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# ABU/SPIREX: The South Pole Thermal IR Experiment

*A. M. Fowler, N. Sharp, W. Ball*
National Optical Astronomy Observatories*
Tucson, AZ

*A. Schinckel, M. Ashley, M. Boccas, J. Storey*
University of New South Wales
Dept. of Astrophysics & Optics, Sydney, Australia

*D. Depoy and P. Martini*
Ohio State University, Dept. of Astronomy, Columbus, OH

*A. Harper and R. Marks*
Center for Astrophysical Research in Antarctica
Yerkes Observatory, U. Chicago, Williams Bay, WI

## 1. INTRODUCTION

ABU is a NOAO IR imaging camera designed for evaluating the performance of the 1024x1024 Aladdin InSb array. For this experiment, it was outfitted with five filters (see Figure 9) in the 3-5 micron range to exploit the low water vapor and lower air temperatures at the South Pole. At the South Pole it was integrated with the CARA SPIREX (South Pole Infrared Explorer) telescope. Figure 1 is a picture of the telescope showing the environmental box (the white box by the author), which protected ABU and its electronics from ambient environmental conditions.

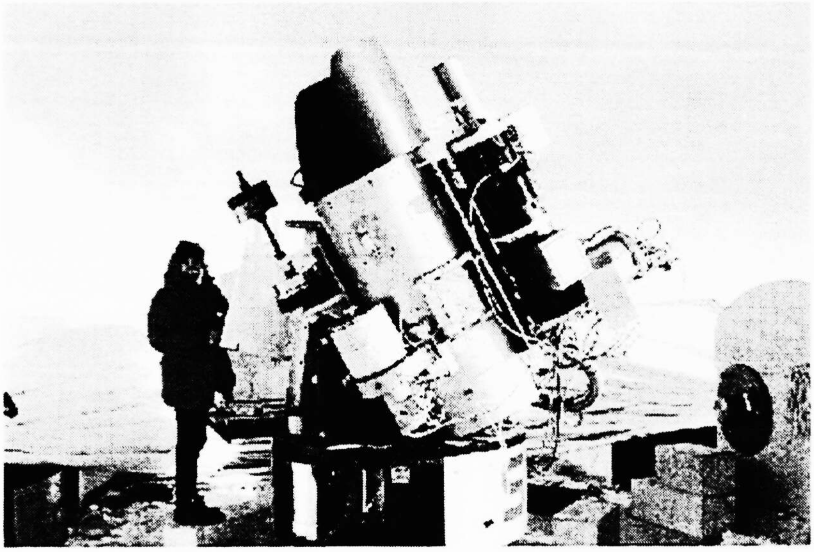
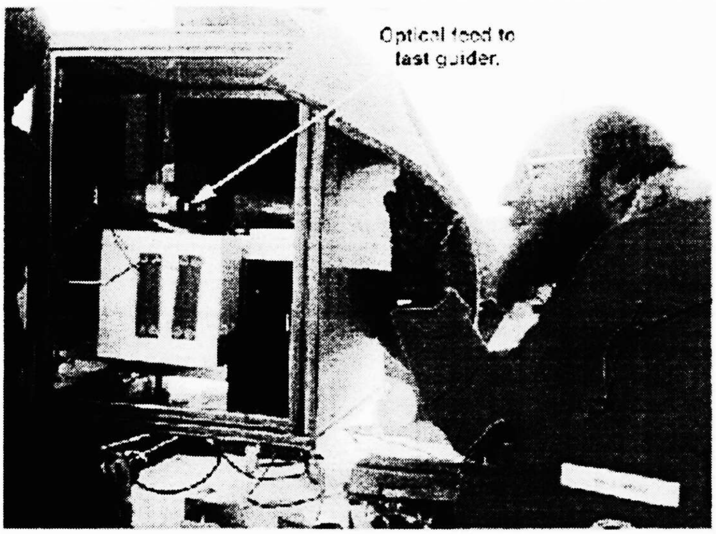


Figure 1

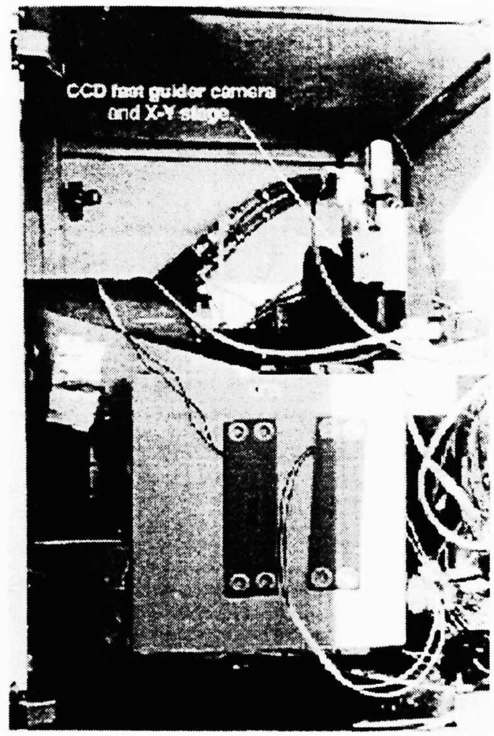
*Operated by the Association of Universities for Research in Astronomy, Inc. (AURA) under Cooperative Agreement with the National Science Foundation.

SPIREX is a 0.6-meter telescope that has been in operation at the pole for several years. To compensate for telescope tower shake and seeing disturbances, the UNSW group built a CCD-based tip tilt/fast guider system. The optical feed is shown in Figure 2 while the CCD camera and X-Y stage are seen in Figure3.




ABU in its environmental enclosure on SPIREX.

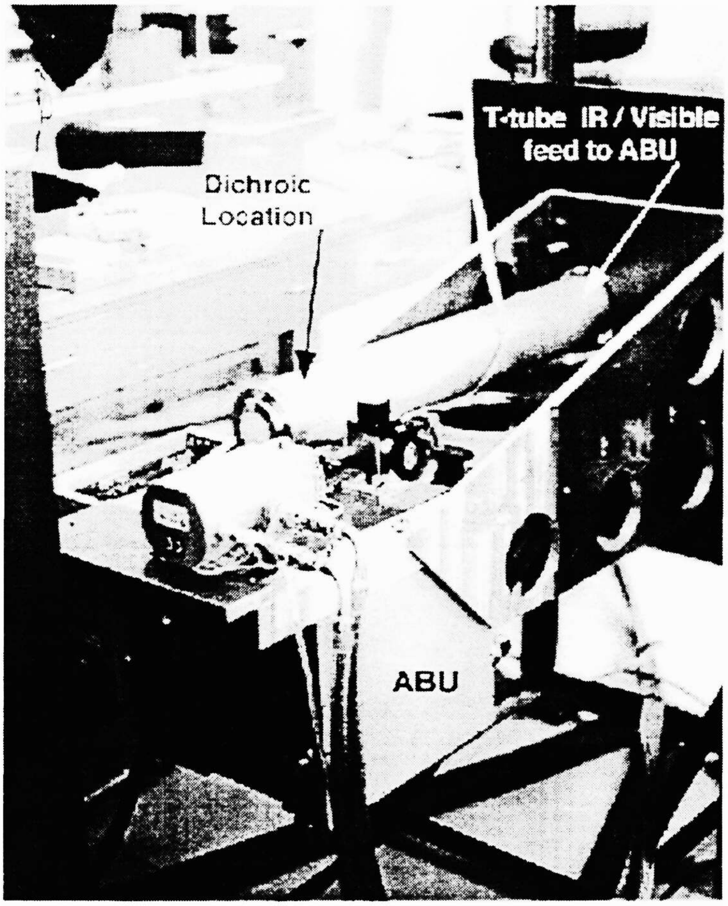
Figure 2




ABU showing CCD fast guider camera system.

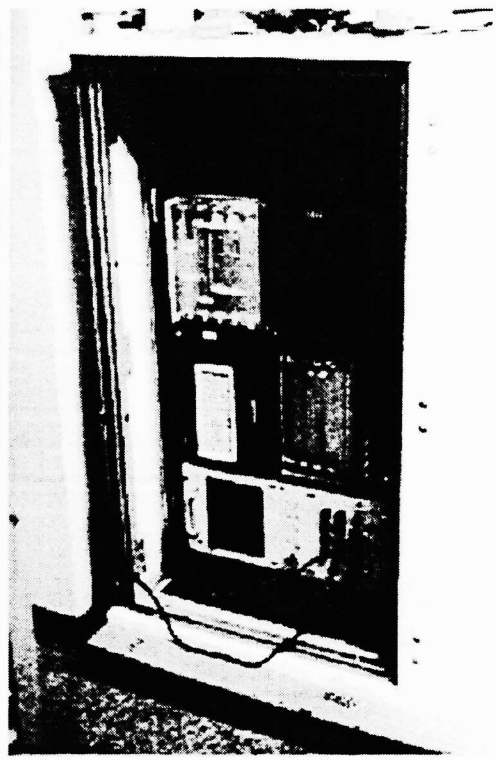
Figure 3

The system consists of a cold dichroic (see Figure 4) in ABU to separate the visible and IR beams, a CCD camera, and a piezoelectric driven secondary in SPIREX. Because ABU was not designed for the harsh environments at the South Pole, it is housed in a thermal enclosure built by the UNSW group (see Figure 1 and Figure 5).




ABU in lab: Mounted to its SPIREX fixture.

Figure 4



ABU electronics shown in the environmental enclosure.

Figure 5

ABU was modified for operation at the South Pole so that it would run entirely on a Closed Cycle Cooler to save the winter-over person from having to open the system to add liquid cryogens. The electronics are the NOAO WildFire system that is used at Kitt Peak and CTIO enhanced to allow continuous in situ image summation (co-adding) on the full 1024x1024 image. ABU is now in operation with all systems checked out. It is being operated at the South Pole by our winter-over person, Rodney Marks, from UNSW.

## 2. ALADDIN 1024x1024 InSb FOCAL PLANE

The heart of the ABU/SPIREX experiment is the Aladdin InSb array. It is one of a group of arrays developed by NOAO and the U.S. Naval Observatory at Santa Barbara Research Center, Hughes Raytheon (SBRC) for ground-based astronomy. A photograph of the array is shown in Figure 6 to give a sense of the size of the device.

In addition it has become the array of choice for most of the 8-meter class of telescopes. The characteristics of this array are given in Table 1. The important features for this experiment are its 1024x1024 format, which gives us an instantaneous FOV of 10 arcminutes, and its response out to the M band (5μ).

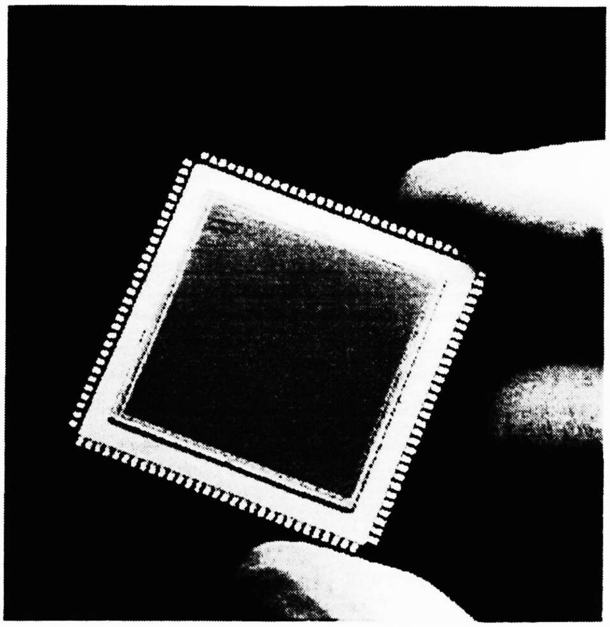


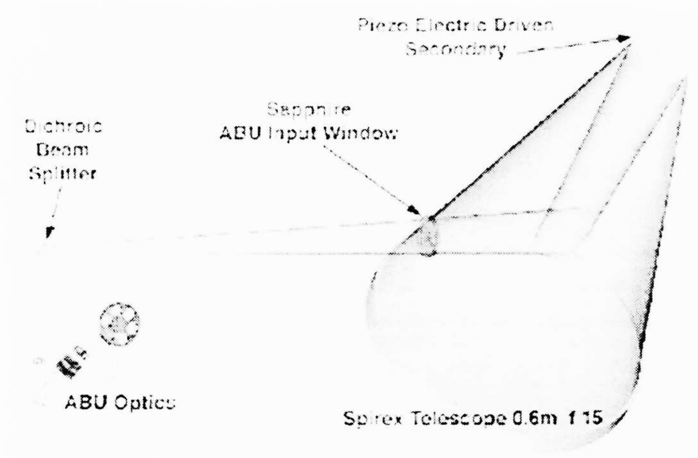
Figure 6
Aladdin InSb Array

**Table 1**
**SCA Specifications**

| | |
|---|---|
| Number of Pixels | 1024 (H) x 1024 (V)<br>1,048,576 elements |
| Architecture | 4-Independent 512x512 Quadrants |
| Pixel Size | 27 μm square |
| Effective Fill Factor | 100% |
| Readout Type | CMOS Shift-registers Control Logic<br>PMOS SFD Unit Cell |
| Number of Outputs | 32 (8 per quadrant) |
| Frame Rate | 50 milliseconds |
| Reset Options | Global or by Row Pairs |
| IR Detector | Thinned InSb |
| Full Well | $300 \times 10^3$ electrons at 1.0v bias |
| Uniformity | < 10% (Sigma/Mean) |
| Wavelength Range | 0.9 - 5 microns<br>Extensible to the UV with special AR coatings |
| Quantum Efficiency | 85% Average 0.9 - 5 Microns |
| Operating Temp | 35K |
| Dark Current | < 0.1 e/sec |
| Noise | ~ 25e rms with Fowler Sampling |
| Defective Pixels | < 0.5% |

## 3. ABU/SPIREX OPTICS

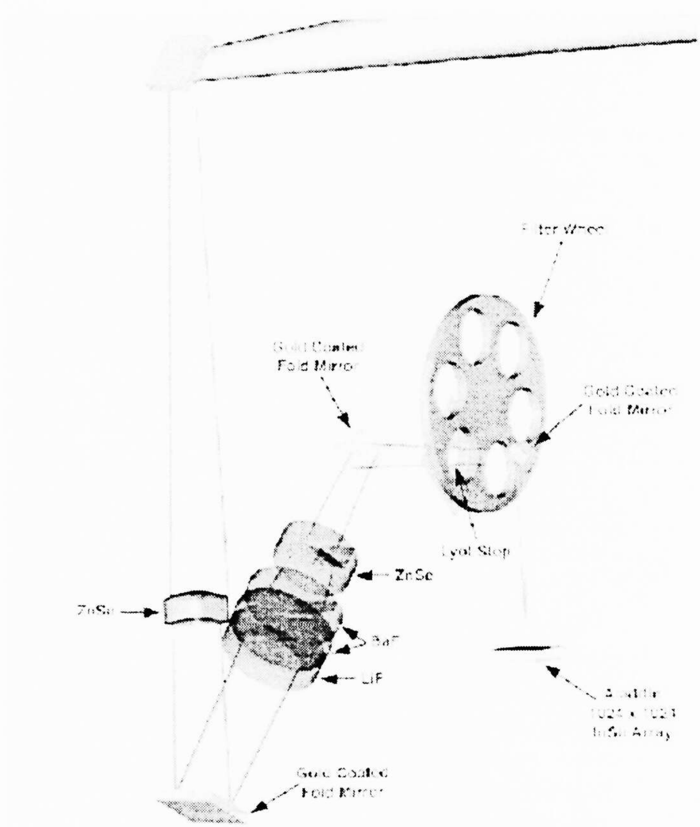
The 3D optical layouts, shown in Figures 6 and 7, show the overall system layout and an expanded layout of the ABU optics.




← Figure 7

ABU / Spirex Optical Layout

Figure 8 →




ABU Optics Layout

SPIREX was configured for f/15 in this experiment. ABU is configured as a 1:1 system with the f/15 input beam. This was not ideal as it over-sampled the diffraction and seeing. We are looking into making changes that would improve that situation.

Figure 9 shows the bandwidth and transmission of the science filters installed in ABU. The system throughput ranged from ~40% at 3.3 microns to 25% at 5 microns.

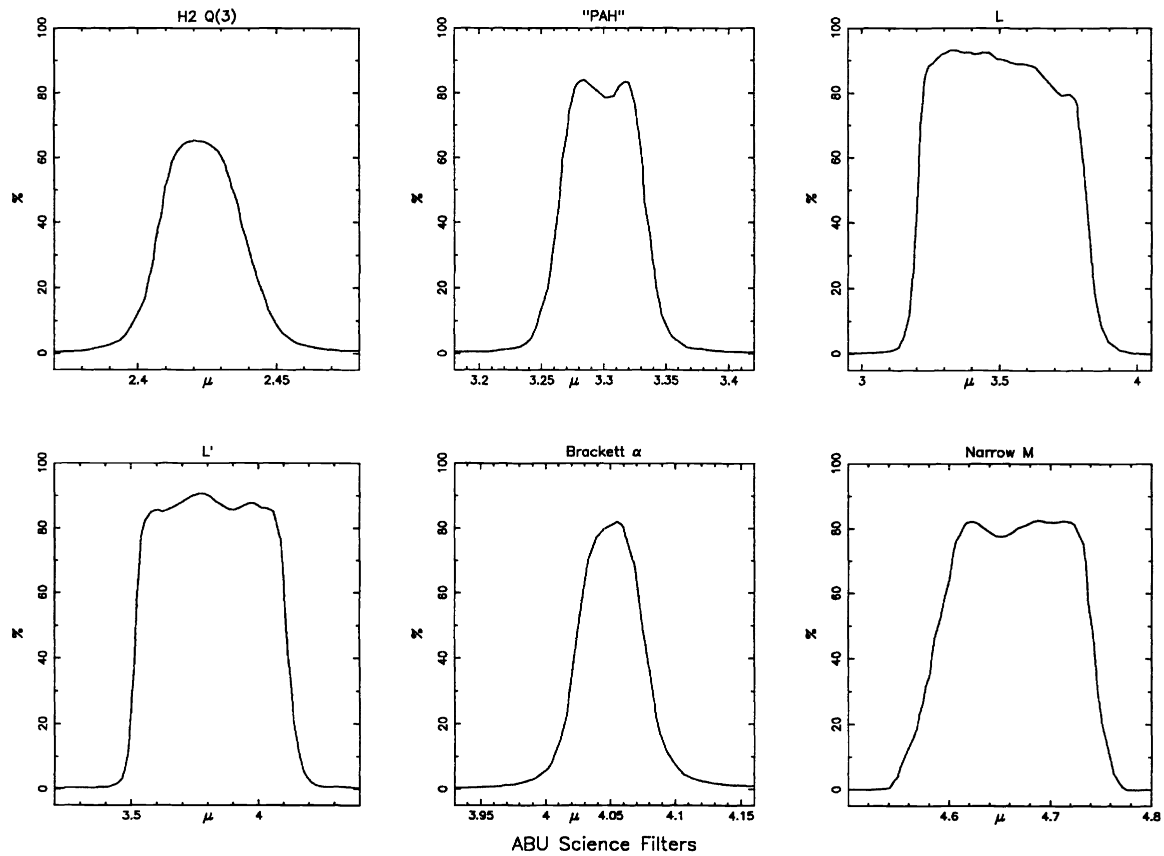



Figure 9
Science IR Filters in ABU

The addition of the fast guider improves the image FWHM from 2.6 arcseconds to 1.8 arcseconds, as shown in Figure 10. This performance is very near the diffraction limit of the system. This definitely demonstrated the usefulness of a relatively slow frequency (10 Hz) tip tilt correction system.

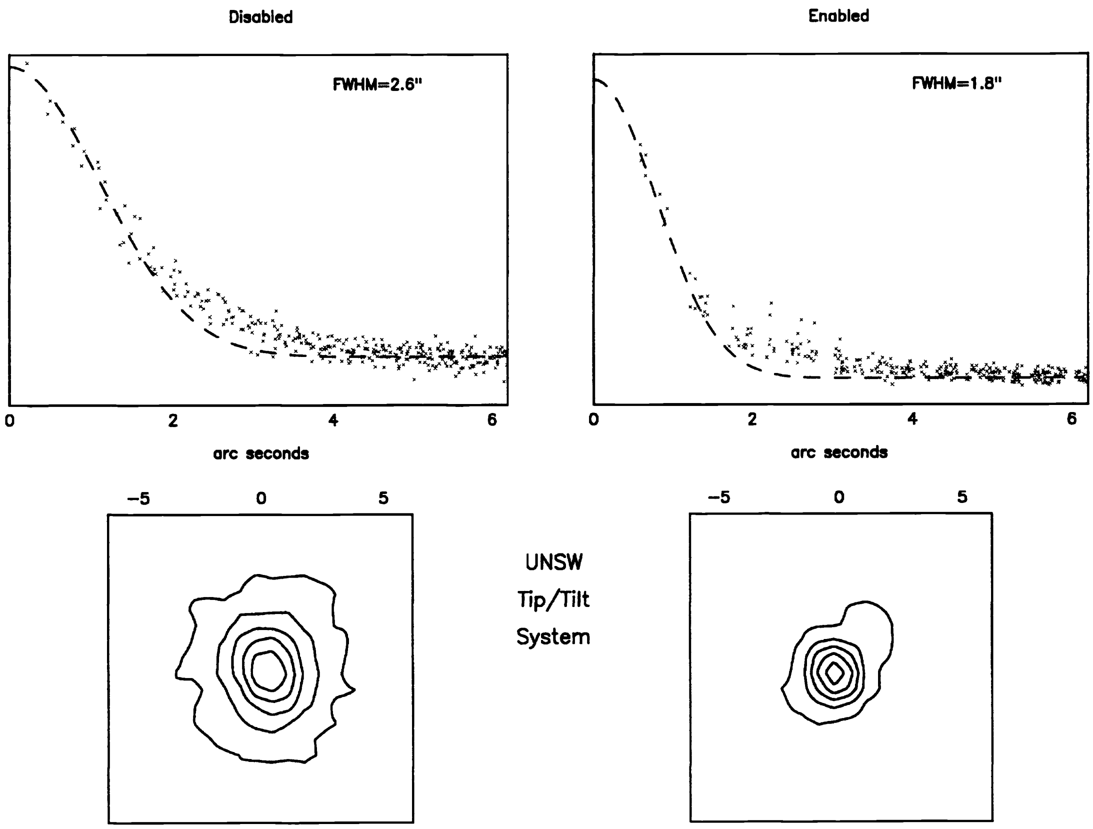



Figure 10
Imaging Results With and Without Tip/Tilt Correction

## 4. SCIENCE

So far, data has been sparse, with the first light picture of the moon (Figure 11); focus and point spread function data with and without the tip-tilt system (Figure 10); 30 Doradus at L (Figure 12); and 3.3 micron data on NGC 6334, which has not yet been reduced. The weather at the pole has seriously delayed our observing plans, since El Nino has been as hard on us as on the rest of the world. In January and February we had ~50 days of partial/full cloudy days. For good data it must be photometric or the background variability generates too much noise to get accurate results. In addition, getting data from the pole to the states via the TDRS satellite link has had its start-up problems. We expect these problems to be worked out before long and the real work can begin when the sun sets the $22^{nd}$ of March.

Figure 11
The Moon at 3.3u

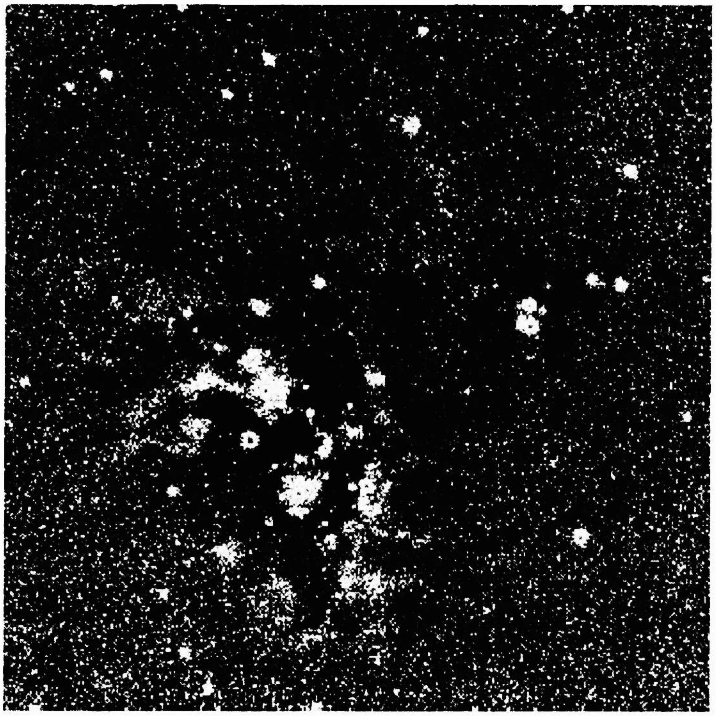


Figure 12
30 Doradus at L

## 5. ACKNOWLEDGEMENTS

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