# A SIT Vidicon for Surface Photometry

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## Introduction

The study of surface brightness distributions of extended cosmic light sources is an essential observational approach to understand their spatial structure. In general, however, surface photometry is difficult to interpret without other supporting observations like spectroscopy, which yields the velocity field or other physical parameters. The reason is that the surface illumination is the total number of light sources within a conical column along the line of sight. This cone is the solid angle of an individual picture element ("pixel") projected onto the sky by the telescope optics. Therefore, astronomical surface photometry yields the surface density of cosmical light sources, which is badly contaminated by light sources in the fore- or background or even in the surrounding field.

Under certain assumptions (spheroidal system, no internal absorption), which seem to be fulfilled in globular clusters, the spatial star and luminosity distribution can be derived using star counts, which give the surface star density, and surface photometry, respectively. Thus the relative mass-luminosity ratio and its variation within these systems can be unambiguously studied.

For some years we have used star counts to investigate the age dependency of physical and structural parameters of open and globular clusters in the Large Magellanic Cloud (LMC). These counts have been made using photographic plates taken with the ESO Schmidt and 3.6 m telescopes. However, this plate collection is not suitable for surface photometry due to different problems inherent to the photographic material. Therefore, we designed at our observatory an efficient area photometer which is based on a digital detector system with a SIT vidicon.

## Methods of Surface Photometry and its Difficulties

Until the advent of modern two-dimensional digital detectors like vidicons or charge-coupled devices (CCDs), astronomers had to rely on the photographic plate and the photomultiplier for surface photometry. Though the photographic plate is still unrivalled as an imaging detector as far as its resolution and geometrical size are concerned, it shows a number of drawbacks: photographic material has no linear response with a very limited dynamic range, it shows the reciprocity failure and has a threshold. As the photographic plate can only be used once, point by point photometric calibrations of the whole plate are impossible and restrict its photometric accuracy.

On the other hand the photomultiplier, which has not the drawbacks of the photographic plate, is a none-imaging detector. It detects all the radiation, to which it is sensitive, from the solid angle which the photocathode sees through the telescope optics. Therefore it is not placed into the focal plane of the optics but into their exit pupil. This solid angle is proportional to the ratio of the square of the diameter of the diaphragm in the focal plane to the telescope's focal length. Due to scintillation and diffraction effects encountered in ground-based observations the angular size of the focal plane diaphragm can't be made smaller than typically 10 arcsec. Thus, doing surface photometry with a conventional single-beam photometer, the extended object must be scanned either by moving the telescope relative to the object or by moving the diaphragm in the focal plane. This observing mode is very time-consuming and all information from points outside the diaphragm, but within the telescope's field, is wasted. For example, during an observing run of 5 nights in November 1979 at the ESO 50 cm telescope we could obtain brightness profiles in B and V of only two globular clusters in the LMC. Furthermore, surface photometry with a single-beam photometer suffers from background variations due to atmospheric transmission and/or airglow. A double-beam photometer, as has been designed for ESO in 1976 by one of us (E. H. G.) can overcome these last difficulties.

## The SIT Vidicon and the Area Photometer

The situation for astronomical surface photometry has recently changed with the introduction of modern two-dimensional multi-element detector devices like vidicons and CCDs. These detectors not only allow digital image processing but also have a large dynamic range ($> 10^3$) and show linear response within this wide range. This offers the possibility to correct for sensitivity variations of individual pixels.

In considering to purchase a panoramic detector for our project we had to take the limited manpower and budget at our observatory into account. Therefore we decided for a commercial digital two-dimensional detector based on a **s**ilicon **i**ntensified **t**arget (SIT) vidicon. Such vidicons have successfully been used at different observatories for several years, mainly for spectroscopy (e.g. at Cerro Tololo Interamerican Observatory: Atwood et al., 1979, *Publ. A.S.P.*, **91**, 120, Hesser and Harris, 1981, *Publ. A.S.P.*, **93**, 139). Our detector system is called

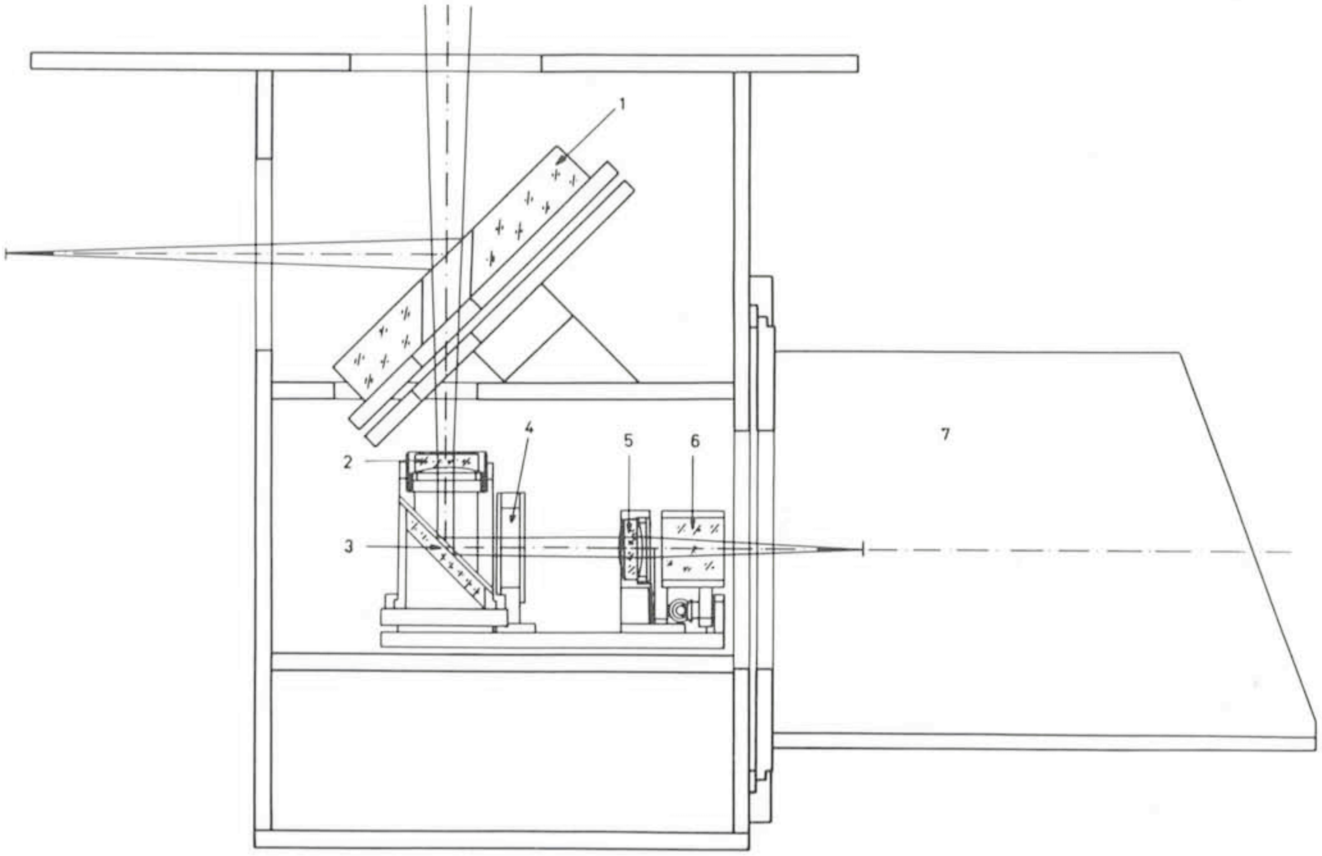



Fig. 1: *Schematic layout of the area photometer. 1 – field observing mirror, 2 – negative achromat lens, 3 – flat mirror, 4 – filter holder, 5 – positive achromat lens, 6 – control ocular, 7 – cooled housing with SIT vidicon.*

"**O**ptical **M**ultichannel **A**nalyzer", OMA 2 (improved version, manufactured by EG & G Princeton Applied Research Co.) and consists of three units: the SIT vidicon, its control unit and a computer console with peripheral plotter and printer. This system has been purchased by a generous grant of the German Science Foundation (Deutsche Forschungsgemeinschaft, DFG, grant Ge 209/8, 11–2).

The physical principles underlying the SIT vidicon have been described elsewhere (e.g. Ford, 1979, *Ann.Rev. A&A,* **17,** 189), so that we summarize them only very briefly. Our SIT or EBS (**e**lectron **b**ombarded **s**ilicon) vidicon consists of an electrostatically focused image intensifier with a S20 photocathode. The photoelectrons are accelerated and focused onto the storing target, which consists of a thin disk of monocrystal silicon with a microscopic array of several million diodes on it. The usable target area is 12.5 x 12.5 $mm^2$. Without image intensifier these silicon diodes behave like photodiodes with a high quantum efficiency (**s**ilicon **t**arget [ST] vidicon). With the image intensifier tube, the target is bombarded by electrons with energies of some keV and an amplification of 1,500 is achieved. The diodes behave like capacitors and can store a charge image corresponding to the optical image for about 0.5 sec at room temperature before it leaks away due to thermal recombination. If the target is cooled to about $-50^\circ$ C with dry ice, thermal recombination as well as dark events are significantly reduced and the charge picture can be stored up to 1 hour. The charge image is then read by an electron beam with a diameter of 25 μm; this can be done using certain scan patterns programmed by the controller and the computer console. The recharging current flowing through the electron beam is a measure for the charge of the target. All scan operations and signal digitization is performed by the multichannel detector controller. This is connected to the computer console, based on a LSI-11 microcomputer, which provides control functions for the controller and for acquisition, manipulation and storage of up to 18,000 16 bit words. The computer operating system and the data are stored on 8 inch flexible disks. Due to its operating system the computer can't be programmed to the user's demand. Nevertheless some routines for reduction using simple arithmetic techniques

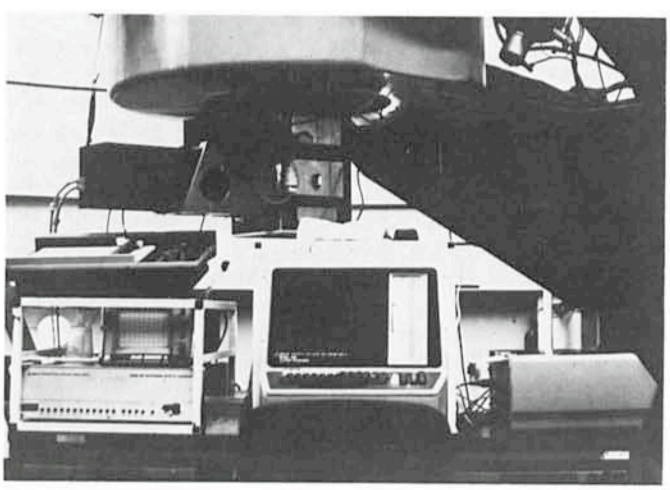
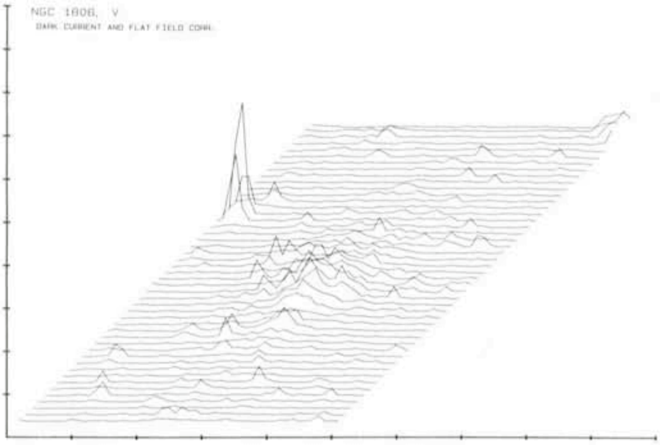


Fig. 2: *The area photometer at the 1 m telescope; detector controller, monitor and computer console can be seen in the foreground.*



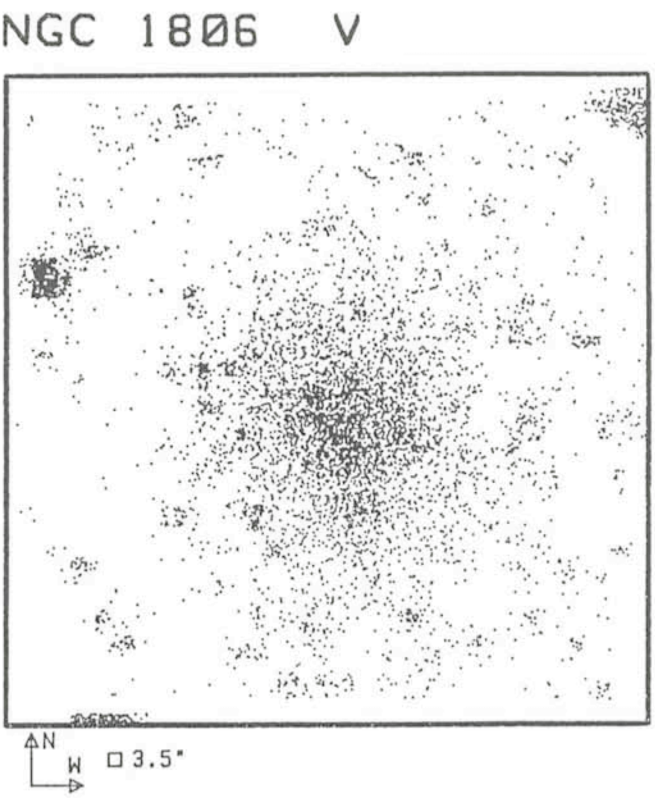


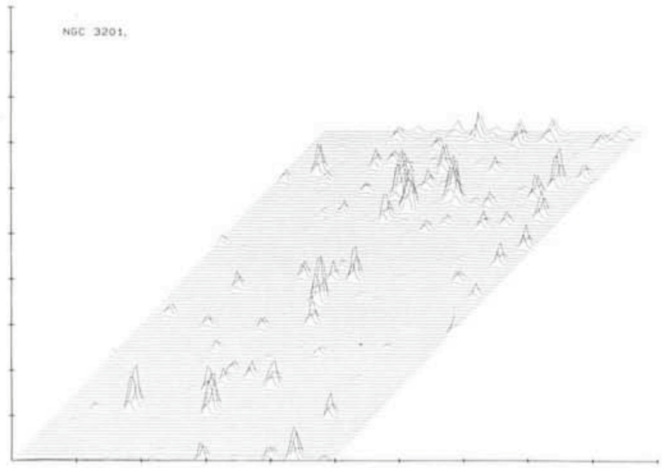

Fig. 3a: *NGC 1806 in V, a red globular cluster in the LMC. This "3D-plot" has been generated by the OMA 2 software and shows 50 tracks shifted by a small amount in the channel direction (x-axis) and intensity (y-axis). Pixel size is 250 × 250 μm² corresponding to 3.45 × 3.45 arcsec² and integration time was 3.5 min, dark current has been subtracted and the image has been corrected for pixel to pixel variations using a flat field.*

Fig. 3b: *Same object. This "grey scale plot" simulates a photographic picture: in each pixel square a number of points proportional to the count rate (intensity) of this pixel has been randomly distributed. Directions on the sky, pixel size and the grey scale with the appropriate count rates are plotted below the picture. Some defects at the edges of the picture—especially in the lower left and upper right corner—are due to some imperfections in the detector system.*

(e.g. background and flat field corrections) and for plots and data transfer are incorporated into the operating system.

For the use at the Cassegrain focus of the 106 cm telescope of Hoher List Observatory, which is identical to the ESO 1 m telescope, a mechanical-optical system, the area photometer (Fig. 1 and 2), has been built in our workshop. Beside different arrangements for finding, centering and guiding the objects to be observed, this photometer has an optical transfer system, consisting of a negative and positive lens, yielding a parallel beam before the image is focused onto the SIT vidicon. Colour or interference filters of different thickness can be inserted into this parallel beam, so that the time-consuming procedure of refocusing the detector is avoided. Presently we are also incorporating grating prisms (grisms) for spectrophotometry in the $\lambda/\Delta\lambda \simeq 200$ resolution range.

The smallest pixel size of the detector is 25 ×50 μm² which corresponds to 0.35 × 0.7 arcsec² at the f/15–1 m telescope. Due to the finite computer memory we use for surface photometry larger pixel sizes of 125 × 125 μm² or 250 × 250 μm² corresponding to 1.7 × 1.7 arcsec² or 3.45 × 3.45 arcsec², respectively, on the sky. This can be



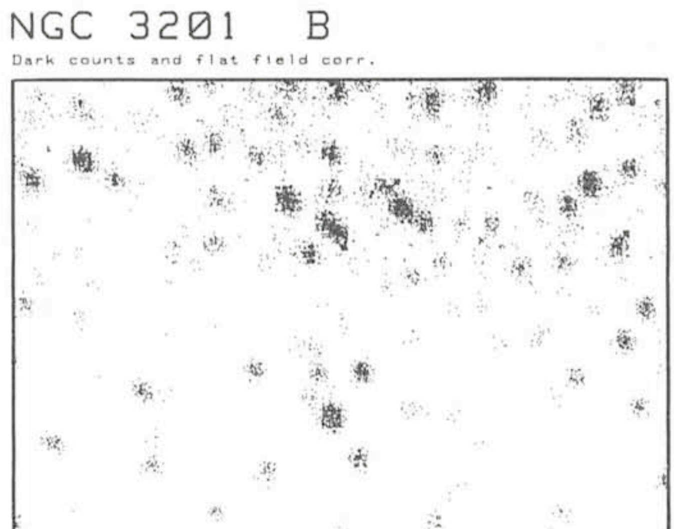



Fig. 4a: *Southern part of NGC 3201 in B. Pixel size is 125 × 125 μm². 3D-plot as in Fig. 3a.*

Fig. 4b: *Same object as in Fig. 4a, grey scale plot as in Fig. 3b.*

allowed for since in most cases the stellar images are blurred to the same size due to seeing. Increasing the pixel size has the advantage that the detector's dynamic range is improved. Therefore the square image frame consists of 100 × 100 or 50 × 50 pixels and the image size corresponds to 2.9 × 2.9 arcmin² at the 1 m telescope.

### The First Observations

Due to some technical difficulties with the system's electronics and bad weather conditions in October and November 1981, the instrument could undergo only short test phases at Hoher List Observatory before it was shipped to Chile. During our observing run of 7 nights in January 1982 at the 1 m telescope on La Silla the instrument worked perfectly: for 20 young (blue) and old (red) globular clusters of the LMC surface photometry with 3.45 × 3.45 arcsec² pixel size could be carried out in the ranges U,B,V,G and R of the UBV and RGU colour systems. (An example of these observations is given in Fig. 3.) The typical integration time per image frame was 3.5 minutes. This shows clearly the enormous effectiveness of such modern panoramic detectors. During the morning hours, when the LMC was too low, we additionally obtained observations of galaxies and some galactic objects (open and globular clusters, Hα regions, planetary nebulae). On 100 × 100 pixel frames (pixel size 1.7 × 1.7 arcsec²) of the globular cluster NGC 3201 stars fainter than $17^{m}_{\cdot}1$ and $16^{m}_{\cdot}3$ in B and V could be detected (Fig. 4). Up to now only preliminary reductions have been done. However, the enormous amount of data we have collected requires more detailed evaluation to derive brightness and colour profiles of these globular clusters. We hope that we can report about the results in the near future.

### Acknowledgement

We thank the ESO technical staff on La Silla for their assistance which contributed significantly to our successful observing run.



# Dust and Young Stars in Puppis

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### Introduction

Two decades ago the presence of a group of young stars in the constellation Puppis was noted and described by Westerlund (*Mon. Not. R. Astr. Soc.* **127,** 71, 1963). This group appears to form an association of hot and luminous O and B stars also containing the long-period cepheid RS Puppis. The association was named Puppis OB 3. In the region occupied by the association a number of small and peculiar bright nebulae were noted as well as several dark globules and dust lanes (Fig. 1). Also present in the region is the H II region RCW 19 which obviously is excited by the most luminous of the association members. The age of the association was estimated from the most luminous member, the O7f star HD 69464, to be no more than $4 \cdot 10^{6}$ years. Thus the stage seemed to be set for the scrutinizing of a relatively restricted region of recent star formation concerning the content of both stellar and interstellar material. The following is only intended to be a progress report of this project as some of the recent observational material is still being analysed.



### Observations

To get as much information as possible about the different constituents in a region of star formation a number of various techniques must be applied, covering a large part of the electromagnetic spectrum reaching from the ultraviolet to radio. Most of the observational material, in the optical and infrared (IR), for this project was collected at ESO, La Silla, partly together with Westerlund, during the period January 1980 to January 1982. Spectra of the 10 brightest OB stars were taken at high dispersion (12 Å/mm and 20 Å/mm) with the coudé camera of the 1.5 m telescope. These spectra yielded spectral types as well