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THE EXTINCTION LAW AND STELLAR CONTENT OF THE 30 DORADUS SUPER-ASSOCIATION

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RESUMEN

Estamos llevando a cabo un programa de estudio de la historia de la formación estelar en la super-asociación 30 Doradus en LMC. Presentamos resultados preliminares de una fotometría *UBV* del cúmulo central de la nebulosa de la Tarántula, NGC 2070. Nuestro resultado principal, es el descubrimiento de una componente de enrojecimiento, que implica la presencia de polvo todavía asociado al cúmulo mismo.

ABSTRACT

We are carrying out a program to study the star-formation history of the 30 Doradus super-association in the LMC. Here we report the preliminary results of *UBV* photometry of the central cluster of the Tarantula nebula, NGC 2070. The principal result presented, is the discovery of a reddening component, which implies the presence of dust still associated with the cluster itself.

Key words: **ISM: DUST, EXTINCTION — STARS: EARLY TYPE — OPEN CLUSTERS AND ASSOCIATIONS: INDIVIDUAL (NGC 2070)**

1. INTRODUCTION

Super-associations are among the largest star-forming structures identified in what seems a scale-free hierarchy, that might extend all the way up from stars to galaxies (Ambartsumian 1963; Melnick 1992; Efremov & Elmegreen 1998). They are second only to extra-galactic H II regions, or H II galaxies, being very close to them morphologically and spectroscopically (Melnick 1992). As part of an effort to understand the origins and astrophysics of these objects we are engaged in a project to study the content, IMF, and the star-forming history of the 30 Doradus super-association in the Large Magellanic Cloud (LMC), the closest example of the class, and the only whose stellar content can be studied from the ground. Understanding the astrophysical processes going on in 30 Doradus is vital for our use of these objects in such varied fields as the determination of cosmological parameters (Melnick et al. 1987; Melnick, Terlevich, & Moles 1988) or the evolution of abundances with look-back time.

We report here the photometry of the cluster NGC 2070, based on observations taken with the SUperb Seeing Imager (SUSI) of the NTT at ESO, La Silla, Chile, under excellent seeing conditions. Figure 1 is an example of a *V* frame obtained with that instrumental configuration. In this paper we particularly emphasize the reddening characteristics of this extreme object. Details of the photometry can be found in Selman et al. (1999). The spectral observations and dynamical analysis will be presented in Bosch et al. (1999). The IMF analysis will be presented in Selman et al. (1998).

2. PHOTOMETRY AND PRELIMINARY RESULTS.

Figure 2 shows the color-magnitude diagram (CMD) of the inner 90″ surrounding the NGC 2070 cluster. Plotted in large white dots are the results obtained by Parker (1993). The small black dots is our photometry.

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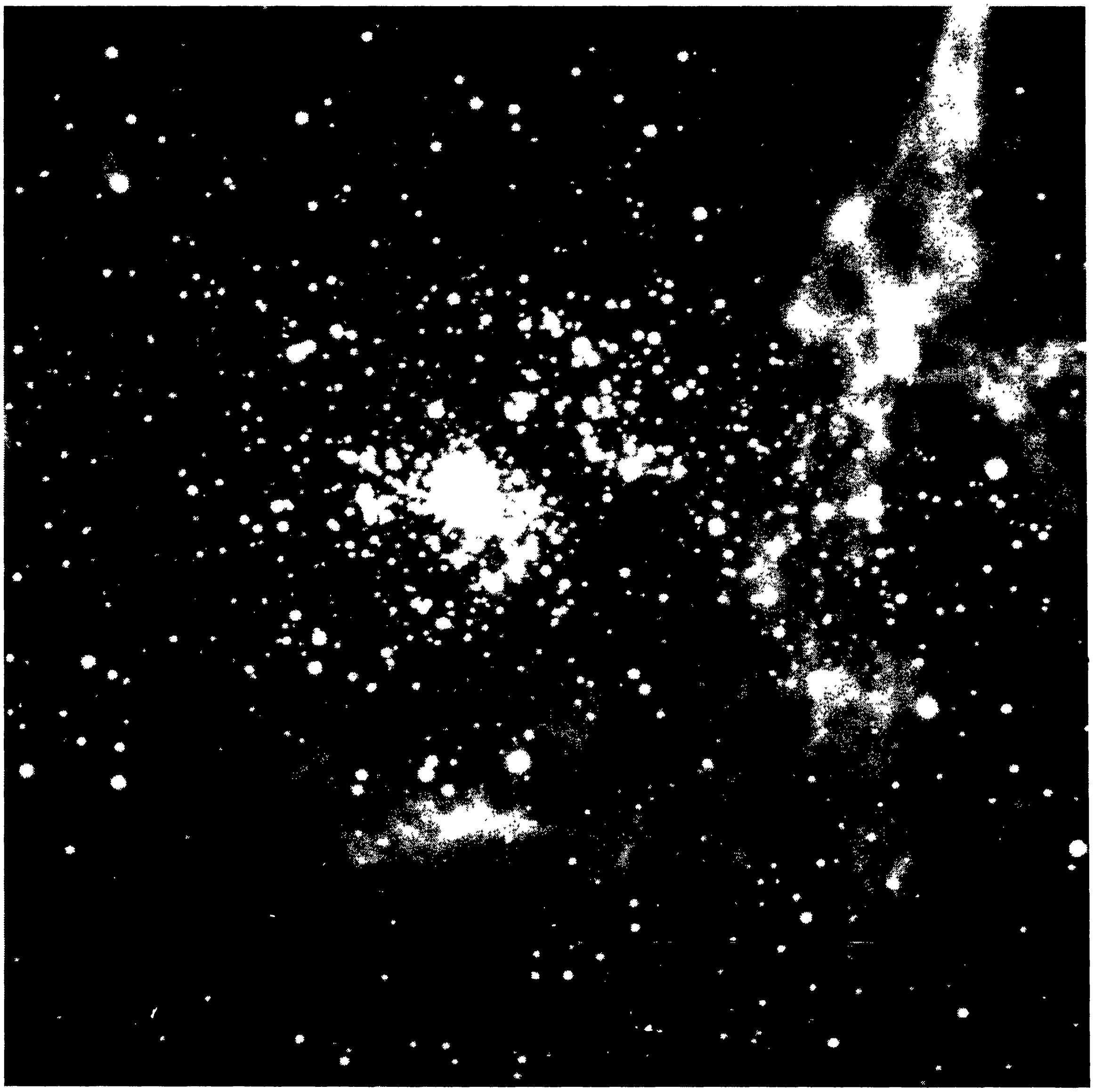

Fig. 1. *V* image of the NGC 2070 cluster taken with SUSI at La Silla, with a seeing of 0.″6 (image taken by S. Bennetti). North is up and East to the left. The width of the image is 130″.

Two things are evident: first, the overall agreement is excellent (although there are small zero point offsets (< 0.05 mag), they are unnoticeable in the scale of the figure), and second, the random errors in our photometry are much smaller, certainly due to the excellent seeing of our observations (0.″6 versus over 1.″2).

One of the quantities we are after is the initial mass function (IMF) of the cluster. Particularly, we want to know whether it shows any radial (or positional) dependency. In order to determine masses and ages for the stars it becomes necessary to place them in the HR diagram. We do this following a procedure outlined by Melnick (1986). A very important part of this procedure is the correction for reddening in a star-by-star basis. One of us (GB) is embarked in a program to obtain spectra for stars in the area surrounding 30 Doradus. There are 116 recent and previous spectral types for the stars in the area covered by this photometry (Bosch et al. 1999; Melnick 1985; Parker 1993; Walborn & Blades 1997).

The value of the reddening law parameter $S = E(U-B)/E(B-V)$ was determined to be apparently constant over the area covered by this research, with some hints of local variations (it seems to raise to values near unity in the northwest corner of the area studied, although further work is needed to determine the reality of such an effect). The value we determined is 0.81 ± 0.03, within 1σ of the values of 0.79 found by Melnick (1985), and 0.89 ± 0.08 reported by Fitzpatrick (1985). It was also found that the total-to-selective absorption parameter R_V is consistent with the normal galactic value of 3.05 quoted by Martin & Whittet (1990).

Figure 3 shows the color excesses of these stars as a function of distance to the cluster center. Two components can be appreciated in this figure: a clumpy component easily visible in the V image of the cluster (Figure 1) in the form of dark patches superposed on a brighter background, and a smooth component, filling the cluster down to the closest distance to R 136 for which the photometry remains reliable. Radial systematic color effects of this magnitude were ruled out with Monte Carlo simulations.

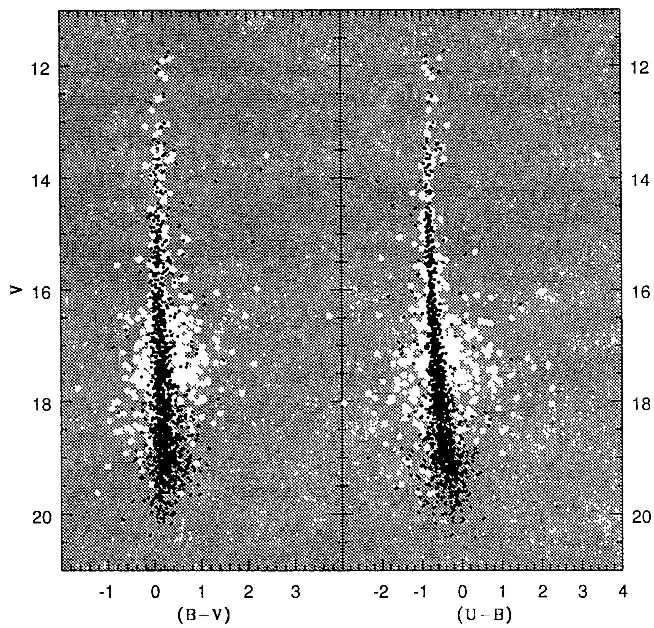

Fig. 2. Color-magnitude diagram for our program (black dots) compared with Parker (1993) (white dots).

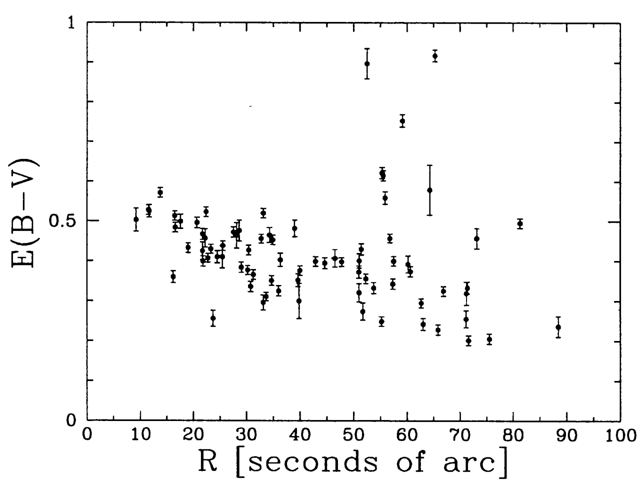

Fig. 3. Reddening as a function of cluster radius for the stars with spectroscopy.

3. CONCLUSIONS

The presence of the smooth reddening component came as a surprise, because we expected that any dust in that area would be either destroyed by the strong UV field, or swept away by the strong winds from the central cluster stars. It appears that the hot stars in the cluster core not only loose mass, but they are able to produce dust in the process, possibly by wind-wind collisional shocks (Usov 1991).

We are now in the process of determining the IMF of the cluster. The major obstacles to the IMF come in the form of many systematic effects. Besides the well known angular resolution problems which lead at one time to the proposal of the existence of a super-massive object in this cluster, there are at least two other important problems. The radially dependent reddening discussed above will lead to radial systematic effects if not considered in the analysis (and it has not been considered in the previous works mentioned below). Furthermore, using a newly designed tool, the color-magnitude stereogram (Selman et al. 1999), we have found that previous determinations of IMF slopes in clusters are affected with yet another systematic error, one that arises from the interplay between the existence of more intrinsically fainter stars, and the errors of photometry which are larger for these stars. With the standard method, this leads to a migration of fainter stars to upper mass bins, and a migration of brighter stars to lower mass bins. Being the former more numerous, the IMF is biased towards higher mass stars. Notice that the effect is expected to be stronger in regions of larger errors, e.g., close to the center of the cluster (precisely the change claimed recently by Malumuth & Heap (1994), and by Brandl et al. (1996)).

A procedure is being designed to correct for these effects, and also, to determine the slope of the IMF in an objective, impersonal way, independent of any binning of the data. The usual method, that consist on fitting a straight line to a parabola-like downward pointing curve is too unreliable (any slope between $-\infty$ and zero could be extracted according to the preferences of the researcher!). The results will be presented in a forthcoming paper (Selman et al. 1998).

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