Publ. Astron. Soc. Aust., 1998, 15, 24–7

The MSSSO Wide Field CCD Hα Imaging Survey

Michelle Buxton[1], Michael Bessell[1] and Bob Watson[2]

[1]Mount Stromlo & Siding Spring Observatories, Private Bag, Weston Creek, ACT 2611, Australia
buxton@mso.anu.edu.au
[2]University of Tasmania, Churchill Ave, Sandy Bay, Tas. 7005, Australia

Received 1997 August 1, accepted 1998 January 15

Abstract: A wide-field Hα survey of the Galactic Plane has been initiated by Mount Stromlo & Siding Spring Observatories in collaboration with the University of Sydney. The primary aim of the survey is to obtain images of the Galactic Plane in Hα and red continuum filters which will be compared with radio continuum images at 843 MHz from the Molonglo Observatory Synthesis Telescope (MOST). The secondary aim is to obtain images in [OIII] and [SII] to provide additional information on the nature of excitation in HII regions. Thirdly, additional images will be taken in B, V and I of interesting areas suitable for general publications as coloured reproductions. The images are taken with a 400 mm f/4·5 Nikkor-Q lens in conjunction with a 2K×2K SITe thinned CCD. The resolution is 12$''$ per pixel and the pixel size is 24 μm giving a 7°×7° field of view. Hα and red continuum observations are expected to be completed by the end of 1997. It is planned to make the results from the survey available on CD ROM and possibly video.

Keywords: instrumentation: detectors — methods: observational — HII regions — ISM: general — surveys

1 Introduction

Hα emission is an important tracer of ionised circumstellar or interstellar material. Hα surveys have traditionally been used to find Be stars, T Tauri stars, Mira variables, interacting binaries and planetary nebulae. Emission in Hα is also used as a tracer of star formation in external galaxies and for studies of the conditions and dynamics of the ionised interstellar medium.

Previous Hα surveys of the Galaxy have been performed with photographic plates or film. This provided reasonably large fields with good pixel resolution. However, this medium suffers from being non-linear with a limited dynamic range, low quantum efficiency (1–5%) and the existence of reciprocity failure. On the other hand, CCDs are linear, have a large dynamic range and high quantum efficiency (60–80%). They are normally much smaller in size than plates of film and have a lower pixel resolution. Larger CCDs are now available (with corresponding small pixel sizes), and by using new techniques of drift scanning (Zaritsky, Shectman & Bredthauer 1996) they are increasingly being used for large-scale surveys.

The Wide Field Hα Survey will be important in two ways. First, comparison with the Molonglo Observatory Synthesis Telescope (MOST) radio continuum images at 843 MHz will help us to understand the nature of both radio and optical sources in and beyond the Galactic Plane. Secondly, calibration of the optical images shall enable us to produce quantitative information which has not been previously obtainable on this scale.

This paper will describe the aims of the project, the instrumentation used and our plan of observations. We shall also describe the reduction of data and how our optical images will be compared to the MOST radio data.

2 Aims of the Survey

There are three main goals of the Wide Field Hα Survey. The primary aim is to obtain Hα and continuum images of the Galactic Plane which will be used in the comparison with the MOST radio images. Our secondary aim is to make corresponding observations in [SII] and [OIII] which will be used in determining the nature of the continuum sources. Thirdly, colour images of some of the well known areas will be obtained for general publication in the form of posters and postcards. These areas include Orion, the Magellanic Clouds, the dark cloud regions of Corona Austrini, Rho Oph and Chameleon as well as the Pleiades, Hyades, Virgo and Coma clusters. The final images will be accessible on CD ROM and possibly interactive video. However, the timing of publication will be subject to whether students are using the survey data in their research.

 1323-3580/98/010024$05.00

https://doi.org/10.1071/AS98024 Published online by Cambridge University Press

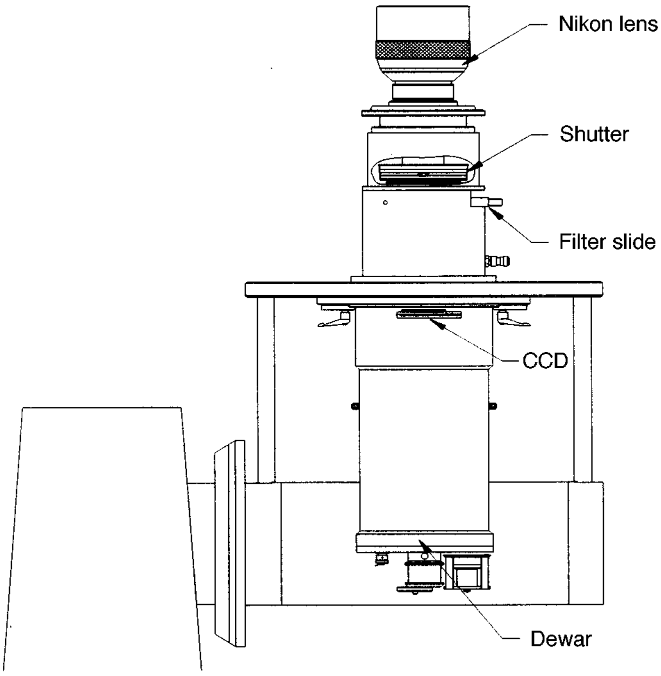

Figure 1—Wide-field camera and CCD as set up at the 16 inch telescope, at Siding Spring Observatory.

3 Instrumentation

The survey is being conducted in the 16 inch telescope dome at the Siding Spring Observatory. The 16 inch telescope tube has been replaced with the camera and CCD as shown in Figure 1. The Nikkor-Q lens has a focal length of 400 mm f/4·5 and a diameter of 122 mm. Each filter is secured in a PVC holder which slides into the casing beneath the lens. The focus changes for the different filters and adjustment for this is made by rotating a knurled ring on which the lens is mounted.

A suite of 75–90 mm diameter interference filters and 75 mm coloured glass filters was available from the ANU 2·3 m telescope. Initial observations were made with a 15 Å wide Hα filter but this was changed to a 55 Å filter (centred on 6563 Å) to ensure uniform transmission of the Hα line across the 7° field. It will also be a better match to the UK Schmidt Hα survey (Parker & Phillipps 1998, present issue p. 28).

We have calculated a maximum blue-shift in the Hα 55 Å filter of 13 Å (Ealing Optics Catalog 1981). This corresponds to incident light being at the maximum off-axis angle of 7·5°.

To record the data we use a SITe (Scientific Imaging Technologies) thinned CCD which has 2048×2048 pixels, with a pixel size of 24 μm. The resolution is 12″ per pixel, producing a field of view of 7°×7°.

4 Observing Plan

Images of the southern Galactic Plane will be taken on 5° field centres. This was the original plan of the UK Schmidt photographic Hα survey and our field centres were chosen to correspond to this survey for comparison purposes. However, the UK Schmidt photographic Hα survey is now using 4° field centres but ours will not change. Those fields further north (up to δ =+30°) are based on the field centres of the emission-line survey of the Milky Way by Parker, Gull & Kirschner (1979). Their survey used a photographic image tube with a resolution of ∼40″ and field size 7·1° in diameter.

There are 148 fields in the southern section, 30 in the northern, 19 Magellanic Cloud and intercloud fields, 35 Orion fields and approximately 10 other fields of interest. This represents an area of ∼6000 square degrees (cf. the UK Schmidt Hα survey of 4000 square degrees, Parker & Phillipps 1998).

Images in Hα, red continuum (6676/40 Å), [SII] (6732/25 Å) and [OIII] (5016/25 Å) will have in total 30 minute exposures, and B (4380 Å) and V (5450 Å) images 15 minute exposures in total. In order to remove the effects of cosmic rays and imperfections in the CCD using median filtering, it is necessary to subdivide the total exposure times, taking three 10 minute exposures per field centre for the interference filters and three 5 minute exposures for the coloured glass filters. Small shifts (∼2′ in declination) in the position of the field centre are made for each set of shorter exposures.

The observations for the survey began near the end of March 1997. At the time of writing, approximately 50% of the southern Galactic fields were obtained in Hα, around 25% in continuum and 25% in [SII]. We estimate that Hα and red continuum images will be completed near the end of 1997.

5 Data Reduction

The images of stars are distorted at the edge of our fields due to the camera optics and filters. As the fields overlap by ∼2°, the worst sections will be removed when combining images of adjacent fields. As our field of view is so large (7° × 7°), the sky gradient becomes significant, particularly in sky flat fields. We have based our techniques of obtaining sky flats on the Chromey & Hasselbacher method (1996). The telescope is moved slightly over from zenith in the opposite direction to the sun. Dome flats have also been obtained with good results and we prefer to use these flats in the reduction of our images. A screen has been set up within the telescope dome and is illuminated by light scattered from two flood lights shining on the opposite side of the dome. The screen is positioned so the telescope is facing almost perpendicular to it.

Reduction of the survey data and median filtering of images will be done within the software package IRAF. IRAF scripts have been produced by Watson

https://doi.org/10.1071/AS98024 Published online by Cambridge University Press

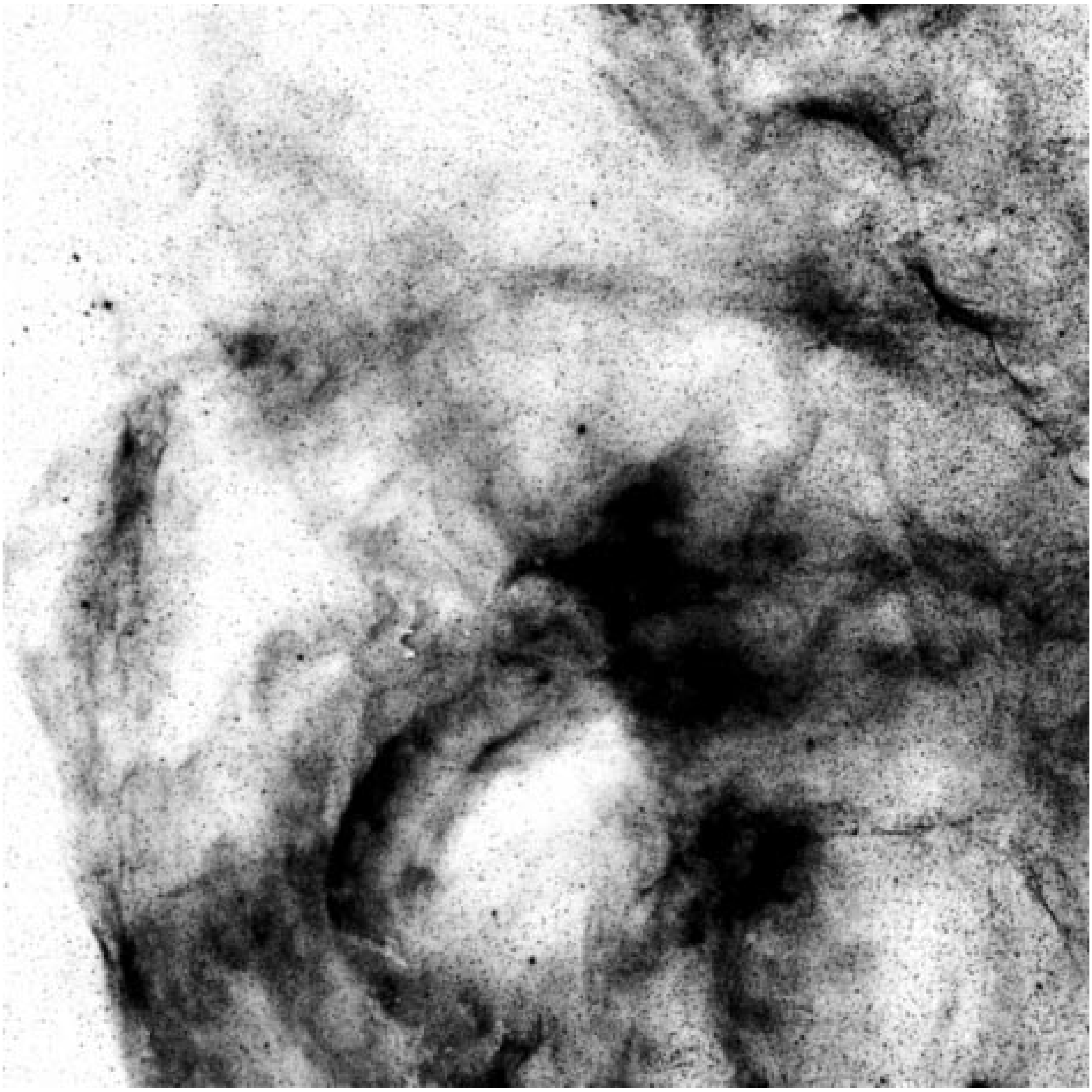

Figure 2—Field 210 taken with Hα(6563/55 Å), 1800 s exposure, where the field size is $7^\circ \times 7^\circ$ centred on RA 08 30, Dec −50 00.

and Buxton for the survey. It is planned to make this procedure as automated as possible.

Figure 2 shows an example of a reduced and combined image in Hα. Images of different filters will be combined to produce colour pictures using Adobe Photoshop.

The emission line standards of Dopita & Hua (1997) will be used for standardisation to absolute fluxes. Preliminary analysis shows a limiting magnitude in Hα of $\approx$3R, however, we are confident of obtaining lower values. The B, V and I images will be calibrated using Landolt (1992) standards. There are up to 30 Landolt standards in the equatorial selected areas in our field of view. The photometric precision from one exposure with its undersampled images (FWHM $\approx$ 1 pixel) using aperture photometry and a radius of 2 pixels is $\pm 0 \cdot 04$ mag for each star.

6 Comparison with MOST Galactic Plane Images

Continuum emission at 843 MHz is dominated by nonthermal processes. Hα is a tracer of thermal emission. A comparison of the two surveys will give insights into the distribution of the different mechanisms. The MOST Galactic Plane survey has a resolution of $43'' \times 43''$cosecδ (Green 1996), while the Hα images have a resolution of $12''$ per pixel.

Because the radio emission is not affected by dust extinction, the MOST images contain many extragalactic objects, in particular, background galaxies which are seen as unresolved sources. These

https://doi.org/10.1071/AS98024 Published online by Cambridge University Press

radio galaxies will not be seen in Hα. However, gas-rich spiral galaxies with significant star formation could well appear as (mostly unresolved) Hα sources. The vast majority of the Hα emission will be from our Galaxy, in the form of extended filaments and clouds. Supernova remnants also characteristically have filamentary structure, in this case produced by the nonthermal synchrotron process. This emission is produced from the interaction of the expanding shock front from the supernova explosion with interstellar and circumstellar material. Studies of nearby supernova remnants such as Vela (e.g. Bock 1997) and the Cygnus Loop (e.g. Straka et al 1986) show large variations in the correspondence between the Hα and radio filaments. The results from the present survey will be used to further investigate this question. Some discussion of the expected correlations are given by Cram et al. (1998, present issue p. 64). The presence of shocked lines of [SII] and [OIII] may help to discriminate between the different excitation mechanisms.

7 Conclusion

The Wide Field Hα Survey in conjunction with the MOST radio survey will provide valuable information to the astronomical community on the nature of excitation in many of the continuum sources in the Galaxy. The survey itself will also produce quantitative information not previously seen on this scale.

It is envisaged that much of the survey will be completed by the end of 1997, the results of which will be published on CD ROM and possibly video. Time and mode of publication may be dependent on postgraduate student thesis requirements. Follow-up observations at higher resolution are envisaged at optical, infrared and radio wavelengths.

The survey will be an important scientific resource and of significant value in the promotion of astronomy in the wider community.

Acknowledgments

We thank John Shobbrook and the amateur astronomy group for their help in observations as well as Bryan Gaensler (University of Sydney) and Andrew Walker (University of Wollongong). Thanks also goes to Anne Green for her advice in writing this paper. The MOST is operated with the support of the Australian Research Council and the Science Foundation for Physics.

Bock, D. C. 1997, PhD thesis, University of Sydney
Chromey, F. R., & Hasselbacher, D. A. 1996, PASP, 108, 944–9
Cram, L. E., Green, A. J., & Bock, D. C. 1998, PASA, 15, 64–9
Dopita, M. A., & Hua, C. T. 1997, ApJ, 105, 515–27
Ealing Optics Catalog 1981, 39
Green, A. J. 1996, PASA, 14, 73–6
Landolt, A. U. 1992, AJ, 104, 340–491
Parker, Q. A., & Phillipps, S. 1998, PASA, 15, 28
Parker, R. A. R., Gull, T. R., & Kirschner, R. P. 1979, An Emission-line Survey of the Milky Way, NASA
Straka, W. C., Dickel, J. R., Blair, W. P., & Fesen, R. A. 1986, ApJ, 306, 266–70
Zaritsky, D., Shectman, S. A., & Bredthauer, G. 1996, PASP, 108, 104–9

https://doi.org/10.1071/AS98024 Published online by Cambridge University Press