Photographing the Sky in 1887 - Australia's Contribution to the *Carte du Ciel* Project

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Abstract

In 1887 the Paris Observatory initiated a project to map the entire sky using the newly developed dry photography techniques. The ambitious project was an international venture and included eighteen observatories from around the world. Each observatory was designated a section of the sky to systematically photograph with the results eventually being collated into the Astrographic Catalogue (AC). In Australia, the Sydney, Melbourne and Perth Observatories took part.

Introduction

In 1838, the director of the Paris Observatory, Francois Arago, produced a photograph of the Moon with the photographic pioneer, Louis Daguerre. In January the following year, on Daguerre's request, Arago formally presented the invention of the *daguerrotype* to a meeting of the French Academy of Science. From that point, as with photography in general, astronomical photography developed at a fast pace and in 1885 a photograph taken of the Pleiades star cluster by the Henry brothers, Paul and Prosper, inspired the then director of the Paris Observatory, Admiral Ernest Barthelemy Mouchez, to propose that the entire sky should be photographed in the manner the Henry brothers had developed.

Sir David Gill, a Scot at the Royal Observatory at the Cape of Good Hope, himself a pioneer in astrophotography, joined with Mouchez in espousing the idea, as did Otto Struve, the Russo-German director of the Poulkovo Observatory. Together, Mouchez, Gill and Struve arranged the "*Congrès International de la Carte du Ciel*" which took place in Paris in 1887.

The result was the launch of the first major international scientific project – the *Carte du Ciel,* which was to produce the first photographic record of the sky. Eighteen observatories around the world agreed to take part in the project with each observatory being designated a region of the sky to photograph.

The *Carte du Ciel* was to have two functions. The first was to make a photographic record of the sky of all stars to 11^{th} magnitude and the second to produce a set of star charts of all stars down to 14^{th} magnitude.

For purposes of consistency it was determined that each observatory would use the same equipment. All of the observatories were equipped with an astrograph based on the design of the Henry brothers. The "double astrograph" was a double telescope with two telescopes mounted together. One telescope, the astrograph, was used for photography while the other telescope acted as a guide scope that allowed tracking of the sky so that images would remain centred during long time exposures. The astrograph had an aperture of 33 cm and a focal length of 3428 mm. This provided an effective field of view of 2.1 x 2.1 degrees for each plate. Therefore approximately 22 000 plates would be needed to photograph the entire sky.

A telescope configuration was agreed on and the foremost telescope maker of the time, the Irishman Sir Howard Grubb, produced seven of the telescopes used in the project. Three of these were used at the Sydney, Perth and Melbourne Observatories.

Astronomy in Australia and the *Carte du Ciel*

At the time of the *Carte du Ciel* science in the Australian colonies was thriving. New South Wales scientists were working with Louis Pasteur to develop an anthrax vaccine, culminating in 1887 with the establishment of the first branch of the Pasteur Institute outside France on Rodd Island in Sydney with Pasteur's own nephew, Adrien Loir, heading the project (Todd 1995). Lawrence Hargraves was pioneering aviation. The Faculties of Medicine at the Universities of Sydney and Melbourne were considered equal to or superior to those at Oxford, London and Cambridge (Twopeny, 1872) and William Lawrence Bragg and William Henry Bragg (later to win the Nobel Prize for Physics) were making ground-breaking discoveries in x-ray crystallography. Australians were considered to be the best-read general population and the Schools of Mines/Mechanics Institutes/Schools of Arts, with their excellent technical libraries and thousands of subscribers, abounded throughout the colonies.

From the arrival of the astronomer, the Reverend William Dawes, who sailed out with the First Fleet in 1788, astronomy in the Australian colonies had always been well-supported and many new discoveries were made as the skies of the southern hemisphere were observed for the first time. Building on the ambitions of Lord Brisbane and the achievements of such astronomers as John Tebbutt, astronomy in Australia was at the forefront of the field, with international recognition.

The *Carte du Ciel* was proposed at a time that Australian astronomy had progressed to the point that it was on the verge of three pivotal developments - the separation of meteorological and time-

keeping functions from scientific research, the advent of "big science" and the separation of amateur and professional astronomy into two identifiably different domains.

From the time of the founding of the colonies, meteorological and time-keeping duties were important observatory responsibilities. Longitudinal calculations, time-keeping for the railways and shipping and weather forecasts for agriculture and shipping constituted the majority of observatory activities. Additionally, from the 1860's the Australian colonies were approaching Federation. For economical integration to be successful it was considered necessary that there be co-operation between the colonies of meteorological observations and co-ordination of time-keeping (O'Keefe & Pearson, 1998). The result of this was that a spirit of co-operation existed between the observatories.

However, there was an increasing emphasis on these duties away from scientific research, which frustrated many astronomers who, as was common throughout the world, proposed the establishment of meteorological bureaus to assume weather and time-keeping duties or the division of observatories into dedicated departments. The great amateur astronomer, John Tebbutt, who had turned down the offer of NSW Government Astronomer so that he could continue with pure astronomical pursuits, was among the critics of the Sydney Observatory's neglect of scientific research. It was suggested that it was his public criticisms of the New South Wales Government Astronomer, Henry Chamberlain Russell, which spurred Russell to commit the Sydney Observatory to the *Carte du Ciel* project (Anglo-Australian Observatory 2000). However, it should be noted that Russell, who had been director of the Sydney Observatory since 1870, had already performed work in astronomical photography and was a pioneer of the field in Australia. On the basis of Russell's appreciation of astrophotography and the general urge for the observatory to be used for research, it would not be surprising that at the 1887 International Congress, Russell dedicated the Sydney Observatory to the –52 to –64 degree field of declination.

Robert Lewis John Ellery was director of the Melbourne Observatory when in 1868 the exorbitant purchase of the largest steerable reflecting telescope in the world from the foremost telescope maker of the time, Sir Thomas Grubb (Sir Howard Grubb's father), had been met with great anticipation. However, when Grubb's use of speculum metal to coat the mirrors instead of silver resulted in poor quality images this excitement turned to disappointment and Melbourne Observatory was in need of a boost in morale and scientific validity. The Victorian government approved Melbourne Observatory's participation in the *Carte du Ciel* in 1887 and Melbourne was assigned the area of declination from –65 to –90 degrees.

Perth Observatory was largely a meteorological station when William E. Cooke became its first official director in 1900. Cooke, who had been Assistant Astronomer at Adelaide Observatory under Sir Charles Todd and who was later to become Professor of Astronomy at the University of Sydney, was however, an excellent astronomer who battled the WA government to maintain the observatory against substantial political opposition. Perth Observatory became one of the last observatories to join the *Carte du Ciel* programme in 1900 when work at Rio de Janeiro Observatory, originally designated the declination from –32 to –40 degrees, was not forthcoming. Perth subsequently accepted the assignment to observe that zone with work beginning in 1902 under Cooke's charge.

Before the *Carte du Ciel* amateur and professional science in Australia were indistinguishable. McGarvie-Smith and Gunn, the scientists who developed the anthrax vaccine which was to replace Pasteur's were still largely working out of their backyard laboratories. Hargraves was inventing the science of flight from home-made box-kites. In astronomy, many of the astronomers used the same equipment, performed the same functions, were members of the same organizations and published their work in the same journals. The *Carte du Ciel* however, was a co-operative venture between observatories throughout the world requiring consensus of method and standardisation of equipment on a scale that had never been attempted before. Moves toward federation of the Australian colonies had prompted effective co-operation for time-keeping and meteorological duties between the observatories which primed them for the level of interaction the *Carte du Ciel* required.

By the time of the Carte du Ciel the Australian observatories were well equipped and eager to take part in the survey that would introduce "big science" to Australia and initiate the separation of professional and amateur astronomy.

Sydney Observatory (-52 to –64 degrees)

Sydney Observatory took delivery of the Grubb lens in December 1890 for a telescope which had mostly been constructed in Sydney. Observing took place discontinuously over a period of fifty-six years from 1892 to 1948 during which 1400 plates were made with 430 000 stars being photographed. During this time the instruments were moved twice

When Cooke left Perth Observatory to take up the directorship of Sydney Observatory in 1912, he was, as he had been in Perth, methodical and meticulous. He continued his participation in the *Carte du Ciel*, assuming responsibility for the project at the Sydney Observatory. He was

unsatisfied with the quality of many of the Sydney plates that had been made before he arrived and had many of the plates re-photographed. He also began having the plates measured at Sydney Observatory instead of at the Melbourne Observatory where they had previously been sent for the purpose.

Melbourne Observatory (-65 to –90 degrees)

The Grubb telescope arrived in 1890 and photographic work took place over a period of thirty-five years from 1892 to 1927, although one plate is marked with Epoch 1940. During this period 1149 plates were made containing 218 000 stars with the majority of the plates being exposed by 1898. Three exposures were made on each plate being of 5 minutes, 2.5 minutes and 20 seconds.

Perth Observatory (-32 to –40 degrees)

Initially the CdC was performed under the direction of Cooke using a Grubb telescope. That these plates were made and in such a brief time was a major achievement, as since the time of its establishment Perth Observatory had been subjected to major political opposition by the government which funded it. The Western Australian government had frequently attempted to close the observatory and only staunch efforts by the observatory staff prevented this. Although starved of funds and reduced at times to only one or two employees, the observatory was still able to comply with its *Carte du Ciel* commitment and from 1902 to the fulfilment of the programme in 1919, 1376 plates were made.

Measuring the Plates

Measuring the *Carte du Ciel* plates was a time consuming and laborious practice. As it had become common practice in observatories throughout the world to employ women as calculators to make routine observations and perform routine calculations and data reduction, several women were engaged as non full-time staff to meet this demand for the CdC plates. At CdC observatories throughout the world many women were employed as plate measurers, including the famous American astronomer Dorothea Klumpe at Paris Observatory. In Melbourne six women were employed for this purpose and in 1908 four women were employed to measure the Perth plates.

Except for at the Vatican all of the *Carte du Ciel* plates were measured using the short screw method or the eyepiece method. The short screw method consisted of the use of a set of spider wires which were hung over the plate. The distances along the wires to points on the plates was measured from the screws on the slides which moved over the wires. The eyepiece method involved using a scale inside the focal plane of the microscope.

Measurement of the Melbourne plates began in 1889 using the short-screw method. Initially the Sydney plates were sent to Melbourne for measurement but when Cooke became director the plates were then measured at Sydney using the eyepiece method.

When Cooke left Perth Observatory for Sydney in 1912, he was succeeded by H. B. Curlewis. During Curlewis' reign the observatory was almost completely deprived of funds by the WA Government who wanted the observatory to be purchased by the University of Western Australia. The result was that there were limited funds available for measuring the plates. Professor Dyson of Edinburgh Observatory responded by offering his assistance and until 1915, staff at Edinburgh measured the plates of the –40 to –38 degree zone. This became known as the "Perth-Edinburgh Zone". The other plates were measured in Perth. All of the Perth plates, both at Perth and Edinburgh, were measured using the eyepiece scale method.

The original Sydney and Melbourne plates are currently archived at Macquarie University in Sydney under the custodianship of Dr. Alan Vaughan and the Perth plates are held at Perth Observatory under the charge of Dr. James Biggs.

The Results

The first task of the programme – a complete photographic record of the sky of stars to 11th magnitude was achieved and surpassed, with stars to the 14th magnitude being recorded on some plates. The results of the photographic catalogue were eventually collated in Paris and published as the Astrographic Catalogue (AC) which was published in 254 volumes. A total of 8.6 million star images were included in the catalogue. The quality of the plates was high with an accuracy to 0.1 arcseconds (Urbain & Corbin, 1998).

The second part of the programme, the drawing of charts of stars to 14th magnitude, was not completed as many of the observatories did not have the resources to complete this massive task.

Context and Significance

To those who recognised the benefits of applying photography to astronomy at the time that photography was an innovative field, the *Carte du Ciel* seemed to be a logical and exciting project. However, as the survey progressed attitudes toward it changed. The project was taking many more years to complete than had been anticipated - it was only deemed officially completed in 1970. The sheer volume of work required had been unforeseen and the commitment of some observatories to the project was unreliable and sporadic.

This prompted much criticism by those who considered the *Carte du Ciel* to be a waste of time and money, tying up valuable resources in a laborious exercise of dubious scientific value. It was argued that the allocation of funds and effort diverted from the development of astrophysics and that it was the non-participation of American astronomers in the *Carte du Ciel* project that allowed American astrophysics to advance ahead of the rest of the world in that field. Eventually lack of interest in the project by the general scientific community led to the *Carte du Ciel* being considered as one of the great white elephants of international astronomy and it may have fallen into historical oblivion as such.

However, more recently, the scientific value of the *Carte du Ciel* has been re-considered and the original plates have gained new significance. The long time baseline involved, one hundred years since the initial photographs were taken, the amount of data they contain and the accuracy of the data make the CdC plates a valuable source of data. Comparison with contemporary catalogues allows the calculation of proper motions (accurate to a few mas/year), detection of binary stars, calculation of the periods of variables stars, detection and tracking of asteroids and observation of nebulae (Urbain & Corbin, 1998). The Australian plates are an important source of data on the southern skies.

New techniques of measurement are being applied to the old plates and new uses for the data are being explored (Ortiz-Gil et al.1998; Geffert et al.1998). In 1997, the US Naval Observatory completed a re-reduction of the original CdC plates and three new catalogues have been produced based on original CdC data (Urban et al. 1998).

The *Carte du Ciel* project is currently overseen by the International Astronomical Union. (*The Working group dealing with the one-century old plates of the astrographic program, Commission 8).* A number of papers have been published reporting the results of several new examinations and applications of the CdC plates, many of which can be accessed through the IAU Working Group web site.

Summary

Historically, the CdC was significant as it was the first attempt to photograph the sky and the first major international collaborative science project. To date it is the most comprehensive photographic survey of the sky.

In Australia, the participation of three observatories in the project symbolised the advent of "big astronomy" and "big science" in general. It initiated the separation of professional and amateur astronomy, inspired the public imagination and helped to enhance the international reputation of Australian astronomy.

The CdC was criticised for tying up resources, diverting them from other scientific work and hindering the development of other fields in astronomy, such as astrophysics. Recently, the scientific value of the project has been reconsidered and the CdC plates have become valuable for observations which require long time baselines such as calculation of proper motions of stars, determination of the periods of variable stars and detection of new bodies such as asteroids and comets.

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