Publ. Astron. Soc. Aust., 1998, 15, 79–82

Searching for Supernova Remnants

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Received 1997 August 1, accepted 1997 November 4

Abstract: The UKST/AAO Galactic Plane Hα Survey has the potential to discover many new objects not visible on red plates taken in past surveys. Recent radio surveys have identified large numbers of new supernova remnants, very few of which have been optically identified. Here we will discuss our plans to use this survey to search for optical emission from both new and known supernova remnants. Observations of these objects in the optical and radio wavelengths will reveal important information about the physical and chemical properties of supernova remnants, and their role in the evolution of the galaxy. We also present a composite image of a newly discovered Hα shell around the Coalsack, named the Coalsack Loop. This object has been detected in radio emission and may represent the remains of an old supernova remnant.

Keywords: surveys — ISM: bubbles — ISM: general — supernova remnants

1 Introduction

The AAO/UKST Galactic Plane Hα Survey presents a new era in the study of Galactic supernova remnants and their optical radiation. While generally brightest in their radio emission, many can additionally be seen optically. In most cases this radiation is dominated by the Hα emission line.

We plan to use the Hα survey to examine all known supernova remnants close to the southern Galactic plane. The primary goal will be to increase the number that have been optically detected. In addition, we will be looking for features of objects not detected by previous work, and other objects that may be new supernova remnants.

Optical searches have been carried out before, most notably the early work of van den Bergh et al. (1973 and references therein). Several more optical detections were made later by use of the ESO/SERC Sky Surveys (e.g. Zealey, Elliot & Malin 1979), and through CCD observations of specific objects. A new search based on the Hα survey will greatly improve on this work. The narrow bandwidth of the Hα filter will reduce the level of continuum emission below that of IIIaJ red plates. This allows us to peer deeper through the absorbing material blocking our view of the galaxy, increasing the number of objects likely to be detected.

2 The Survey

The first stage of this search will be to obtain plates containing all known supernova remnants in the area of the survey. In Table 1, we show some statistics of the 215 known Galactic supernova remnants as of August 1996 (Green 1996). This shows that of the greater number visible in the southern sky, a smaller proportion have been optically detected than in the northern sky. The presence of the Galactic centre below the equator has resulted in more objects being detected through radio surveys at larger distances across the galaxy. This, combined with the increased amount of obscuring material present, has resulted in fewer southern remnants being seen optically.

Digitised images of these objects' fields will be obtained, and enhanced with image processing software to bring out the faintest possible detail. Where Hα emission is observed, comparisons will be made with survey images available in other bands, and previously published observations.

Due to supernova remnants being concentrated along the Galactic plane and towards the Galactic centre, plates from only a small fraction of the survey will be required to complete this work. A time requirement of a year seems likely. A longer term project for the duration of the survey and beyond, will be to examine in detail all of the survey plates, searching for the faint filamentary and shell structures typical of supernova remnants.

What can we expect to find? Primarily the objects found will include HII regions, planetary nebulae and Wolf-Rayet shells, all of which can be similar in appearance. It is likely, however, that a significant number of supernova remnants will be discovered. High resolution radio surveys have detected many new remnants close to the Galactic plane (e.g. Whiteoak & Green 1996). These may

 1323-3580/98/010079$05.00

https://doi.org/10.1071/AS98079 Published online by Cambridge University Press

miss some objects due to faintness, confusion, or a lack of clear structure. Further from the plane the density of supernova remnants decreases, but less obscuration increases their chance of being optically detected.

Table 1. Supernova remnant statistics compiled from Green (1996)

Hemisphere	Total	Optically detected
Northern	66	27
Southern	149	19

3 Further Work

Some of the most interesting discoveries made will be from work further to and in parallel with the Hα survey. In relation to supernova remnants this will involve spectroscopy, radio observations and optical imaging.

One goal of this project is to discover new supernova remnants, and so we need methods to confirm that objects belong to this class. The spectra of supernova remnants are dominated by emission lines. Hydrogen lines are nearly always seen, along with forbidden lines produced by a wide variety of other elements (Fesen & Hurford 1996). One such pair often observed are the 6717 Å, 6731 Å [SII] lines. If these are observed to be strong in comparison with the Hα line, the object is likely to be a supernova remnant. This method works best with evolved SNR, which are probably the most common. Lower values of the Hα/[SII] ratio can be produced by SNR, HII regions and planetary nebula; with Balmer-dominated and oxygen-rich SNR the [SII] lines are very weak or absent (Fesen, Blair & Kirshner 1985; Weiler & Sramek 1988). Therefore spectral data will often need to be used with other information to establish an object's identity.

For example, by comparing radio maps with IRAS Sky Survey Atlas images (Beichman et al. 1985), or using multi-frequency radio observations, it is possible to determine the thermal or non-thermal nature of objects. The Molongolo Observatory Synthesis Telescope (MOST) has been very successful using IRAS data to identify supernova remnants. Its new wide-field survey runs over the same timespan as the Hα survey, allowing discoveries made in one to be followed up using the other.

In the near future we will be concentrating on completing a comprehensive examination of Hα films produced by the survey. This will be in conjunction with spectroscopy and radio observations to confirm the identification of new supernova remnants. Eventually we will be in a position to produce a catalogue of Galactic optical supernova remnants and candidate objects, bringing together information which is already available from a wide range of sources. This will help in deciding possible directions for future research.

Optical identifications of supernova remnants allow us to study their properties in much greater detail than otherwise possible. Here we list some of the main areas in which the efforts of researchers may be directed.

Optical emission lines have been used in a variety of ways to study the physical and chemical properties of supernova remnants. Simple line-ratio diagnostics can be used to estimate properties such as temperature, pressure, electron density and shock velocity. Velocity measurements may also allow the determination of age and distance. Computer modelling has also been used to study the chemical makeup of observed regions.

There is also a lot of future work in investigating the morphology of new supernova remnants, which have been observed to come in a wide variety of types. Higher resolution work will allow the association between optical and radio features to be studied, as well as possible new pulsar/remnant associations to be discovered. CO and other molecular lines may also be used to find new cases of supernova remnant triggered star formation.

CCD imaging will have less detail but will detect features fainter than visible in the Hα survey. Imaging in other lines, such as [SII] and various oxygen lines, will show the different conditions present across a remnant, and the differences in structure between remnants.

4 The Coalsack Loop

The most exciting feature of the new Hα survey is its potential to discover unique and unusual objects. In this section we present a newly discovered object which may be one of several new large scale objects detected by this survey.

The Coalsack Loop (Figure 1) is a large ring of Hα emitting nebulosity surrounding the Coalsack Nebula, about 10° in diameter. It was first noticed on ESO/SERC Sky Survey plates, though it is only partly visible and very faint. During February 1997, this region was imaged using the 16-inch telescope at Siding Spring Observatory. The telescope has been greatly modified for the Mount Stromlo CCD survey described by Buxton, Bessell & Watson (1998, present issue p. 24). Images covering 7° of sky are obtained using a 400 mm f/4·5 lens in front of a 2k×2k CCD, which have replaced the original mirror and tubing.

The image contained here is a composite of four fields, each being a 15 minute exposure through a 15 Å Hα filter and using standard ESO/SERC Sky Survey field centres. Each image has been flat field corrected, and had bias and dark frames subtracted using standard IRAF procedures. On these images the loop is visible over about three-quarters of a circle. [SII] images have shown this emission to be weak.

https://doi.org/10.1071/AS98079 Published online by Cambridge University Press

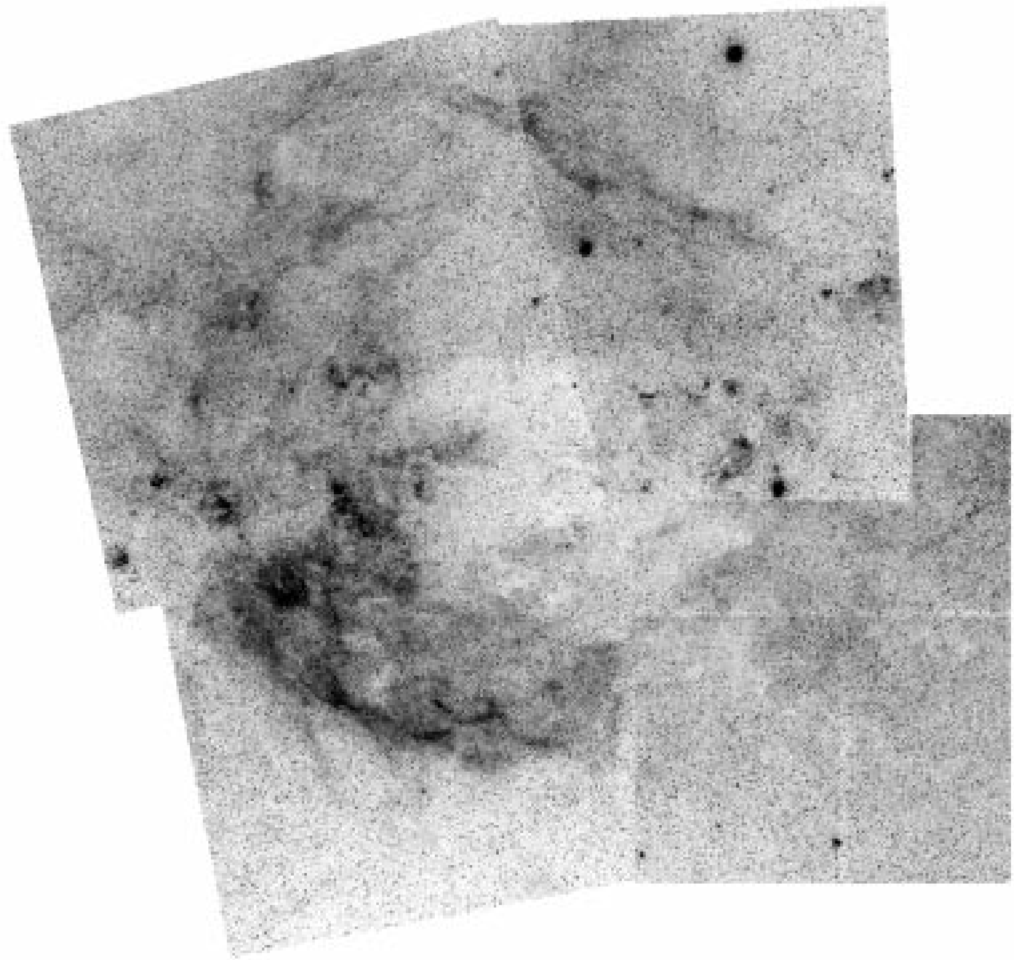

Figure 1—The Coalsack Loop. Composite of four Hα images centred on the ESO/SERC Sky Survey fields 95, 96, 131 and 132. Note the presence of the Southern Cross in the upper-right (north-west) portion of the image.

This object is most likely the expanding remains of an old supernova remnant or HII region, and its location suggests that it may be interacting with the Coalsack. Further observations will be necessary to examine these possibilities, most importantly determining the object's distance. The Coalsack is composed of two clouds located at distances of 188 pc and 243 pc (Seidensticker & Schmidt-Kaler 1989). Adopting an angular size of 10° gives a diameter of 33 pc or 43 pc respectively if the Coalsack Loop is interacting with either cloud.

The Coalsack Loop has been identified as G303·5+0 in the radio continuum survey of Duncan et al. (1995). Here a near complete shell structure is visible. It is also clearly visible in images from the PMN 4850 MHz survey (Griffith & Wright 1993). These surveys show the presence of several large shell structures along the Galactic plane. The MOST survey will allow detailed examination of these objects' structure, as well as establishing if they are non-thermal. This Hα survey will reveal deeper and finer detail in the Coalsack Loop, as well as possibly detecting emission from the other observed radio structures.

5 Conclusion

The AAO/UKST Galactic Plane Hα Survey promises to substantially increase our knowledge of optical supernova remnants and their properties. Complementary work in the optical and radio will allow us to fully exploit any discoveries made.

Acknowledgments

We would like to thank Mike Bessell for providing access to his wide-field imaging equipment which made the images presented here possible, as well as to Quentin Parker for being the driving force behind the survey and organising a wonderful conference.

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