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THE S4 SPIRAL ARM IN M 31
GALAXY - INFRARED VERSUS OPTICAL

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1. INTRODUCTION

The spiral arms of M 31 have been a subject of extensive studies over the last two decades in the Department of Astronomy at the University of Sofia (Ivanov & Golev 1984, Ivanov 1984, Georgiev & Ivanov 1985, Kurtev & Ivanov 1986, Nikolov & Tasheva 1989, Nedialkov & Ivanov 1999, Veltchev et al. 1999, Kurtev 2002). The fragment of the spiral arm S4 along the major axis is extremely interesting region because the existing wealth of data on the stellar content as well on the hydrogen (atomic and molecular) and PAH dust emission (Lequeux 2000) offers an excellent opportunity to discover the fine details of star formation history (Chernin et al. 1995) in this Local Group galaxy. We describe here a technique to obtain continuous maps of the stellar populations, and present some preliminary results.

2. TECHNIQUE

The discrete distribution of the stars presents a significant difficulty while trying to compare the spatially distributed parameters of stellar populations with continuous radio or mid-infrared maps.

This problem prompted us to convolve the discrete stellar distributions with Gaussian filters. Our approach has multiple advantages:

1. It takes into account both the number and the apparent magnitudes of the observed stars.

2. The convolution allows us to obtain a continuous picture of the surface brightness from which the background and foreground contamination can be subtracted easily.

3. It alleviates the blending problem which affects severely the individual extinction estimates.

4. The comparison with other 2-dimensional distributions is straightforward.

5. The investigation of the various hierarchical structures (clusters, OB associations, young star complexes and dust clouds), is simplified since they all are defined as regions encompassed by isophotes of constant surface brightness or lines of constant color.

The individual stars were treated as δ-functions. We implemented Gaussian filters with standard deviation $\sigma = 20''$, cut-off levels of 3σ and peak values of $10^{-0.4 \times \mathrm{magnitude}}/(\mathrm{pixel\ size})^2$, and the pixels size is $2''$.

3. DATA

We used archival near-infrared and optical photometry for a $20' \times 20'$ field, centered at $\alpha(2000) = 0^{\mathrm{h}}\,40^{\mathrm{m}}\,40^{\mathrm{s}}$ and $\delta(2000) = 40°\,39'\,30''$ (see Lequeux 2000).

The JK photometry of 277 stars was taken from the *Two Micron All Sky Survey* (2MASS) and was selected as follows: $\mathrm{K} > 12.6^{\mathrm{m}}$ and $\mathrm{J} - \mathrm{K} > 1.2^{\mathrm{m}}$. The comparison with a nearby field of equal area well outside the boundaries of M 31 and at the same Galactic latitude indicates a contamination of less than 15% (Fig. 1). The optical photometry (BV) was compiled from the catalog of Magnier et al. (1992), imposing criteria: $\mathrm{V} > 16.5^{\mathrm{m}}$ and $\mathrm{B} - \mathrm{V} < 0.4^{\mathrm{m}}$. It consists of 1473 stars. As seen in Fig. 3, the foreground contamination is negligible.

The color and magnitude criteria described above were designed to select massive stars. Indeed, Figs. 2 and 4 show that the majority of objects in our sample is located inside the boundaries of the classical "OB associations" as delineated by van den Bergh (1966).

4. RESULTS

1. Several subgroups of enhanced surface brightness within the stellar complexes are detected and the brightest of them have typical sizes of $\sim 60''$ (~ 200 pc).

2. The spiral arm S4 is much more prominent and tighter in the K-band (Fig. 5) than in the optical (Fig. 6), suggesting that the near infrared wavebands are more reliable for tracing of the spiral arms.

3. There exists a well defined offset between the ridge of the gas arm and the surface brightness in K, especially strong in the region of OB 78, and between the inner side of OB 82 and OB 81.

4. The association OB 79 has no gas and relatively few RGS candidates, yet it is extremely reach of OB stars, probably indicating a recent burst of star formation.

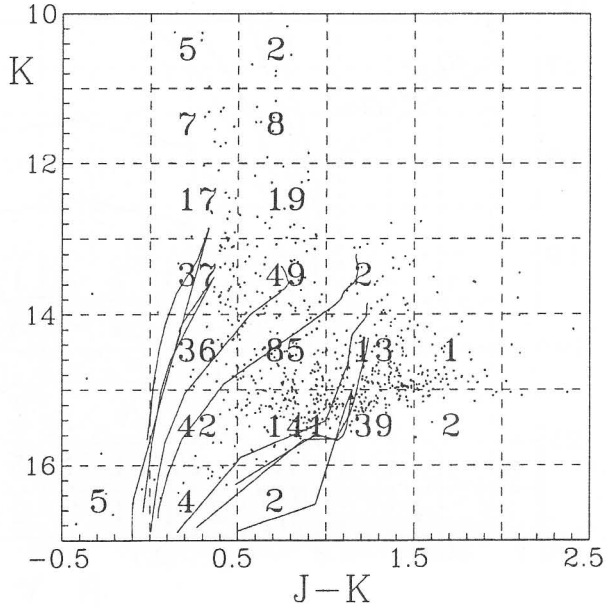

Fig. 1: All stars with JHK photometry from 2MASS catalog within the selected area. The number of predicted (foreground+background) contamination objects is shown in several bins.

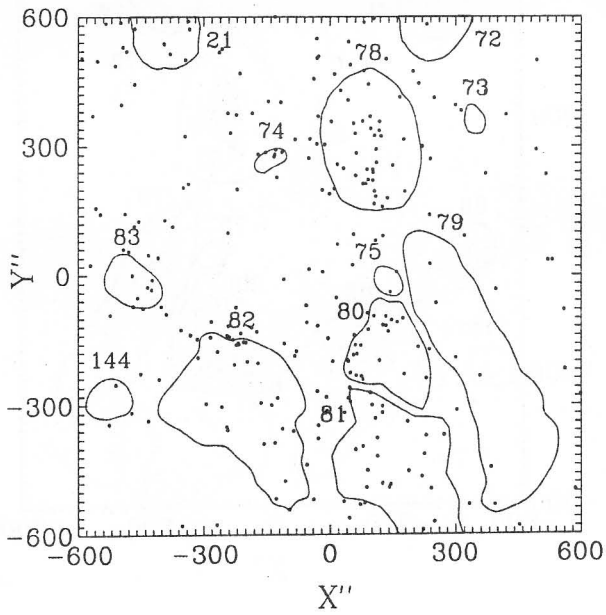

Fig. 2: Red supergiants candidates within the same area with the outlined boundaries of the OB associations (van den Bergh, 1964).

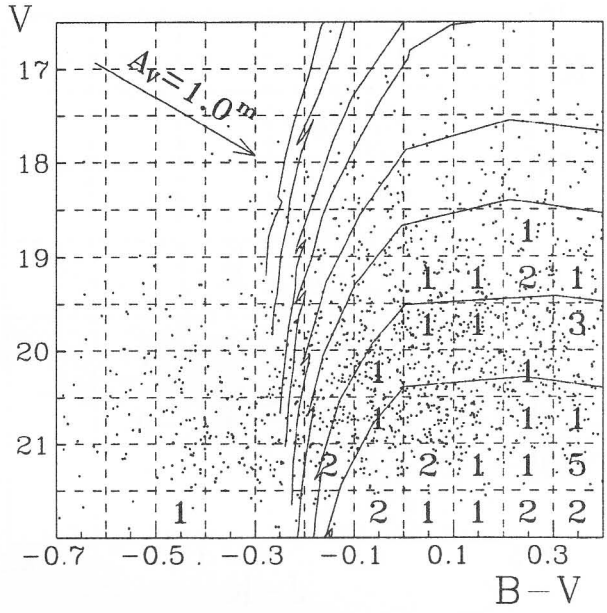

Fig. 3: Blue stars from the catalog of Magnier et al. (1992) within the selected area.

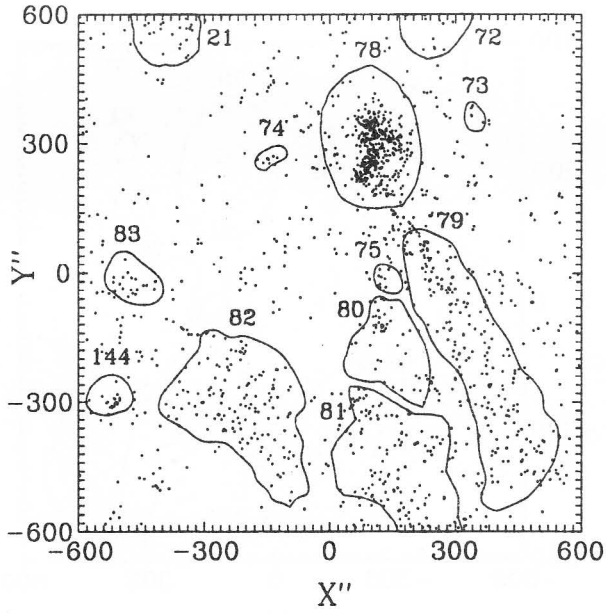

Fig. 4: The positions of the stars from Fig. 3 with the outlined boundaries of the OB associations (van den Bergh, 1964).

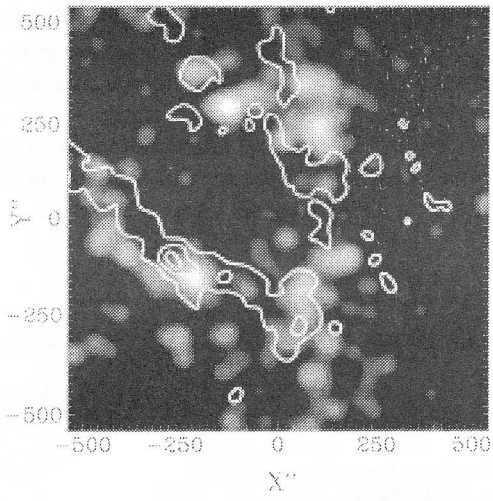

Fig. 5: A grey-scale surface brightness map in K-band, obtained after convolution of the stars from Fig. 2 with 2D gaussians (st. dev. = 20″). The values of μ_K vary from 20.2^m (white) to 24.1^m per square arcsec (black). The contours indicate the CO($1 \rightarrow 0$) line intensity from the map of Guelin et al. (2000). Levels are from 2 to 17 K km/s in steps of 5 K km/s.

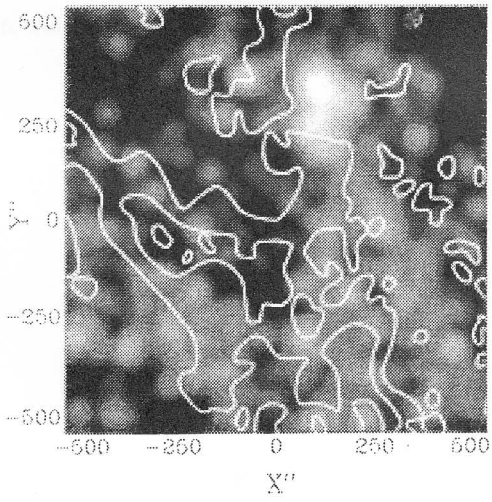

Fig. 6: A grey-scale surface brightness map in B-band, obtained after convolution of the stars from Fig. 4 with 2D gaussians (st. dev. = 20″). The values of μ_B vary from 23^m (white) to 30^m per square arcsec (black). The contours indicate the 21 cm H I line integrated intensity from data in Brinks & Shane (1984). Levels are from 1500 to 3000 K km/s in steps of 500 K km/s.

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