronomy & Astrophysics, 18-22 September.
Talks: "The Hubble Constant", "Stellar Populations", "The Australia Large Telescope"

National Taiwan University Department of Physics, 19 September.
Talk: "The Hubble Constant"

National Central University Department of Astronomy, 21 September.
Talk: "Stellar Populations"

University of Chile, Astronomy Department Colloquium, 24 October.
Talks: "The Hubble Constant", "The Australia Large Telescope"

International Astronomical Union General Assembly, 6-18 August, University of Manchester.

Prof J Norris
Conference "Fundamental Processes in Astrophysics", July, University of Heidelberg, Germany.
Invited paper: "The Most Metal-Poor Stars"

IAU General Assembly, Joint Discussion 5, August, Manchester.
Invited paper: "The Special Case of omega Centauri"

University of New South Wales, October, Sydney.
Colloquium: "The Most Metal-Poor Stars and the Primordial Lithium Abundance"

Dr B Schmidt
Harvard-SAO, 23 March, Cambridge, Massachussetts
Invited colloquium: "The Transient Universe"

Oort Symposium, 24 April, Leiden, Netherlands
Invited Speaker: "The Accelerating Universe"

Australian Institute of Physics, 11 May, Adelaide.
Invited Public Speaker: "Measuring the Universe with the Hubble Space Telescope"

UIMP Course on the Philosophy of Cosmology , 10-14 July, Santander, Spain.
Invited Lecturer: "Shifting the Paradigm of the Standard Cosmological Model"

Kapteyn Institute, 23 August, Grongingen, Netherlands.
Colloquium: "The Transient Universe"

The Bohr Insitute's Cosmological Constant, 24 August, Copenhagen, Denmark.
Invited Speaker: "Measuring the Cosmological Constant with Type Ia Supernovae"

Oxford University, 30 August, Oxford, UK.
Colloquium: "The Transient Universe"

Space Futures Conference, 6 October, Canberra.
Invited Lecturer: "Cosmology from Space"

NATO conference on Phase Transitions in the Early Universe, 8-15 December, Erice, Sicily.
Invited Lecturer: "Measuring the Universe with Supernovae"

The Texas Symposium of Relativistic Astrophysics, 17-19 December, Austin, Texas.
Session Organiser, "The Cosmological Constant"

Dr M Sevenster
Astronomical Society of Australia Annual Scientific Meeting, 3-7 July, Hobart.

OzLenz Workshop, 4-6 December, Melbourne.
Talk: "Microlensing and an inner ring in the Galaxy"

Dr P Wood
Conference: "Evolution of Binary and Multiple Star Systems", 25 June-1 July, Bormio.

Conference: "Post-AGB Objects as a Phase of Stellar Evolution", 5-7 July, Torun.

TEACHING/COURSES TAUGHT

Dr G Bicknell
"Planets and the Universe" (cosmology section) (ASTR1002)
"High Energy Astrophysics" (4^{th} year course)
8 lectures on Astrophysical Fluid Dynamics in "Molecular Spectroscopy and Shock Waves" (PHYS 3034)

Dr M Colless
RSAA Graduate Student Lecture "Astrophysics from Spectra"
Centre for Continuing Education "Mapping the Universe"

Dr M de Kool
"Stars and Astrophysical Fluid Dynamics "(with Dr P Wood) (ASTR3001)

Dr G Da Costa
2 lectures "The evolution of low mass stars" in course ASTR3001

Dr P Francis
"Astrophysics" (ASTR1001)
"Planets and the Universe" (ASTR1002)
"The Big Questions" (PHYS1007)

Prof K C Freeman
"Galaxies and Cosmology" (with Prof J R Mould) (C3002H)

Dr C Jackson
Physics undergraduate 1st year guest lecture "Extragalactic radio sources: Populations & Evolution"
ANU CCE lecture "Extragalactic radio sources"
MSASS (Yr 10) guest lecture "Radio-loud AGN: bright radio beacons in the distant Universe"

Prof J R Mould
"Galaxies & Cosmology" (with Prof. K C Freeman) (C3002H)

Dr B Schmidt
ANU Centre for Continuing Education course "Astronomy By Astronomers"

Dr M Sevenster
Twighlight talk, Mount Stromlo Visitors' Centre "Detecting Exoplanets"
ANU Centre for Continuing Education lecture "Disk Galaxies"
Three lectures on "Astronomical Instrumentation"

Dr P Wood
"Stars and Astrophysical Fluid Dynamics" (with Dr M de Kool) (ASTR3001)

Monash Visits
In consultation with Jackson, Jerjen, Schmidt and Vennes, Da Costa provided oversight for two 4 day visits (April and October) of approximately 30 Monash third year astrophysics undergraduates. The students learnt basic observing and reduction techniques through use of the 74-inch telescope.

COMMITTEE SERVICE AND RELATED RESPONSIBILITIES

MEMBERSHIP OF EXTERNAL COMMITTEES

Prof M Bessell
President Astronomical Society of Australia
Member National Committee of Astronomy
Member Editorial Board of PASA
Member AAO Schmidt Telescope Panel
Immediate Past President of IAU Commission 29 on Stellar Spectra

Dr G Bicknell
Member, Scientific Organising Committee, Workshop on AGN Variability

Dr M Colless
Chair, Anglo-Australian Observatory Users' Committee
Member, Australia Gemini Science Advisory Committee
Chair, 6dF Science Advisory Group
Member, Mid-term Review Working Group of the National Committee for Astronomy

Dr G Da Costa
President, IAU Commission 37 (to August)
Immediate-Past President and Member, Organizing Committee IAU Commission 37 (from August)
Member, Organizing Committee, IAU Division VII
Australian Gemini Project Scientist, Committee Memberships:
Chair, Committee of Gemini Offices
Member, Gemini Science Committee
Chair, Australian Gemini Science Advisory Committee
Member, Australian Time Allocation Committee
Member, Scientific Organizing Committee, Joint Discussion 5 "Mixing and Diffusion in Stars: Theoretical Predictions and Observational Constraints", IAU General Assembly, August 2000
Member, Scientific Organizing Committee, "Extragalactic Star Clusters", IAU Symposium proposal, Pucon, Chile, March 2001
Member, Scientific Organizing Committee, "The Dynamics, Structure and History of Galaxies", Dunk Island, July 2001
Chair, Local Organizing Committee, "The Dynamics, Structure and History of Galaxies", Dunk Island, July 2001

Prof. M Dopita
President, IAU Division VI & Commission 34 on Interstellar Matter. (1997-2000)
Chairman IAU Executive Committee Working Group for the International Development of Antarctic Astronomy (1997-2000)
Co-chairman, Scientific Organising Committee, IAU Symposium 209, "Planetary Nebulae: Their Role in the Universe"
Member, Scientific Organising Committee, IAU Symposium 205, "Galaxies and their Constituents at the Highest Angular Resolutions"
Member, Scientific Organising Committee, IAU Joint Discussion 11, "First Results of the FUSE Mission"
Member, Board of Editors, Astrophysics and Space Science. (1993-)
Member, Visiting Committee of the Capodimonte Observatory
Member, NASA Science Oversight Committee for the Wide Field Camera-3
Member, Antarctic Astronomy Working Group (1993-)

Dr P Francis
Member, Astronomical Society of Australia Education sub-committee
Consultant to design part of a WWW Astrophysics course for Swinburne University

Prof K Freeman
Member, Parkes Multibeam Working Group, Australia Telescope National Facility
President, International Astronomical Union (IAU) Division VII and IAU Commission 33 (Structure and Dynamics of the Galactic System)
Receiving Editor, "New Astronomy" (Elsevier)
Member, Scientific Organising Committee, Conference on "Dynamics of Star Clusters and the Milky Way", Heidelberg, March 20-24, 2000
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