

Preface

1. Introduction

IAU Symposium Number 221, *Star Formation at High Angular Resolution*, was the last of the six Symposia to start during the XXVth General Assembly of the International Astronomical Union, held in Sydney, Australia in 2003. The meeting ran for four days, from Tuesday 22nd to Friday 25th of July, ending with the end of the GA. It took place inside the palatial Sydney Convention Centre, spectacularly located in Darling Harbour, adjacent to the central business district of Sydney, and one of the major venues for the Olympic Games in 2000.

Star formation is at the heart of the process of evolution in the Universe, from the time of the first star formation, a hundred million years or so after the Big Bang, to the present day. Its affects are profound, with the short-lived, massive stars it produces powering the luminosity of galaxies and driving the feedback cycles that enrich the interstellar medium, keeping it in a state of dynamic flux and triggering further star formation. To understand the distant universe, and the formation of galaxies, requires one to understand the process of star formation, and how it varies with environment. Yet the phenomena of star formation itself are poorly understood even within our own Galaxy.

This Symposium concentrated on our knowledge of the phenomenon of star formation within the Galaxy. Low mass star formation is relatively well understood, at least the stages through which a collapsing cloud goes through before a main sequence star(s) emerges from inside it. The situation for high mass stars, those that drive the galactic ecology, is very different. Short timescales, concurrent phenomena, multiple sources and great distance, have so far conspired to hide from us the sequence of events that massive stars go through as they form. To make progress greater clarity is needed of the structure of the dense cores where star formation is taking place; i.e. higher angular resolution. Even for low mass stars, while the basic processes may appear understood, the most interesting aspects—the formation of disks, and of planetary systems within them—take place on spatial scales that have so far been largely closed to our gaze.

This science driver of telescope design provided the motivation for IAU Symposium 221, the use of new techniques to gain higher angular resolution views of the process of star formation across the electromagnetic spectrum. These ranged from the extended baselines of VLBI in the cm-band radio, to the development of interferometers at mm and sub-mm wavelengths, and even in the mid-infrared, to the use of adaptive optics in the optical and near-IR bands in order to reclaim the diffraction limit from the turbulence-induced seeing.

2. Themes

IAU Symposium 221 had six principle scientific themes relating to studies of star formation:

- Molecular clouds to protostellar cores, where star formation is initiated.
- Low mass star formation, in particular the investigation of the formation of multiple systems and clusters.
- Massive star formation, and the hidden world of hot molecular cores.
- Extragalactic star formation, and the superstar clusters that are being resolved in other galaxies.
- Jets, outflows and disks, and how their structure and dynamics are being uncovered.
- Planets, how they might influence the formation of the central star and what signatures they may leave in its disk.

To accompany these themes there were talks given describing specific high spatial resolution techniques at different wavebands, with an emphasis on the new insights these techniques can provide for star formation studies. There was also a session presenting the first results from several new facilities, operating with improved angular resolution, that had been commissioned over the previous few months to the Symposium. Finally, there was a discussion on where the future of star formation research lies. S221 was broken down into 14×1.5 hour sessions (S1 to S14) covering these topics, as follows:

S1 provided an introduction to the subject, both from a theoretical and an observational perspective. As with all the Symposia at the GA, this session was aimed at providing an overview for the professional astronomer, and not just the star formation specialist. Many of the ideas presented here received greater attention in later sessions.

S2 and S3 looked at the earliest stage of the star formation process, the transition from molecular clouds to protostellar cores. It considered how clouds turn themselves into cores, what the cores look like, and what is happening inside them? It also included the first techniques talk, on mm and sub-mm interferometry.

S4 covered extra-galactic star formation and completed the first day. How does star formation reveals itself in other galaxies, what do we know about their molecular content, and how may they be probed using X-ray observations?

S5 and S6 on the second day covered the subject of massive star formation, the most poorly understood aspect of star formation. Our state of knowledge was reviewed, the accretion scenario examined, the utility of masers to probe the environment considered, and the results of new techniques to probe cores at high resolution presented.

S7 and S8 were on low mass star formation. The paradigm for our understanding of this event was examined, and our knowledge of the formation of binary and multiple systems looked at, as well as our understanding of forming star clusters. The second techniques talk was given, on X-ray imaging.

- S9** started the third day with a presentation on the state of development, as well as the first results, from several new facilities: the mm-interferometer of the Australia Telescope, the Smithsonian Sub-Millimeter Array, the Very Large Telescope and Keck Interferometers, as well as adaptive optics measurements made with the Calar Alto 3.6m, the VLT and Subaru.
- S10** ended a shortened third day (to make way for the General Assembly in the afternoon and the Australian-themed banquet that followed) with a look at jets and outflows, examining our view of them from the optical, the mm and the cm-bands. It also included the third techniques talk, on adaptive optics.
- S11 and S12** started the final day with a look at disks. The talks examined how disks form within their envelopes, and the best views that had been obtained in the IR and the mm, looked at their internal chemistry and examined models of what is happening inside them.
- S13** looked at the influence of planets during star formation. It examined the signatures planets may leave and how they may be found within disks. The fourth techniques talk, on IR and optical interferometry, was also presented.
- S14** closed the Symposium with a look at where the field of star formation is heading. There were three techniques talks; on nulling interferometry (needed to image disks and planets directly), on the prospects for star formation studies with the next great radio observatories (ALMA and the SKA), and on the prospects for the field from future optical / IR observatories.

There was also a full set of poster presentations, covering every aspect of research into star formation. These were located outside the Symposium auditorium. Their titles are listed in these proceedings. The full program, with abstracts for oral and poster presentations, as well as many of the power-point presentations, can be found on the S221 website, www.phys.unsw.edu.au/iau221.

The Symposium didn't lack for evening entertainment either. Each night had a separate designated watering hole for first-hand experimentation on some of those exotic interstellar molecules. A special event, 'Science in the Pub' was held in the nearby Harlequin Inn, to allow a panel of esteemed luminaries to discuss what they understood by the simple-sounding question 'What is a Planet?'. The answer was not so simple! Science in the Pub is actually an exercise in science communication, and this event was part of a large program of public events put on before and during the GA, both in and around Sydney, and through much of the state of New South Wales as part of UNSW's 'Astronomy on the Go' program. Ewine van Dishoeck also delivered one of the three Invited Discourses at the GA, on a theme close to the heart of many at the Symposium, 'From Molecules to Planets: Milky Way Dreaming'. Apart from synthesising the entire field of star formation within a single evening's entertainment, the talk also included regular digression to the indigenous culture of Australia—for the spectacular beauty of the Milky Way in the southern winter, with the Galactic

Centre passing directly overhead at midnight, is encapsulated within the Aboriginal culture. The nearby star forming clouds that many of the Symposium participants study are clearly etched across the Milky Way. They also feature in the constellations of the Aboriginals, the only culture to incorporate the dark features of the sky, as well as the bright ones, into their mythology this way.

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Acknowledgments

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