Session I: Current Millimetre Facilities

Australian Facilities

Tony Wong
Australia Telescope National Facility

I'll introduce the high-frequency capabilities of Parkes, Tidbinbilla, Mopra, and the Compact Array, as well as some enhancements, which are currently in development. Major initiatives include 7mm (30-43 GHz) receivers and broadband spectrometers for Mopra and the Compact Array. I'll end with some recommendations for prospective users.

Science Possibilities with Australia's millimetre telescopes

Andrew Walsh
University of New South Wales, Australia

Apex – The Atacama Pathfinder Experiment *(Invited Talk)*

Karl Menten
Max Planck Institute for Radio Astronomy, Bonn, Germany

The Atacama Pathfinder Experiment is a 12-meter diameter telescope for submillimeter wavelengths that operates at 5100 meters altitude in the Chilean Atacama desert. The telescope's excellent surface and performance allow efficient operation throughout all of the submillimeter atmospheric windows accessible from the ground. Successful observations in the highest frequency window (at 1497 GHz) have already been performed. I'll give an overview over the project, describing existing and future instrumentation and present first science results. I'll also describe major large-scale projects that are being planned which will benefit greatly from complementary data produced by Australian facilities.

Collaborations between Australian radio facilities and NANTEN: Present and Future *(Invited Talk)*

Yasuo Fukui
Nagoya University, Japan

There are many interesting aspects in which Mopra and other Australian facilities can work together with NANTEN (NANTEN2) based in Chile. I will present a few astronomical results which on-going collaboration have already been producing, and will discuss future prospects to be obtained by combining the mm/cm facilities in Australia and the wide field sub-mm telescopes NANTEN2.

JCMT legacy programs and the role for southern telescopes *(Invited Talk)*

Mark Thompson
University of Hertfordshire, UK

The JCMT is in the process of upgrading its instrument suite with the commissioning of the HARP-B heterodyne focal plane array and the SCUBA-2 wide-field sub-mm continuum camera. These new instruments dramatically improve the mapping capability of the JCMT and the JCMT community is planning a series of ambitious Legacy Surveys, which will exploit these new capabilities to the full. I will describe some of the planned survey projects and outline the role that southern hemisphere telescopes can play, particularly mm-wave spectroscopic follow-ups to determine the kinematic distances of Galactic objects.

Session II: Future Southern Facilities

Terahertz Astronomy from Antarctica

John Storey[1] & Vincent Minier[2]
[1]University of New South Wales, Australia [2]CEA Saclay, France

It is terahertz frequencies that hold the key to understanding the energy balance of galaxies. However, because of the difficulty of observing at wavelengths where the earth's atmosphere is normally opaque, astronomers have yet to properly exploit this regime. Our knowledge of the terahertz spectrum comes solely from a few balloon flights, some airborne observations with the now defunct KAO, and a handful of space missions. However, measurements at short sub-mm wavelengths at both South Pole and Dome C hold out the tantalizing prospect that ground-based terahertz astronomy could be routinely performed from Dome A in the Australian Antarctic Territory. In this talk I will discuss the feasibility of doing this, and describe how the proposed HEAT instrument could open up the last remaining window in the electromagnetic spectrum to astronomy.

ALMA – The Atacama Large Millimetre Array *(Invited Talk)*

Tony Beasley
ALMA, Chile

The Atacama Large Millimeter Array (ALMA) is a large international telescope project under construction in northern Chile, on a site at 5 km elevation. The site provides excellent atmospheric transmission in the millimeter and sub-millimeter wavelength ranges. The project consists of two parts: (1) the 12m Array, composed of sixty-four 12-meter antennas that can be placed on 216 different stations for baselines up to 18 km and (2) the Atacama Compact Array - ACA - that consists of twelve 7 meter telescopes placed in compact configurations and four 12 meter telescopes for measuring source total power. In addition to high sensitivity, frequency coverage and dynamic range, ALMA will record both interferometric and the complete source flux density. At the shortest planned wavelength (0.3 mm) and longest baseline, the angular resolution will be 0.005". The receivers use superconducting (SIS) mixers, to provide the lowest possible receiver noise contribution. At first light, the ALMA project the 6 highest priority receiver bands will be installed, each observing both polarizations with a bandwidth of 8 GHz. In this talk, the status and plans for ALMA will be discussed.

Session III – Science Opportunities I

Turbulence-regulated star formation

Maria Cunningham
University of New South Wales, Australia

It is clear that turbulence plays an important role in the chemistry and dynamics of the compressible fluid that is the interstellar medium (ISM). However, the exact role that turbulence plays is not quite so clear, nor is the effect that turbulence has on one of our most important tools for investigating star formation - interstellar chemistry. In the past decade developments in theoretical modeling, observational technology and data analysis methods mean that we now have the ability to characterize turbulence in the ISM, and to examine how this turbulence may be affecting both interstellar chemistry and star formation. In this talk we discuss the Delta Quadrant Survey (DQS), which is a large collaborative project to investigate both the turbulent properties and interstellar chemistry of the G333 giant molecular cloud complex, using the capability of the Mopra telescope to observe a number of molecular transitions simultaneously. The Mopra observations are discussed here, as well as potential extensions to the project that exploit other facilities and wavelengths.

Studies of high-mass star formation from the southern hemisphere: NGC 6334, G327.3-0.6, SgrB2 and the Orion Bar

S. Thorwirth[1], P. Schilke[1], F. Wyrowski[1], A. Belloche[1], C. Hieret[1], C. Comito[1], K. Menten[1], H. Beuther[1], A. Walsh[2], T. Hunter[3]
[1]Max Planck Institute for Radio Astronomy, Bonn, Germany [2]University of New South Wales, Australia [3]Harvard-Smithsonian Center for Astrophysics, USA

We present first results from unbiased molecular line observations obtained toward the high mass star-forming regions NGC 6334I and I(N), G327.3-0.6, SgrB2(N)/(M) as well as the Orion bar as the prototypical PDR. The data were obtained through concerted observing runs with APEX, ATCA, SEST and the IRAM 30m telescope and are expected to improve our understanding of the chemistry associated with high-mass protostars and their surroundings.

Hot Molecular Cores

Cormac Purcell
University of New South Wales, Australia

Science with HEAT in Antarctica

Wilfred Walsh, John Storey
University of New South Wales, Australia

New technologies permit terahertz frequency astronomical observations, but only from select locations on the Earth's surface. We propose to install a terahertz-capable radio telescope (HEAT) on the highest point of the Antarctic plateau, the best terrestrial site for such an instrument, thus opening a significant new astronomical window. This talk reviews our scientific aims. These include the first terahertz imaging of molecular clouds within the Galaxy, key components in the formation and evolution of planets, stars and galaxies. By studying key interstellar cooling lines, we can understand the progress of star formation and galaxy evolution from the early universe to the present time.

Should we use Australian millimeter telescopes for VLBI experiments?

Roopesh Ojha
United States Naval Observatory, USA

After a brief overview of the types of science addressed by millimeter-VLBI, we consider both the motivation and the feasibility of using Australian millimeter-capable radio telescopes to conduct such observations. It is argued that there are strong scientific reasons for using the ATCA with northern hemisphere arrays including VERA and the recently funded space mission VSOP2.

VSOP-2 and Opportunities for millimetre astronomy

Phil Edwards
Institute of Space and Astronautical Science, Japan

Following on from the successes of the VLBI Space Observatory Programme (VSOP), the VSOP-2 mission has been selected by the Institute of Space and Astronautical Science (ISAS) of the Japan Aerospace Exploration Agency (JAXA). The VSOP-2 satellite will deploy a 9m off-axis Cassegrain mesh antenna, and use cooled receivers for observations at 22 and 43 GHz. Observations with arrays of ground radio telescopes will enable gains of an order of magnitude in angular resolution and sensitivity over VSOP observations. In this presentation an overview of the mission and the opportunities for millimetre astronomy will be given.

Session IV – Science Opportunities II

Starformation's most wanted

Mark Wardle
Macquarie University, Australia

I shall describe key unknowns in the theory of star formation and outline the observations with future mm facilities that may be able to resolve them.

Line Surveys at 3 and 12 mm

Andrew Walsh
University of New South Wales, Australia

With the advent of the new 8GHz MOPS on Mopra, the possibilities of millimeter line surveys in the southern hemisphere have been vastly improved. It is now possible to search the entire 3mm band from 77 to 115GHz with as little as five observations. Furthermore, it will be possible to search the 12mm band, from 17 to 25GHz in a single observation. I will discuss some interesting applications of such line surveys, and the sort of science that can be done, including a pilot 3mm line survey of five times as many sources as have been done to date, a 12mm southern Galactic plane line survey, and new possibilities to search for interesting biomolecules such as glycine, the simplest amino acid.

Unbiased surveys of dense molecular clumps in the southern Galactic plane

Yoshinori Yonekura[1], Peter Barnes[2], Yasuo Fukui[1], and the NANTEN-team
[1]Osaka Prefecture University, Japan, [2]University of Sydney & University of New South Wales, Australia [3]Nagoya University, Japan

We are now conducting unbiased surveys of dense molecular clumps using NANTEN, MOPRA, ASTE, and other telescopes. Main purposes of the surveys are (1) to reveal the differences in physical properties among massive-star-forming clumps, low-mass-star-forming clumps, and non-star-forming clumps and also (2) to find massive young stellar objects. So far, observations toward the Carina arm (longitude between 280 and 300 degrees) have been finished with NANTEN in C18O (J = 1-0), and 85 clumps are identified. In the workshop, we will present a brief introduction of the survey together with the result of the statistical study of the identified clumps.

Large-scale surveys of low- and high-mass star formation

Peter Barnes[1], Yoshinori Yonekura[2] & NANTEN team, Tyler Bourke[3] & C2D team
[1]University of Sydney & University of New South Wales, Australia [2]Osaka Prefecture University, Japan [3]Center for Astrophysics, USA

We will be conducting 2 major astrochemistry surveys in low- and high-mass SFRs in the next few seasons, primarily using Mopra's new 8 GHz backend. We present results of pilot work along these lines from the last few seasons, including the demographics of chemistry and kinematics over large samples of SFRs covering a range of mass and luminosity. We examine prospects for Mopra and the ATCA to reap this spectroscopic harvest over the next 5 years, even while new facilities like ALMA and the LMT come online.

Opportunities at 7-mm for studying protostellar jets and disks

Kate Brooks
Australia Telescope National Facility

All six antennae of the Australia Telescope Compact Array will be equipped with 7-mm (30-50 GHz) receivers in mid 2007, making the Compact Array the only interferometer in the world that can observe in discrete wavebands spanning the range 1 to 100 GHz. The 7-mm waveband opens a window of opportunity in the study of young massive stellar objects, particularly in the hunt for collimated jets and circumstellar disks. Frequencies close to 50 GHz mark the turnover between emission from ionised gas (associated with jet) and emission from dust (associated with a disk). I will demonstrate how the Compact Array is perfectly suited to the task of detecting collimated jets and disks towards massive stars.

Investigating grain growth in southern protoplanetary disks

Sarah Maddison[1] , Lommen[2], Wright[3], Bourke[4], Burton[3], Hughes[1], Jorgensen[2], van Dishoeck[2], Wilner[4]
[1]Swinburne University, Australia [2]Leiden Observatory, Netherlands
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In order to understand planet formation, we would like to be able to probe the physical conditions of protoplanetary disks to see when and where grains begin to grow in size. There are several observational signatures that indicate grain growth, including the 10-micron silicate emission feature and the millimetre slope of the spectral energy distribution (SED). Over the past four years we have been undertaking a 3 mm continuum survey with ATCA of disks around young stars (both T Tauri and Herbig Ae/B stars) in southern molecular clouds to investigate the evolution of protoplanetary disks and grain growth within these disks. The goals of our project are to obtain fluxes and hence spectral energy indices, as well as resolve disk structures to probe the physical conditions and help constrain disk models. Here we present preliminary results from our successful 2005 millimetre season. We observed 14 southern T Tauri sources (10 in Chamaeleon and 4 in Lupus), detecting nine sources at the 3*f*ã level and obtaining strict upper limits for a further three sources. The values we obtain for the opacity indices suggest the presence of mm-sized dust aggregates and hence grain growth in the disks. However, as noted by Dutrey et al. (1996) the disks need to be spatially resolved to break the degeneracy in fitting the SED for small optically thick disks with small grains and extended optically thin disks with larger grains. Hence in order to really study grain growth at millimetre wavelengths, we need to be able to resolve the disks with ATCA.

The Initial Conditions for Massive Star Formation

Michael Burton
University of New South Wales

This talk will discuss the role that millimetre wave astronomy can play in understanding how massive star formation is initiated, and in determining the sequence of events that must take place for a dense molecular cloud core to produce a clutch of massive young stars. It will examine the role for facilities such as Mopra, Parkes and the ATCA, as well APEX and NANTEN2, in this science endeavor, and how these can then feed the science that ALMA will tackle.

The Galactic Centre at Millimetre Wavelengths

Jürgen Ott
Australia Telescope National Facility

The Galactic Centre region is obviously the most nearby core of a galaxy and is subject to extreme physical conditions, e.g., it contains the most nearby massive black hole Sgr A* and the very prominent star forming region Sgr B2. I will show first results of a high-resolution, wide-field, multi-line ammonia survey of the Galactic Centre region obtained with he ATCA. Furthermore, an outlook on potential future surveys and targeted (sub)millimetre observations toward the Galactic Centre region will be presented.

Molecular clouds and star formation in the Large Magellanic Cloud

Akiko Kawamura[1], M. Filipovic[2], L. Staveley-Smith[3], Y. Mizuno[1], T. Minamidani[1], N. Mizuno[1], T. Onishi[1], Y. Fukui[1]
[1]Nagoya University, Japan [2]University of Western Sydney, Australia [3]Australia Telescope National Facility

The Large Magellanic Cloud (LMC) offers an ideal laboratory to study how the interstellar medium evolves and how stars are formed in a lower metal abundance environment at the unrivalled closeness to us. It is known that young populous clusters like R136 are still being formed in the LMC, making us possible to study cluster formation. A large-scale survey in CO (J = 1-0) toward the LMC has been carried out with NANTEN at Las Campanas Observatory, Chile. We identified about 270 molecular clouds. Comparisons of the giant molecular clouds with young clusters (e.g., Bica et al. 1996) and HII regions show about one forth of the clouds are associated with clusters and HII regions, while a half are only with HII regions. The rest show no evidence for massive star formation. We have further carried out a comparison of the CO clouds with radio continuum sources by Australian Telescope Compact Array (ATCA). The detection limit of HII regions by ATCA is well below the flux of the Orion nebula. It is found that the starless clouds are not associated with candidates of HII regions by ATCA either. This high ratio of starless GMCs is different from what we see in the molecular clouds within a few kpc from the Sun.

Mopra Observations of the Magellanic Clouds

Annie Hughes[1] on behalf of the ATNF-Nagoya-Bonn-Swinburne
[1]Swinburne University, Australia

A significant fraction of Mopra extragalactic observing time in 2005 was devoted to a high-resolution survey of the 12CO(J=1-0) emission in Magellanic Clouds. While the project is not yet complete, the survey team has already generated a fully sampled data cube of the Large Magellanic Cloud's (LMC) molecular ridge region, which extends ~2kpc south of the 30 Doradus star-forming complex and includes some of the most massive molecular clouds in the LMC. In this talk, I will present the new data and discuss some early findings. One striking result of our preliminary analysis of the LMC molecular ridge data is that the X factor (NH2/ICO) appears to show a systematic spatial variation along the molecular ridge, decreasing with distance (and UV intensity) from the active 30 Dor complex. I will discuss our plans for the project in 2006, which include i) mapping the molecular clouds near the kinematic centre of the LMC, ii) mapping the molecular gas in the Small Magellanic Cloud, which exhibits an even lower metallicity than the LMC, iii) using the new MOPS spectrometer to obtain spectra of multiple molecular transition lines along the molecular ridge in order to investigate the chemistry of different molecular species as a function of the radiation field.

Submillimeter observations of the Magellanic Clouds

Tetsuhiro Minamidani[1], N. Mizuno[1], Y. Mizuno[1], A. Kawamura[1], T. Onishi[1], Y. Fukui[1], T. Hasegawa[2], K. Tatematsu[2], M. Ikeda[2], J. Ott[3], T. Wong[3,4], E. Muller[3]
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It is of particular interest to observe the dense molecular gas in the Magellanic Clouds, where populous clusters are still being formed. These galaxies located at unrivalled closeness to us of around 50 kpc, and their metallicities are less than that of the Galaxy. These unique properties make them an ideal target to study formation of rich stellar clusters (Fukui et al. 1999). To reveal the differences in physical properties between active cluster-forming GMCs and less/non cluster forming GMCs, high-resolution submillimeter observations with ASTE were performed. We have mapped 13 GMCs in CO(3-2) and 9 GMC peaks in [CI] for both LMC and SMC. ASTE has a 10m dish, and the angular resolutions are 15arcsec. and 22arcsec. for [CI]:492GHz and CO(3-2):345GHz, respectively. This corresponds to the spatial resolutions ~5pc. We have detected [CI] emission from 3 and 2 molecular peaks in LMC and SMC respectively. We have found that the extent of [CI] emission of 30Doradus and N159W is compact and that of N159S is extended. This seems that the [CI] lines in 30Dor and N159W are PDR origin but that is not in N159S. We have derived [CI]/CO(1-0) ratio at 3 peaks of GMCs located in 30Dor-N159 region. They are 0.4, 0.3 and 0.1 for 30Dor, N159W and N159S respectively. This variance would be caused by the incident far-UV field. We have also derived density and temperature of clouds from CO(3-2)/CO(1-0) ratio based on LVG analysis. In this talk, their cloud properties will be compared in detail with those of the well-known galactic GMCs in order to highlight the difference in the physical characteristics. We will discuss the connection of the GMC properties with metallicity and other properties in the context of star/cluster formation.

Searches for molecular gas in the distant universe

Ilana J. Klamer, Elaine M. Sadler
University of Sydney, Australia

I shall provide an overview of current and future capabilities for the Compact Array to perform both targeted and blind searches for CO in distant galaxies, with emphasis on those at the highest redshifts (z>2).

First results of the ATCA 20 GHz survey

Roberto Ricci
Australia Telescope National Facility

The radio-population above 5 GHz has not been well studied yet. This is mainly because large radio telescopes typically have fields of view of a few arcmin at high frequencies, making it extremely time-consuming to carry out large area surveys. Measuring the high-frequency properties of extragalactic radio sources is important in its own and also crucial for interpreting the high-sensitivity and high-resolution maps of the Cosmic Microwave Background radiation. We present the first southern-sky high-frequency (20 GHz) blind survey that we have been carrying out at the Australia Telescope Compact Array. We explain how the survey is technically possible and show the first results obtained in the 2002 pilot study and 2003-2005 main survey. The final aim of the project is to cover all the southern sky down to a flux density limit of 40 mJy.

Session V – Technology Opportunities

Emerging opportunities for millimetre receivers and arrays

Warwick Wilson
Australia Telescope National Facility

Presented will be an outline of some possible future directions for the development of millimetre-wave receivers, including focal plane array receivers, on ATNF telescopes.

Water Vapour Radiometers

Bob Sault
Australia Telescope National Facility

Terahertz radio systems

Trevor Bird
CSIRO ICT Centre, Australia

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