THE STELLAR CONTENT OF 10 DWARF IRREGULAR GALAXIES

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We examine the stellar content of 10 dwarf irregular galaxies of which broad-band CCD photometry was published in Hopp & Schulte-Ladbeck (1995). We also present Hα images for several of these galaxies. The galaxies in the sample are located outside of the Local Group. Yet, they are still close enough to be resolved into single stars from the ground but only the brightest stars (or star clusters) are detected and there is severe crowding. The sample galaxies were selected to be isolated from massive neighbors; about half of them are (mostly peripheral) members of groups, the other half is located in the field. We discuss the vicinity of the sample galaxies to other dwarf galaxies.

In order to interpret single-star photometry and draw conclusions about the stellar content or other distance-dependent quantities, it is crucial that accurate distances to the galaxies be known. The distances to the sample galaxies are not well known since all but one have not had a primary distance indicator measured. We make an attempt to constrain the distances by identifying the envelope of the brightest supergiants in B, B-R and R, B-R color-magnitude diagrams, but the results are not very accurate (we estimate the minimal error on the distance modulus is 1.36 m). Nevertheless, the fact that the sample galaxies are resolved with direct ground-based imaging indicates that they are sufficiently nearby to represent good candidates for observations with instruments that provide high spatial resolution, e.g., adaptive optics systems on large ground-based telescopes, or the Hubble Space Telescope.

We discuss the morphologies, color-magnitude diagrams and frequencies of the resolved stars together with the morphology of the ionized gas, as well as the surface brightness profiles and colors of the underlying light distributions of unresolved stars. We point out the occurrence in half of the galaxies studied
of HII regions and young stellar associations located well outside of the main body of resolved stars. This appears to be in conflict with the hypothesis of self-propagating star-formation. All of the sample galaxies contain HII regions and young massive stars with ages of a few Myr to around 10 Myr. For supergiants beyond an age of about 50 Myr, incompleteness is already a problem in the single-star photometry. However, we can also gain insight into the stellar content from the integrated colors of the unresolved stars. The light distribution of the unresolved stars is more extended than that of the resolved stars and is of a more regular and elliptical shape. We provide ellipticities, central surface brightnesses and scale lengths for the sample galaxies. The background-light colors indicate a range of star-formation histories for the sample galaxies, with galaxy colors at one extreme being dominated by the old, metal-poor population, and at the other extreme, by the most recent star-birth event. The results provide insight into the stellar content and the star-formation histories of isolated, late-type galaxies.

*Subject headings: galaxies: Irregular*
1. INTRODUCTION

Irregular galaxies (IGs) represent a class of low-mass galaxies with active star formation. The basic, integrated properties of IGs have been summarized by Gallagher & Hunter (1984) and Hunter & Gallagher (1986). IGs can be found isolated in the field and without any near and massive neighbors. Such isolated IGs that can be well resolved into single stars are excellent laboratories to study the star-formation and propagation processes intrinsic to IGs. Star formation can apparently be a self-initiating process in isolated IGs, since it is unlikely to have been triggered by galaxy-galaxy interactions, a mode of star formation suggested to apply to many starburst galaxies (Larson & Tinsley 1978). While Brinks (1990) has proposed that interactions of dwarf irregular galaxies (dIs) with other dwarf galaxies could stimulate star formation in dIs, and Taylor et al. (1995, 1996) have found an appreciable number of HI companions to several star-forming dIs, it still remains unclear whether interactions are a trigger of current star formation even for those dIs which have companions (Skillman 1994).

IGs are structurally simple objects which rotate more slowly than spirals (Gallagher & Hunter 1984) and so star formation is also unlikely to be induced by density waves. While some IGs are presently undergoing global bursts of star formation (see Gallagher & Hunter 1984 and references therein), star formation in most IGs has been suggested to be a local phenomenon on theoretical grounds, starting in one part of the galaxy and then self-propagating to other parts, as the supernovae originating from the evolution of massive stars in one star-forming region induce star formation in adjacent regions of the galaxy (Gerola & Seiden 1978).

A census of the resolved, luminous stellar content of nearby IGs can be taken with photometry from the ground. Local IGs thus furnish nearby and resolved analogs of somewhat more distant HII galaxies, which, in most cases, have not been resolved into
single stars and of which only integrated spectra can be analyzed (but see, e.g., Meurer et al. 1994, Schulte-Ladbeck et al. 1998). Nearby IGs may also represent present-epoch examples for the large numbers of galaxies with irregular morphologies discovered at redshifts of 0.3 to 0.5 in the Hubble Space Telescope (HST) Medium Deep Survey. The evolution of IGs may explain the “faint blue galaxy” problem, the excess numbers of blue galaxies observed in deep images of the sky (e.g., Griffiths et al. 1996, Glazebrook et al. 1995). Studying isolated IGs locally will allow us to better understand the morphology and stellar content of such galaxies and will have bearing on the question of whether the faint blue galaxies can be explained with intrinsically star-forming dwarfs or whether they are merging progenitors of today’s galaxies. Isolated, nearby IGs can therefore play an important role for our understanding of the stellar populations of distant galaxies.

Owing to the small resolutions and limiting magnitudes achievable from the ground, most studies of the resolved stars in IGs have concentrated on the Local Group (cf. Table 1 in Bresolin et al. 1993, discussion in Greggio 1995, Gallart et al. 1996, Table 2, Grebel 1997). However, it cannot be excluded that the star-formation history of Local Group dwarfs has been influenced by their proximity to the Galaxy and M31 (e.g., van den Bergh 1994). Thus, if we want to gain insight into the intrinsic star-forming properties of IGs, we have to look beyond the Local Group. Our work has centered on galaxies which are located beyond the Local Group, but which are still close enough to be resolved into single stars from the ground (Hopp & Schulte-Ladbeck 1987, 1991, 1995; Schulte-Ladbeck & Hopp 1995). While several studies of IGs have achieved deeper limiting magnitudes than our’s (see above, also Tolstoy 1995), all of these studies focussed on the exploration of a single, or very few, galaxies. The comparison of the single-star photometry of the IGs studied by different groups has been notoriously difficult owing to the different filters and different filter systems used by the different investigators, different reduction methods, etc. Thus, previous comparisons have been hampered by uncertainties in the magnitude conversions
between different filter systems, and have been limited to a few galaxies. We here present a homogeneous dataset of single-star photometry for 10 galaxies.

Our study, however, has its own limitations. Due to the large distances of the sample galaxies only the brightest and hence, most luminous objects are resolved. They may be star clusters rather than single stars. Even in such nearby objects as the LMC, resolving clusters of massive stars into single objects has presented difficulty (e.g., the case of R136, see e.g., Weigelt et al. 1991). Any single-star photometry of the fainter, older populations (like asymptotic giant branch stars, red giant stars) will have to await high-resolution imaging. Data of sufficient quality to resolve old populations can be obtained with the HST for galaxies even beyond the Local Group (e.g., Schulte-Ladbeck et al. 1998). In this paper, only the integrated light of the faint stars is analyzed. Therefore, this paper is only a first step towards characterizing the star-forming properties of distant dIs from the investigation of their resolved stellar content.

2. THE SAMPLE

The sample was drawn from the volume-limited catalog of nearby galaxies by Kran-Korteweg (1986, KK). The galaxies in our sample were selected because of their relative isolation from massive galaxies. In Table 1, we give an overview of the sample; all data are from KK. The first column is the UGC number of the galaxy, the second column provides other names, the third column is the galaxy type, the fourth column gives the group membership classification, the fifth and sixth column provide the size of the major axis in arcsec and the ellipticity ($\epsilon=1-b/a$), the seventh and eighth columns are the apparent blue magnitude, $B_T$, and the apparent blue magnitude corrected for galactic and internal absorption, $B_T^{0,i}$, the ninth and tenth column list the distance in units Mpc for a Virgo cluster infall model with $v_{VC}=220$ km s$^{-1}$, and the corresponding absolute blue magnitude...
based on this model, $M_B^{0,i}$, and corrected for galactic and internal extinction, while the eleventh and twelfth column provide the same values for the model with $v_{VC}=440$ km s$^{-1}$. The Virgo Cluster distance used by KK is 21.7 Mpc. Notice that UGC 8091=GR 8 is classed “Field, LG?” in KK. Its location is certainly at the fringe of the Local Group. Hodge (1974), e.g., placed it within the Local Group. Recently, a single Cepheid was discovered in GR 8 by Tolstoy et al. (1995), who suggest that this dI is more distant than previously thought.

Considering now the location of the galaxies in our sample with respect to the spatial distribution of other nearby galaxies, as well as the numbers and distances of their nearest neighbors, we may better recognize the relative “isolation” of the sample galaxies and rank-order them by increasing isolation or decreasing environmental galaxy density. Among the galaxies located in groups (see Table 1) UGC 7559 is the only galaxy found within the inner, denser region of its group. UGC 4459, UGC 8024, UGC 8091, and UGC 8320 are situated in the outskirts of their respective groups and hence, in low-density regions. While UGC 8320 is listed as a field galaxy in KK, we caution that there are four relatively nearby galaxies. UGC 5272 A,B, UGC 5340, and UGC 8760 are all in the field and have few, distant neighbors; UGC 6456 is the most isolated of the galaxies in our sample.

The term “irregular” has been used in the literature to describe a wide variety of morphologies including peculiar and interacting systems. Following Hunter & Gallagher (1986) there is, however, a group of normal, non-interacting, and intrinsically irregular galaxies. These are usually divided into the Magellanic-type Ims, for which the morphological prototypes are the Magellanic Clouds and into the smoother, IOs, which are usually referred to as amorphous IGs. Table 1 shows that the galaxies studied here belong predominantly to the Im type. The term “dwarf galaxy” has been applied to galaxies fainter than $M_B=-16$ (e.g., van den Bergh 1966, Hodge 1971); and the data in Table 1 suggest that
in that sense, all of the galaxies studied here are dwarf irregular galaxies (dIs). We note that our sample galaxies are rather similar to the Local Group dI IC 1613 (Freedman 1988) in terms of absolute blue magnitude and metallicity.

The observational details of 11 dIs studied by us with CCD photometry in Johnson B and Cousins R were given in Hopp & Schulte-Ladbeck (1995, HS). The observations consist of a uniform sample of 10 dIs (i.e., observed in the same run, calibrated with the same standards) and another run in which only the galaxy DDO 210 was observed. Since DDO 210 was not observed with the same set-up and the same calibrations as the other dls, we exclude this galaxy from our comparison. We presented preliminary results on DDO 210 in Hopp & Schulte-Ladbeck (1994). The seeing conditions for the uniform-sample observations ranged from about 1" to 2", and the limiting magnitudes reached at a DAOPHOT error of 0.1" were between 22" and 23", with the B images usually going about 0.5" to 1" deeper than the R images (see HS Tables 1 & 2). We note that the total magnitudes derived by us (to the 26.5"/arcsec² isophote, HS Table 3) are in excellent agreement with those given by KK (quoted to be in the B_T-system of the Second Catalog of Bright Galaxies, RC2, which uses the 25.0"/arcsec² isophote). The difference between our total blue magnitudes and KK's is (-0.07±0.11)". We take this good agreement to indicate that there are no large systematic errors in our calibration. We also compared single-star photometry of two galaxies in the uniform sample, UGC 8024 and UGC 8091, with previously available photometry by other groups of authors. The comparison revealed that the difference in the zero-point calibrations of single-star photometry is smaller than 0.2" in B, and that the colors agree very well.

The goal of this paper is a comparison of the stellar content of the 10 dIs. Our results for UGC 5272 (which we found to have a small, neighboring dI, hence the nomenclature UGC 5272 A,B) were already published in Hopp & Schulte-Ladbeck (1991). In the present
paper then, we shall examine the properties of an additional 8 dls from the same observing run. We wish to emphasize that whenever we are comparing the properties within the uniform sample, the results will be less affected by errors in the calibration. Therefore, the relative properties of these galaxies will be more reliable than their absolute properties.

3. Hα imaging

In addition to the B and R images introduced in HS, we also obtained Hα images of several sample galaxies between March 6 and 8, 1988. These data were taken during an instrument test run at the prime focus of the Calar Alto 3.5-m telescope, with the focal reducer, and a 371 by 561 pixel GEC chip which did not have the best cosmetic properties. The images have a scale of 0.37 arcsec per pixel. We used an Hα filter centered at 6580 Å with a width (FWHM) of 100 Å. We employed an I-band image centered at 8700 Å and with a width of 1200 Å to accomplish the continuum subtraction. Exposure times and seeing values (FWHM) are given in Table 2. The resulting Hα-I images are displayed in section 4.

After the usual CCD corrections, the I images were scaled to the Hα frames by measuring the fluxes of several well isolated stars on both frames, dividing the I frames by the flux ratio, and subtracting them from the Hα images. The electronics of the camera and of the chip produced unexpected, remnant over-exposure features and read-out bugs. They are easily visible in the images. Given the sharp edges of the CCD bugs, it is unlikely that they would be confused with real features in the galaxies. We shall therefore use the data to discuss the Hα morphologies of the sample galaxies, but shall not give absolute fluxes. Similarly, I frames were not used to conduct single-star photometry; owing to the bad seeing the galaxies are also not well resolved in I. No I frames could be taken for UGC 6456 and UGC 8320, and the Hα images shown therefore still contain a continuum contribution.
While \( H_\alpha \) data exist in the literature for most of our galaxies (e.g. Hunter et al. 1993, HHG), we present the first published image for UGC 8024. This galaxy has attracted much interest owing to its dark-matter halo (Carignan & Beaulieu 1989). In addition, most of our images are deeper than those presented by HHG and add some interesting new morphological details like the giant shell in UGC 7559.

4. THE RESOLVED STARS

The B & R single-star photometry data were corrected for galactic foreground extinction, using the values given in Table 3 of HS. The galactic extinction law used was that of Cardelli, Clayton & Mathis (1989), and the value for the total-to-selective extinction, \( R_V \), used was 3.1.

We begin our presentation of the resolved stellar content with a set of three Figures for each galaxy. In each set, there is an illustration of the resolved objects identified with DAOPHOT in the B images. The brightness-coded position plots can be compared with the R images reproduced in HS; they have the same orientation, S is up and W is to the left. Dashed lines on the B charts were drawn to separate the area encompassing the galaxy from surrounding areas on the chip which are thought to contain mostly galactic foreground stars as well as a few distant and unresolved galaxies. The very brightest stars were ignored by setting the saturation switch in DAOPHOT to 55,000 CCD counts. In some cases, DAOPHOT identified extended objects that look like background galaxies on the original images with single “stars” or chains of “stars”; these are labeled on the B charts. The second set of plots is a color-coded position plot. For each galaxy, the bluest objects are plotted with the largest symbol, yellower objects are shown by using an intermediate-sized symbol, and the reddest objects are displayed with the smallest symbol. The B-position plots, color-coded position plots and the third set of plots, the color-magnitude diagrams
(CMDs), use the same plot limits and the symbols are coded in the same way, thus facilitating a comparison of the data between different galaxies.

The CMDs, given both for B vs. B-R and R vs. B-R, show, plotted in separate panels, all stars found in both B and R, the foreground stars and the galaxian stars. Of course, this is not intended as a rigorous distinction of the foreground vs. galaxian stars, but merely as an illustration of the properties of the foreground contamination. Our procedure to select stars belonging to the galaxies is a trade-off: CCD images of areas at larger distances from a galaxy are needed, but can in reality rarely be obtained due to the pressure on observing time at large telescopes (cf. also Tolstoy 1995). Since we use on-chip areas to learn about the foreground stars, and since the sample galaxies will not have sharp boundaries to the distribution of the resolved stars, we are very likely to include some stars that belong to the respective galaxy in the foreground contribution. On the other hand, the CMDs labeled “Stars in the Galaxy” will sometimes show a few very bright objects, clearly foreground stars which happen to be projected onto the area of the galaxy. Of course, these objects were ignored in interpreting the CMDs of the sample galaxies. The on-chip data indicate up to tens of objects in the foreground over the area of the CCD chip.

Lacking galaxy-by-galaxy filed-star corrections, we applied the following statistical approach to understanding the contaminations. We combined into one CMD the data for the field stars of all sample galaxies. Using the combined field-star data, we calculated how many field stars we should expect within the area of a given sample galaxy (i.e., within the borders outlined on the position plots), and in which color and magnitude intervals they would be most prominent. We find that corrections (of typically 5 stars) are predicted primarily in the color-magnitude range of 23<B<22 and 0.5<B-R<2.0; in all other areas of the CMDs the corrections are very small.

An alternative way to obtain an estimate of the expected foreground contamination
is to use a model of the number of Galactic stars (i.e., Bahcall & Soneira 1980). This method has its problems since the Bahcall & Soneira model does not always agree with observations (Kraft 1989). The total number of Galactic stars predicted from the model in the B filter between magnitudes 16 and 24 towards the sample galaxies is between 10 and 20, in agreement with the data (but note the small number of stars involved in both the data and the model).

The interpretation of the CMDs depends very much on both the incompleteness of the data, as well as on the distances of the galaxies studied. In measuring stars at fainter and fainter magnitudes in a sample galaxy, we miss larger and larger fractions due to incompleteness. To model the incompleteness of the data, we added test stars covering the same range of magnitudes as the original detections, to the B images of those galaxies for which we detected more than 100 stars. We then used DAOPHOT to recover the test stars. These simulations show that we expect 100% completeness to the 21st magnitude, and 90% completeness to the 22nd magnitude. For all of the sample galaxies, the brightest member-stars are found to be at $B_v \leq 21$ (see Table 4). The simulations were carried out with test stars scattered uniformly across the sample galaxies. It is expected that the incompleteness in the detection of luminous blue stars in star clusters or HII regions is actually higher than simulated ("R136 effect").

The interpretation of the CMDs also depends on the effects that crowding has on the magnitudes and colors of sources which are assumed to be single but are not. In our discussion of the CMDs of individual sample galaxies an issue that will come up repeatedly is how to interpret bright, yellow objects. Although crowded objects can be de-blended in DAOPHOT using a pre-defined point-spread-function, one anticipates that this procedure eventually has its limits in very crowded regions. This will lead to intermediate colors as the light of red stars is mixed with that of blue stars (Greggio et al. 1993). Gallart
et al. (1996) present an in-depth discussion of crowding and find in particular that the
distribution of magnitude- and color-shifts at any given magnitude or color index is not
Gaussian. There are a few galaxies in our sample which show very outlying, blue data
points on their observed CMDs. They can probably be explained with the large tails seen
at faint magnitudes and extreme color indices in crowding simulations, or they could be
background galaxies which we mis-classified as stars.

Another explanation for the bright, yellow point sources is that they are unresolved
star clusters in the sample galaxies. Bica et al. (1990) published colors for populous,
young and intermediate-age clusters, whose colors would occupy the areas of concern in our
CMDs. Note that the Bica et al. results are based on empirical data, i.e., cluster spectra
which hence include the contribution of H$_\alpha$-line emission to the R filter.

In order to assign approximate spectral types from the B-R colors, we used the Johnson
(1966) Tables, after transforming the R magnitudes to the Cousins system using Bessel
(1983). These apply for Galactic stars; the colors of stars in low-metallicity galaxies will be
shifted to earlier spectral types. The Johnson Tables do not contain data for early O-type
stars. When we measure colors that are more extreme than those listed for the latest
O-type stars in Johnson's Tables, we identify such an object as an O star. We note that the
colors of O stars are degenerate (e.g., Massey et al. 1995).

In the absence of primary distance indicators, distances to resolved galaxies have been
estimated using the brightnesses of the three brightest blue and red supergiants as distance
indicators (e.g., Hubble 1936, Sandage & Tammann 1974, Humphreys 1983). A recent
summary of available data was given by Karachensev & Tikhonov (1994). The method has
a number of problems (e.g., Humphreys & Aaronson 1987). Since massive stars are usually
found in associations, these could be mistaken for the brightest blue stars. Discriminating
the brightest red supergiants against galactic dwarf stars of the same color is extremely
difficult, and so they too are problematic distance indicators. Both blue and red supergiants are usually variable stars (e.g., Sandage & Carlson 1985).

An excellent summary of the problems that observers are faced with when attempting to apply the method of the brightest supergiants, as well as calibration relations that use apparent (i.e., directly observable) magnitudes, were recently published by Rozanski & Rowan-Robinson (1994). Rozanski & Rowan-Robinson present calibrations which make use of the well-established observation that there is a dependence of the luminosity of the brightest stars on the luminosity of their parent galaxy. Significant scatter about these relations (presumed linear) however results in a distance-modulus error for any given galaxy of no less than 0.55".

The dependence of the luminosity of the brightest stars on galaxy luminosity has been explained as a statistical effect. For the blue supergiants, numerical simulations with a constant star-formation rate qualitatively re-produce the above relation as well as the significant scatter observed about it (e.g., Schild & Maeder 1983, Greggio 1986).

In section 6.1, we use the calibrations by Rozanski & Rowan-Robinson to derive distances for the sample galaxies. To do so, we had to adopt a philosophy for how to find the apparent blue magnitude of the brightest blue supergiants, and we wish to outline our approach before discussing the actual CMDs. As we go to fainter and fainter magnitudes into the observed CMD of a galaxy, we must eventually encounter its stellar content, and so separate it from foreground contamination. Due to crowding and increasing errors for fainter magnitudes, the main-sequence/blue-supergiant plume and the red-supergiant region of the "Stars in the Galaxy" CMDs exhibit wide scatter. While it may be difficult to identify correctly the three individual, brightest blue or red supergiants (foreground contamination, crowding, blending in color), it may nevertheless be possible to define an upper envelope to the stellar contents of a sample galaxy, presumably comprised of its supergiants. In a B,
B-R CMD such an upper envelope has a large negative color slope, whereas in an R, B-R CMD, the envelope is nearly constant, especially for the red supergiants.

To illustrate this supergiant envelope, we show some template CMDs in Figure 1, constructed using the absolute visual magnitudes of stars in the MK system as listed by Schmidt-Kaler (1965) together with the colors given by Johnson (1966), and transforming the R magnitudes into the Cousins system using Bessel (1983). The difference in the color of the envelope slopes in B, B-R vs R, B-R can readily be recognized; sliding the CMDs of Figure 1 onto the “Stars in the Galaxy” CMDs of the sample galaxies helps guide the eye in determining the apparent magnitude at which the transition from foreground stars into the supergiant stars of a sample galaxy occurs. This difference in color slope of the envelopes can also be reproduced using stellar evolutionary models. For instance, adopting the Bertelli et al. (1994) isochrones we investigated the theoretical supergiant envelopes for their Z=0.001 model (to offset from the Galactic metallicity, Z=0.020, implicit in the empirical data of Schmidt-Kaler) and for three different ages between 10 and 100 Myr. The feature of the different color slopes in M_B, B-R vs. M_R, B-R is clearly seen at all ages; the older the stars, the lower the envelopes in terms of absolute magnitude, as expected. In section 6.1, we discuss further how the brightness of the brightest supergiants is translated into a distance estimate.

The distribution of stars on the CMDs of the sample galaxies indicates that red giants were below the detection limit in all cases. The tip of the first-ascent red giant branch (TRGB) has been seen in the CMDs of resolved galaxies, and a method using V, I photometry of the TRGB to determine galaxy distances was developed by Lee et al. (1993). Since we cannot identify the TRGB in our data, we cannot apply this method as a distance indicator.
4.1. UGC 4459.

The B brightness-coded position plot is displayed as Fig. 2. Fig. 3 illustrates the location of objects of different colors. Both Figures show a higher concentration of stars, and a preference for blue and yellow stars, in the area marked as belonging to the galaxy.

Inspection of the CMDs (Fig. 4) and the frequency plots reveals that objects brighter than 20'' in either B or R are likely to be foreground stars. In particular, the brightest object on the chart, which is also fairly red (object number 17, see HS), is concluded to be a foreground star fortuitously projected onto the face of the galaxy. The brightest blue stars in UGC 4459 start to appear at $B_v \sim 20.5''$ and $B-R_v \sim -0.2''$. Notice that there is no contribution to this portion of the CMD expected from galactic foreground stars (Fig. 4). The colors of the blue objects correspond to a population of early B supergiants in UGC 4459, capable of ionizing their surroundings. Since the effect of H$_\alpha$ emission on the R filter leads to redder observed colors, these blue objects could actually be of even earlier spectral types than those which are indicated by the observed colors. A V vs. B-V CMD of UGC 4459 was published by Karachentsev et al. (1994), who also suggest that the brightest blue supergiants start to appear at around 20.5'' in B.

The spatial distribution of stars in the R image (HS) as well as in the B chart (Fig. 2) shows two elongated, parallel features which appear more densely populated than other areas across the face of the galaxy. The gap is unlikely to be due to absorption, i.e., a dust lane. Both the R and the B image indicate that fewer bright stars are found in the gap than in the features, while the color map (Fig. 3) shows that blue stars are being detected in the gap. We therefore interpret the two features as being due to higher stellar densities in these regions of UGC 4459.

Our H$_\alpha$ image is shown in Fig. 5. HHG also published an H$_\alpha$ image of UGC 4459; the two agree very well. Another H$_\alpha$ image is available from Strobel et al. (1990). The overall
morphology of their image also compares well with our's. Fig. 5 shows several bright HII regions which coincide spatially with the two areas of high stellar density. There is also faint and diffuse emission in this galaxy as well. The bluest stars with $(B-R_o \leq -0.1^m)$ are all located in the areas outlined by the H$_\alpha$ emission. We count 14 HII regions in UGC 4459 (see Table 4). Strobel et al. distinguish 18 HII regions in their image. Of course, in both cases, there is an arbitrariness in the object identification and where the boundaries of HII regions are drawn. For instance, our image does not suggest the large number of HII regions Strobel et al. identify as regions 1 to 7, and instead displays more detail in regions 10 and 11.

The B vs. B-R CMD shows a number of bright, yellowish objects, with $B_o \approx 21$ and colors in the approximate range of $0.2^m \leq B-R_o \leq 0.5^m$. There seem to be no foreground objects having similar properties. The yellow objects are located in the same regions across the face of UGC 4459 as the blue stars. Three possible explanations present themselves. First, the bright and yellow objects could be an artifact of the reduction. Since they are situated in the densely populated regions of the galaxy, crowding is a problem. Second, populous clusters of young to intermediate age ($\leq 2 \times 10^8$ yr) produce colors in this range $(0.3^m \leq B-R_o \leq 0.4^m$, Bica et al. 1990). The brightest of the yellow objects could therefore be interpreted as star clusters. In the case of UGC 4459, we do not believe this to be the case often, since the brightest yellow objects seem to be part of a distribution of stars on the CMDs that extends smoothly to fainter magnitudes, and they also fit in with the overall brightness level of potential blue and red supergiants. Third, the yellow supergiants could be the evolutionary descendants of the most recently formed massive stars in UGC 4459.

The red objects with $B-R_o \approx 2^m$ and $R_o \leq 20^m$, although severely ($\sim 50\%$) contaminated by galactic foreground stars, may contain a contribution by red supergiants in UGC 4459. In spite of the fact that we are dealing with a very small number of objects, this can be
seen by comparing the B vs. B-R with the R vs. B-R CMD. The upper envelope to the most luminous stars in the B vs. B-R decreases by about 2.5\text{m} from blue to red, whereas that in the R vs. B-R remains quite level. This is the expected behavior for Ia supergiants (compare Fig. 1). Using the luminosity and color calibrations cited previously, we find that red giants in UGC 4459 are below the detection limit. Furthermore, the colors of the bluest stars and the detection limit rule out that our data reach the main-sequence for this galaxy.

4.2. UGC 7559.

Figures 6 to 9 display the data for UGC 7559.

The two brightest objects (objects 133 and 112, see HS) in the B vs. B-R CMD of stars in the galaxy (Fig. 8) coincide with regions of HII emission (Fig. 9). This might explain their yellowish colors with H\alpha contribution to the R filter. An H\alpha image of UGC 7559 has also been provided by HHG, but our image shows more detail. For instance, not detected by HHG but clearly visible on our image is a super-shell measuring \sim 27\arcsec. Several blue stars are coincident with the shell region (Fig. 7). We count a total of 12 HII regions on our image.

The R vs. B-R CMD of the galaxy shows the tip of the distributions of objects which might be interpreted as the brightest, single yellow and red supergiants in UGC 7559 at R_o \approx 19.5\text{m}-20\text{m}. This is consistent with the brightest blue stars being found at B_o and R_o of just above 20\text{m}. There is a gap in the B vs. B-R CMD in the brightness distribution of the brightest blue supergiants between the brightest object at B_o \approx 20\text{m} and the remainder of the blue (B-R_o \leq 0\text{m}) population, which continues below B_o \approx 21\text{m}.

The spatial location of the stars with colors around B-R_o = 0\text{m} is along the perimeter of the face of the galaxy as seen on the R image. However, the main "blue" supergiant
plume in this galaxy is quite yellow, with B-R\textsubscript{o} \approx 0.5\text{mag}. These yellow supergiants with colors between 0\text{mag} and 1\text{mag} are distributed much more uniformly across the face of the galaxy than the bluer objects. They also populate an outlying association which can be seen on the B chart at coordinates of X=10" and Y=90", and which on the R image of HS looks disconnected from the light distribution of the main body of UGC 7559. As Figures 7 and 9 show, this association coincides with an area of \text{H}_\alpha emission. Outlying associations or HII regions are also noticable in other galaxies in this sample (see below).

Since the galaxy subtends a large area of the CCD chip, what is displayed as foreground contamination in the CMDs is even more uncertain for this than other sample galaxies. Bearing this in mind, we infer from the CMDs that there is a substantial red supergiant population in UGC 7559.

4.3. UGC 8024.

Figs. 10 - 13 feature our data for UGC 8024.

Optical images as well as an HI map of UGC 8024 were published by Carignan & Beaulieu (1989). The inner HI-surface-density isophotes display a trianugulary shaped morphology that is similar to the shape of the body of the galaxy in the optical images. The HI envelope of this galaxy is found be to very extended, about 5 times the Holmberg diameter. In order to explain the rotation curve, a dark-matter halo is needed.

The galaxy has been well resolved into single stars by our observations, and the CMDs (Fig. 12) show a high contrast in the numbers of stars within the galaxy to those observed outside of the boundaries drawn in Fig. 10. The envelope of the brightest supergiants is well defined, and there is little concern about confusion with galactic foreground stars. The supergiants of UGC 8024 appear at magnitudes of around 20\text{mag}. Carignan & Beaulieu
(1989) also obtained single-star photometry of UGC 8024; they resolved 25 stars. They find $<B(3)> = 20.34 \pm 0.24$ for the three brightest blue supergiants. The blue plume of the CMD in Fig. 12 is very well populated. The mean color of the plume is $\sim 0.1''$, typical of A-type stars. There is also a fair number of stars with colors of G-to-K supergiants.

A few data points, which have large error bars, are found at $B-R_o \sim -0.7''$. Several of these are well above the detection limit, and so we do not believe their colors to be artifacts of the measurement process. The colors either suggest several mis-identified, very blue background galaxies, or they can be interpreted as being indicative of the presence of O-type stars in the galaxy. Since the magnitudes of these objects start at 2.5'' below that of the envelope of the brightest supergiants, they would include main-sequence O stars. The stars in the blue plume are located all across the face of the galaxy. Even bluer objects with $B-R_o \leq -0.2''$ also follow this distribution.

Our H$_\alpha$ image of UGC 8024 is displayed in Fig. 13. The Figure shows about eight distinct HII regions, and diffuse emission from across the entire face of the galaxy. A prominent HII region is found to be located outside of the main body of the galaxy as defined by the R (HS) and I (Fig. 13) images. The R and I images mainly show a triangularly shaped body of the galaxy. Faint resolved stars are detected curving from the tip of the body to the northeast towards this outlying HII region. Diffuse H$_\alpha$ emission is seen in the H$_\alpha$ image to extend to the northeast of the tip of the main body as well. This area of emission coincides with several blue objects near $X=110''$, $Y=135''$ in Fig. 11, suggesting that it might be another case of an outlying association.

4.4. UGC 8091.

Our data for this galaxy are displayed in Figs. 14 through 16.
According to Hodge et al. (1989) the center of this galaxy is dominated by HII regions; they count 32 individual HII regions. The H\alpha image of HHG shows only one, maybe two, fairly weak HII regions. HHG classified one as a possible shell. This shell is clearly visible on the deep R frame of HS. Drissen et al. (1993) searched UGC 8091 for the presence of Wolf-Rayet (WR) stars, the descendants of the most massive O stars, and found none. They suggest that this is due to the low massive-star content of this galaxy. In other words, the lack of WR stars could be a statistical effect. We further note that at low metallicity, only a small fraction of massive stars is expected to enter the WR phase; and the WR phase is also predicted to be a short stage in the evolution of massive stars - at ages of 7-10 Myrs the WR stars of a coeval population disappear while there are still low-mass O stars that can produce nebular emission (Meynet 1995).

There is a plume of blue stars with colors B-R\approx-0.1^m, equivalent to mid-B supergiants. The frequency plots and the CMDs (Fig. 16) indicate that most of the brightest objects are members of the galaxy. If the brightest supergiants are those objects with R\alpha and B\alpha of about 19m, we may expect to see some early-type main-sequence stars in the CMDs. According to Fig. 16, for these objects, confusion with faint blue foreground stars is also likely. The plume of blue supergiants is much narrower in color than in some of the other sample objects, probably due to the fact that this object is closer and better resolved, hence the effect of yellower colors resulting from insufficient de-blending of the stellar images is not so severe. The frames of this galaxy are also those with the best seeing (see HS, Table 1) in the sample. The bright objects with colors B-R\approx2^m are considered to be the red supergiants of UGC 8091.

A number of previous studies of the stellar content of UGC 8091 based on CMDs exist, however, all of them use different color systems than HS (e.g., Hoessel & Danielson 1983, de Vaucouleurs & Moss 1983, Aparicio et al. 1988, Tolstoy 1994, Tolstoy 1995). The data
presented here do not go to deeper limiting magnitudes than the ones published before, so they merely provide a consistency check. Tolstoy et al. (1995) derive an extinction corrected Cepheid distance modulus for UGC 8091 of (26.75±0.35)m, based on the identification of one Cepheid variable. We see the brightest blue supergiants at a B magnitude of 19.0m; Hoessel & Danielson find the brightest blue supergiants at B≤19.5, and Aparicio et al. give ⟨B(3)⟩=18.88. We derive a distance modulus based on the blue supergiants in section 6.1, and it is in agreement with Tolstoy et al.'s value.

Tolstoy (1995) discusses the morphology of neutral gas (HI), ionized gas (HII) and of blue and red stars in UGC 8091. She finds that red stars are spread uniformly across her UGC 8091 images, whereas blue stars and HII regions lie more in the center of the galaxy and follow the peaks in the HI distribution. From the interpretation of the CMDs she suggests a declining star-formation rate over the past 1 Gyr.

4.5. UGC 5272 A and B.

The B-filter frequency plot and the chart (Fig. 17) show that there are several bright blue objects that are located within the body of UGC 5272 A and which have no counterparts of similar brightness in the foreground. In the B vs. B-R CMD (Fig. 19), these show up as four bright objects with colors around 0.4m.

We have argued (Hopp & Schulte-Ladbeck 1991) that at least three of these objects (objects number 43, 23, and 80, see HS) could be star clusters in UGC 5272A. They coincide with the location of HII regions, which suggests that they may be the ionizing clusters. (Note that HHG presented an Hα image of UGC 5272 showing faint emission from the position of UGC 5272 B as well, which was located outside of the Hα frame of Hopp & Schulte-Ladbeck 1991). There are few resolved stars in that galaxy. Hopp &
Schulte-Ladbeck (1991) assumed that the fourth object, which is also the fourth brightest blue object in UGC5272 A, could be a bright blue supergiant and used it in estimating a distance from the method of the three brightest blue supergiants. After also comparing the blue supergiants in this galaxy with those of the LMC, they decided to adopt a distance of about 6 Mpc, much closer than that indicated in KK. (The estimate derived in section 6.1 puts UGC 5272 A at an even smaller distance.)

The frequency plots suggest with some certainty that the galaxy population in UGC 5272 A sets in below 20". The uncertainties both in terms of error bars and foreground confusion are large in the red part of the CMDs (Fig. 19). This makes it difficult to assess the number of red supergiants. Our data indicate that the number of red supergiants in UGC 5272 A is small. The bluest stars, B-R_0\leq0", are faint, starting at magnitudes of around 21.5". Several of these stars cluster in the outlying association labeled in Fig. 1 of Hopp & Schulte-Ladbeck (1991) and located near X=150", Y=130" on the charts (Figs. 17 & 18). The B vs. B-R CMD shows a prominent, bright plume of yellow supergiants, which reaches up to about B_0\leq20.7" or R_0\leq20.2". These objects are likely to contain additional blue supergiants, which appear at redder colors due to the effects discussed above (blending, H_0).

UGC 5272 is considered a blue compact dwarf galaxy (BCD, also known as isolated extragalactic HII regions) in the list of Kunth & Sévre (1986). This is also the case for several other of the sample galaxies, illustrating perhaps the absence of a firm definition that distinguishes BCDs from dIs.

### 4.6. UGC 5340.

Our data for UGC 5340 are presented in Figs. 20 - 23.
The R image of HS shows that this galaxy is poorly resolved. The CMDs (Fig. 22) of the foreground stars indicate that the contamination is severe for the brightest objects in UGC 5340. There are few stars in the CMDs which are actually expected to be objects in UGC 5340. It is therefore difficult to decide at which magnitude level the brightest supergiants occur. According to the frequency plots, stars in the galaxy are certainly found at magnitudes larger than 21". Most of them are rather blue. It is difficult to detect a genuine red supergiant population.

An Hα image of UGC 5340 was published by HHG. Our image is shown in Fig. 23 and is qualitatively in agreement with HHG, but at higher signal-to-noise it shows more detail. In addition to numerous distinct HII regions also seen on HHG’s image, Fig. 23 suggests that there is diffuse emission in the central regions of UGC 5340 as well. The CMDs indicate a small population of blue objects in the center. A comparison of the star chart in Fig. 20 with the R image of HS shows that many of the detected stars are situated in an outlying patchy extension at the northern end of the main body of UGC 5340. This extension contains some of the bluest stars and - according to the Hα images - at least 3 bright and 3 or 4 faint HII regions. At the southern end of the main body, another extension is visible in the R frame of HS which is also associated with faint Hα emission, but we detected no stars inside this region.

UGC 5340 is listed as a type Im/BCD in the catalog of Binggeli et al. (1990).

4.7. UGC 6456.

Figs. 24 to 27 show our data for this galaxy.

Very few objects are detected in UGC 6456. The R image of HS reveals that this galaxy is not well resolved. While the integration times were as long as those for most other
sample galaxies, this was an observation taken under poor seeing conditions. The frequency plot indicates that only blue objects are seen within the area considered to belong to the galaxy. A comparison of our B-Chart with our Hα image suggests that these blue sources coincide with regions of strong Hα emission. The blue objects are found in a small region of about 20" in diameter which is offset from the center of the galaxy in the R-band image of HS. Thuan et al. (1987) counted 8 HII regions in UGC 6456. Fig. 27 indicates 5 bright, and perhaps another 5 faint HII regions. That this galaxy is very actively forming stars is indicated by the recent detection in X-rays of a hot gas outflow driven by the present starburst (Papaderos et al. 1994)

The morphology of UGC 6456 resembles that of UGC 8091. UGC 6456 has also been classified as a BCD (Kunth & Sèvre 1986). It is considered the nearest BCD, and amongst the BCDs, belongs to the morphologically most frequent type of “iE” galaxies, which show elliptical outer isophotes and several areas of active star formation distributed irregularly near, but offset from, the center (Loose & Thuan 1985).

A V vs. B-V CMD was previously published by Karachentsev et al. (1994), but we are unable to match their chart of resolved stars up with our’s. This could be due either to the poor quality of their chart or the small number of point-sources identified in our frames. Since several of the bright objects we identified as point-sources and plotted on the CMDs coincide spatially with areas of very strong Hα emission, they may me unresolved stellar associations rather than single stars. This, and the small number of sources has prevented us from deriving a supergiant-envelope based distance for UGC 6456. We are currently in the process of analyzing HST images of this galaxy, which are of much better resolution than the available ground-based images and allow us to produce better CMDs for this galaxy (Schulte-Ladbeck et al. 1998).
4.8. UGC 8320.

Our data for UGC 8320 are displayed in Figs. 28 through 31.

The two brightest objects in the CMDs (Fig. 30) are considered to be foreground stars which happen to be projected onto the face of the galaxy. The next two brightest blue objects are identified as members of UGC 8320, owing to their association with HII regions.

An H$_{\alpha}$ image of UGC 8320 was published by HHG, and our image is shown as Fig. 31. On either image, UGC 8320 displays a wealth of bright HII regions, which are found distributed across the entire face of the galaxy. This suggests that the entire galaxy is presently in a state of vigorous star formation. There is a chain of regions forming a ridge across the center to the north-west edge of the body of the galaxy as seen in the R image of HS. Most of the resolved blue objects are distributed along that ridge as well (see Fig. 29). A few bright HII region are found near the southern tip of the galaxy and also include a blue object in our single-star photometry. A group of stars near X=80", Y=80" on Fig. 29 does not match up with any HII regions.

We assume that the blue supergiants have $B_0 \approx 19.5''$. Whereas there is a plume of blue supergiants, very few stars that could be red supergiants in UGC 8320 are seen. The bluest stars in UGC 8320 have colors which are consistent with those of O or early B. The CMDs may reach the main sequence for these stars.

4.9. UGC 8760.

In Figs. 32 to 34, we present our data for UGC 8760.

We interpret the data to indicate that the supergiant component of UGC 8760 appears at $B_0$, $R_0 \approx 20.5''$. There is a pronounced plume of blue objects in the B vs. B-R CMD
(Fig. 34), with $B-R_0 \approx 0^m$ and no serious foreground confusion. For objects with reasonable error bars, the blue plume extends to $B-R_0 \approx -0.5^m$. Three of six objects with bluer colors are also at the detection limit of our photometry. Thus, these objects could either be interpreted as O-type stars, or they could be spurious detections (see above). The fact that all six very blue objects coincide spatially with two areas of HII emission (HHG) at either end of the elongated body of this galaxy argues in favor of them being early-type stars in UGC 8760. Considering the galactic foreground contribution, the CMDs can only have a small population of red supergiants belonging to UGC 8760.

Morphologically, the appearance of this galaxy on the R image of HS is that of a very flat elliptical main body evenly populated with red stars. The blue stars (see Figs. 32 & 33) follow this distribution as well, thereby giving this galaxy a not-so-irregular appearance.

5. THE UNRESOLVED STARS

An underlying light distribution is evident in the B and R images of all sample galaxies. In HS, we described in detail how we extracted these smooth light distributions, in order to apply the PSF-fitting photometry discussed in the previous section. Here, we study the smooth light distributions which result from unresolved sub-threshold stars and - to a smaller extent and mainly in the R filter - from the emission of gaseous nebulae (see the discussion in Hopp & Schniite-Ladbeck 1987).

While the inner parts of the light distributions of the unresolved stars are often patchy, the overall appearance of the sample galaxies in both colors is relatively regular. They have elliptical shapes with only minor variations in the amount of ellipticity and orientation as a function of radius. We were able to follow most of these distributions out to a surface brightness, SB, of $\sim 27.0^m$ arcsec$^{-2}$ in B as well as in R. Thus, the light distributions
of the unresolved stars can be traced to twice the distances of the distributions of the resolved stars. The angular sizes, $2a_{\text{max}}$ ["], at which the brightness levels start to become indistinguishable from the background, are given in Table 3.

After smoothing the data with a spatial filter of a scale length 5", we studied the regular part of the underlying light distribution. We applied the ellipticity fit of Bender & Möllenhoff (1987) to the data. Figs. 2 & 3 of Hopp & Schulte-Ladbeck (1991) show an example of the resulting surface brightness profiles. These fits demonstrate quantitatively that the amount of ellipticity as well as the orientation are either constant as a function of radius or vary only slightly. Mean values for $\epsilon$ are given in Table 3. The observed surface brightness profiles also yield values for the central surface brightness in both colors, $\text{SB}(0, \text{fit})$ and the isophotal Holmberg diameter, $2a_H$, in ["] (Table 3). A comparison with Table 1 shows that the new sizes do not always agree with those listed by KK.

While the ellipticity and the position angle of a galaxy are very similar in the two colors, the surface brightness profiles $\text{SB}(a)$ are different. In particular, the color profile, $\text{SB}_B(a)-\text{SB}_R(a) = \Delta \text{SB}(a)$, varies with radius. In most cases, the profiles can be traced to larger distances in R than in B and the galaxies are becoming redder toward larger radii.

Most SB profiles are relatively regular, showing only small deviations from a linear behavior in SB over most of the spatial extension of the galaxies. (In some cases, central flattening and/or outlying cut-offs exist). This kind of light distribution is well described by the exponential disk law. Within the errors, the values given in Table 3 of the scale length, $\alpha^{-1}$, are identical in B and R for most sample galaxies. In UGC 4459, UGC 8091 and UGC 8760, the value in R is slightly larger than that in B.
6. DISCUSSION

Table 4 is a summary of derived characteristics of the sample galaxies. The column headings are quite self-explanatory. The entries in columns 2-5 concern the supergiant luminosities and distances of the galaxies, as described in detail section 6.1.

In column 6, we list the number of HII regions seen in each galaxy. This is a subjective number since it depends on the depth of available exposures and the stretch of the published images and should be taken as a lower limit to the actual number of HII regions in a galaxy. We compared our numbers with those given by other authors in the sections on individual objects.

We also give numbers and percentages for OB, AF, and GKM stars, which can be compared with results of other authors, e.g., Hunter & Gallagher (1985). They were derived by counting the numbers of stars in the B-R color interval smaller than 0.0$^m$ for the OB stars, 0.0$^m$ to 0.99$^m$ for the AF stars, and 1.0$^m$ and above for the GKM stars. Star counts in these color bins were carried out for both, stars in the galaxy and foreground star, samples. A correction was applied to account for the different areas on chip subtended by the galaxy and the foreground. UGC 6456 and UGC 5272 B have no entries, due to the paucity of data on their resolved stellar content. For all of the entries on the numbers of resolved stars, we are of course dealing with small number statistics.

In column 10, we list the B-R color of the underlying light distribution of unresolved stars as derived from the data in section 5. Finally, column 11 provides an indication of whether or not an outlying association or HII region is observed with a clear separation from the main distribution of stars in the respective galaxy.
6.1. Supergiant Luminosities, Distances

In Table 4, we give an estimate of the apparent blue magnitude corrected for galactic extinction, of the envelope of the brightest stars which we conclude to be members of the respective galaxy, $B^0_{env}$. As this step is quite subjective, both authors independently derived a value for $B^0_{env}$ by inspecting the CMDs as well as the luminosity functions, and the results agreed reasonably well. Our method is accurate to $\pm 0.5^m$ at best, and so we give magnitudes rounded to the nearest half magnitude. In Table 4, the objects are sorted by increasing $B^0_{env}$ and presumably distance.

In order to determine distance moduli from the observed envelope brightnesses, we used the calibration relations by Rozanski & Rowan-Robinson (1994). Their Figure 10(f) relation gives a calibration for the apparent blue magnitude of the three brightest blue supergiants minus the total apparent blue magnitude of the galaxy, versus the total absolute blue magnitude of the galaxy. The total, extinction corrected, apparent blue magnitudes of the galaxies were derived from the integrated B magnitudes given in Table 1 of HS, where the error is estimated to be about $0.1^m$ (except for UGC 4459 where part of the galaxy was not included on the CCD chip). Note that the magnitude difference for UGC 8091 places it well below the calibrated data range; we extended it with the regression. The resulting $M^0_{B,T}$ values are listed in Table 4. The photometric error for the apparent magnitude difference was derived by quadratically adding the supergiant-envelope error ($0.5^m$) and B-magnitude error ($0.1^m$), and is of order $0.51^m$. Together with the error that Rozanski & Rowan-Robinson list as that on a single observation using the regression, $0.88^m$, this leads to an uncertainty of $1.02^m$ in the $M^0_{B,T}$ values listed in Table 4.

We then used Rozanski & Rowan-Robinson's Figure 10(c) B-band luminosity calibration to derive the absolute blue magnitude of the brightest blue supergiants, $M^0_{B,BSG}$, see Table 4. The distance moduli can now be derived. For the error in this calibration we adopted
their minimum error on the distance modulus using the regression, $0.90''$. The propagated minimum error on $M_{0,B,BSG}$ and the distance modulus is $1.36''$.

In our sample, a Cepheid distance exists only for UGC 8091 (Tolstoy et al. 1995), $m-M=(26.75\pm0.35)''$, yielding $-12.43''$ for the extinction-corrected, total absolute blue magnitude of the galaxy. Recall that our observed parameters for UGC 8091 lie beyond the extent of Rozanski & Rowan-Robinson’s calibration relations but we assumed the linear regressions continue to be valid for galaxies with lower absolute blue magnitudes. This predicts $-6.93''$ for the B luminosities of the brightest blue supergiants, and $19.82''$ for their apparent B magnitudes. We find the brightest blue supergiants at $(19.0\pm0.5)''$. This is, within the errors, in agreement with the above prediction, and in excellent agreement with the work others (Hoessel & Danielson 1983, Aparicio et al. 1988). We derive $M_{0,B,T}=(-12.2\pm1)''$, which agrees well with Tolstoy et al. The Rozanski & Rowan-Robinson calibrations yield $M_{0,B,BSG}=-6.9$ and $m-M=25.9$, with a minimum error of $1.36''$, values that agree with Tolstoy et al. within the errors. Kharachensev & Tikhonov (1984) list $M_{0,B,BSG}=-6.26''$, $M_{0,B,T}=-10.4''$ and a distance modulus of 25.10 for UGC 8091. A small distance modulus seems unlikely because then the TRGB should be visible in Tolstoy’s (1995) CMDs.

Our sample galaxy UGC 4459 is considered a member of the M 81 (or B2) group. The Cepheid distance of M 81 is $m-M=(27.80\pm0.20)''$ (Freedman et al. 1994). We find the brightest blue supergiants of UGC 4459 at $(20.5\pm0.5)''$, and the resulting distance modulus is $27.8''$, in excellent agreement with the M 81 distance. (Recall that the distance-modulus error is expected to be larger than the formal $1.36''$ error due to the unknown measurement error on the total apparent blue magnitude of the galaxy.) Kharachensev & Tikhonov (1984) give $M_{0,B,BSG}=-7.36''$, $M_{0,B,T}=-13.2''$ and a distance modulus of $27.66''$.

For UGC 6456, Schulte-Ladbeck et al. (1998) used an HST/PC2 I, V-I CMD to find
a TRGB distance modulus of $(28.4 \pm 0.09 \pm 0.18)^\text{m}$. We can use this distance estimate to evaluate at what apparent B magnitude we should be finding the brightest blue supergiants in the calibration of Rozanski & Rowan-Robinson. Using HS for the apparent blue magnitude of the galaxy, $14.19^\text{m}$, and the above distance modulus, we find the absolute blue magnitude of UGC 6456 to be $-14.21^\text{m}$. The Rozanski & Rowan-Robinson Figure 10(c) B-band luminosity calibration then yields $M_{B,BSG}^0 = -7.43$, indicating we should see the brightest blue supergiants at an apparent B magnitude of about $21.0^\text{m}$. The HST data do not include the B and R bands. The three brightest blue supergiants are found at a V magnitude of about $20.1^\text{m}$ with colors that correspond to early A-type supergiants. This predicts that in the B-band, they should become visible around $20.2^\text{m}$ (recall the minimum error from the Figure 10(c) regression is $0.9^\text{m}$, so ground-based and HST results are not inconsistent). In order to make another, more direct comparison with the HST data, we may also use the brightest red supergiants, which appear at a V magnitude of about $21.2^\text{m}$ in the HST CMD. We can now use Rozanski & Rowan-Robinson’s Figure 10(a) relation to derive the absolute V magnitude of the brightest red supergiants to be $-7.08^\text{m}$, and their apparent V magnitude should hence be $21.3^\text{m}$. Here, the agreement between the data and the Rozanski & Rowan-Robinson prediction is excellent.

A comparison of our distances with those of KK shows that we place UGC 5272 A and UGC 5340 about a factor of two closer, from the 8 to 9 Mpc range to the 4 to 5 Mpc range. Our results make sense since we resolve many stars in these galaxies. We also find that UGC 8024 and UGC 8320 may be closer than their KK distances. For UGC 6456, on the other hand, the HST TRGB distance is twice that of its KK distance.
6.2. Stellar Content and Star-Formation Histories

As a note of caution before we start our deliberations on the stellar content of the sample galaxies, we point out that colors and magnitudes of stars of different stellar masses and ages depend on metallicity, and that the interpretation of the data is sensitive to the stellar models produced by different groups. We mean the age bins into which we grouped the discussion sections below as a rough division of ages as indicated by the presence of certain stellar types and by the color of the integrated light.

6.2.1. Stars younger than 10Myr

There are several indicators for the presence of very young stellar components in galaxies, namely direct observation on the CMD of main-sequence stars with masses of around $15 \, M_\odot$ and above, detection of $\text{H}_\alpha$ emission which also evidences massive, H-ionizing stars, observation of WR stars which represent a very short-lived phase ($<3\,\text{Myr}$) in the evolution of massive stars.

The detection of WR stars is usually accomplished with either imaging or spectroscopy data by discriminating the “WR feature” at around 4650Å against the continuum. The sample galaxies as a whole have not been surveyed specifically for presence of WR stars. The exception is UGC 8091 which was searched for WR stars with imaging, but none were found (see section 4.4). Kinman & Davidson (1981) combined spectra of several galaxies exhibiting similar spectra, including UGC 5272 A, and detected a weak “WR feature” in the resulting spectrum of higher signal-to-noise. It is not clear, however, how much of this feature is attributable to WR stars in UGC 5272 A. Absence of the “WR feature” in UGC 6456 indicates that no WR stars are present in this galaxy, at least at those positions sampled by the spectrograph’s entrance aperture (Izotov 1998). We did not find information
on other of the sample galaxies in the literature. Hence, our knowledge of star births in the last few Myr is limited. The observation of both blue and red supergiants in the CMDs suggests, however, that star-formation in the sample galaxies did not experience a recent, sharp temporal cutoff.

All of the sample galaxies display HII emission, clearly organized into HII regions and coincident with young stellar associations. For several galaxies, we thought the main-sequence was detected in the resolved stars as well. Following Maeder & Meynet (1989), the H-burning lifetimes of OB stars are of the order of several $10^6$ to $10^7$ years. Hence all of the sample galaxies have made massive stars within the last about 10Myr. The observation of both blue and red supergiants in the CMDs of the sample galaxies suggests that star-formation was active over a recent period of several 10Myr.

One of the sample galaxies deserves to be noticed. UGC 8320 clearly stands out in a comparison of Hα images of the sample galaxies. It also has the highest fraction of OB stars in the sample (although there does not appear to be a correlation between the number of HII regions and the fraction of OB stars among the sample galaxies in general). Its background-light color is so blue that we suggest this galaxy has made a significant fraction of its stellar mass in recent history.

The locations of the HII regions and of the young stellar associations show diverse morphologies among our sample of galaxies, ranging from being distributed all across the entire face of a galaxy, to being concentrated only in specific regions, sometimes near the center of a galaxy. This suggests that at a given time a variety of locations within the potential well of a dI can act as star-forming sites.
The presence of supergiants can be used to track star births into the several 100Myr interval of the star-forming history of the sample galaxies. The distances are crucial here to reveal how deeply we view into the stellar content to fainter magnitudes and hence, lower masses and larger ages. Overlaying stellar-evolutionary tracks onto our CMDs (e.g., Bertelli et al. 1994) we find that we can in general detect supergiants with ages of up to around 50Myr. Beyond 50Myr, the data are severely affected by incompleteness and blending.

With the usual caveats, we find that blue and red supergiants are detected in all of the sample galaxies. (The “non-detection” of red supergiants in UGC 8320 is most likely due to small-number statistics combined with an over-correction of the Galactic foreground. In other words, we do not claim that the data prove an absence of red supergiants in this galaxy.) In particular, we do not observe the presence of red supergiants without the simultaneous presence of blue supergiants as well. This means that none of the systems we investigated has had a subdued recent star-formation rate.

The sample galaxies show, quite in general, a large fraction of yellow supergiants, usually over 50% and up to about 75%. This is probably due to the poor resolution of the galaxy images. The Hunter & Gallagher (1985) spectroscopically investigated dI sample has, on average, only a little over 20% of AF stars and they find about 35% of OB stars and about 45% of G-M stars as the typical fraction resulting from their population synthesis analysis. Due to the small numbers of resolved stars, we do not feel that our data can contribute to the question of the ratio of blue-to-red supergiants in galaxies, one of the major unsolved problems of stellar astrophysics. The blue-to-red supergiant ratio of galaxies is observed to be in the range from 0.4 in the SMC, to 3.6 in young Galactic clusters, and is a function of metallicity (see Langer & Maeder 1995). Six of our sample galaxies have had their HII-region abundances measured and show low oxygen abundances with respect
to solar. Keeping in mind that in our data, the number of red supergiants is expected to be affected by incomplete foreground-star subtraction, and that the blue supergiant counts will include main-sequence stars, our result for the average blue-to-red supergiant ratio of the sample galaxies is consistent with published ratios. Clearly, data of higher spatial resolution are needed to contribute to this interesting question.

6.2.3. Intermediate-age and old stars

We cannot distinguish stars such as asymptotic giant branch stars or red giants, which would allow us to access older stellar populations based on the CMDs. However, we can make use of the integrated color of the background light to learn about the older stars.

What is the stellar content indicated by the underlying light distributions? We presented in section 5 our findings of the regular, elliptical morphology of the background light distributions and the large extent of most sample galaxies in the R band, as well as their redder colors towards larger radii. This provides some indication for the presence of dynamically older stellar components.

As a first step towards an interpretation of the background-light colors, we can make the assumption that the bright, resolved stars belong to a population that is young, and that the faint light of the unresolved stars originates from a population that is old. Using the Johnson (1966) Tables, the colors of the underlying light distributions correspond typically to mid-F-type main sequence stars. Such stars have lifetimes of the order of several Gyr.

A more detailed interpretation of the color of the underlying light distributions, which accounts for its (presumed) low metallicity, can be carried out using the population synthesis models of Schmidt et al. (1995). To model the color of an old, metal poor population,
Schmidt et al. use a combination-spectrum of several low-metallicity, Galactic globular clusters. The B-R color of their cluster template is $1.18^m$. A red color of the background light with $B-R>1^m$ is observed in two of our sample galaxies, UGC 6456 and UGC 8091, suggesting the presence of a stellar population substratum with an age of several Gyr to a Hubble time.

In the remaining galaxies, the background light is bluer. This either indicates that the underlying stellar populations that we detect have been made less than a few times $10^9$ yrs ago, in some cases, even less than a few times $10^8$ yrs ago, or we must explore the idea of a more complex star formation history. The next simplest step that we can take in the interpretation of the background-light colors is to assume the background light itself is composed of a mix of at least two stellar generations. To do so we compare the background-light colors with the colors predicted by Schmidt et al. from a combination of the Galactic globular cluster template with that of young clusters having a range of ages. B-R colors in the range of $0.8^m$ to $1^m$, as seen in several sample galaxies, (see Table 4) can easily be reproduced with a combination of the oldest- and various younger-population templates. Both the ages of star-forming events, and their strengths need to be considered when predicting galaxy colors. Specifically, the model colors will depend on just how much light (or mass) is contributed by a younger population to dilute the light from the old population; young populations contributing just 0.1% to 10% in mass and with ages from a few 10 Myrs to 500 Myr can thus produce the colors of UGC 7559, UGC 4459, UGC 8769, and UGC 5272 A. An alternative interpretation of this result is that these galaxies have experienced a more-or-less constant star-formation rate over long time scales.

The fairly blue colors, in the range of $0.3^m$ to $0.5^m$, which we observe for the background-light distributions of UGC 8320, UGC 8024, UGC 5272 B and UGC 5340, can only be produced (in the Schmidt et al. models) with a large mass fraction (10% or more)
of young stars. In such cases, the underlying old population remains undetectable.

6.2.4. Star-formation Histories

An attempt at interpreting the results on the resolved stellar content and the background-light colors in terms of the star-formation histories of the sample galaxies leads to the following picture. It is highly likely that all of the sample galaxies contain old stars, i.e., with ages of the order of a Hubble time, but that due to different mass fractions of stars produced throughout the histories of individual galaxies, the light from these faint, red stars is diluted by light from bluer and younger stars to various degrees. In UGC 6456 and UGC 8091 we observe red background-light colors indicative of old stars, and we also see HII regions and resolve young stars. After their initial star-forming events, these galaxies may have experienced a long period of quiescence before the onset of a more recent episode of star formation. UGC 7559, UGC 4459, UGC 8760, and UGC 5272A show resolved, young stars and, in addition, intermediate colors of their background light, indicating that the light of the old stars is partially diluted by that from younger stars. These galaxies may have been making stars more continuously, such as in a series of several events, in their recent histories. UGC 8320, UGC 8024, UGC 5272 B, and UGC 5340, showing the bluest colors of their background light and also resolved, young stars, may have been producing large mass fractions of stars in their recent histories.

6.3. Environmental Effects

As a result of section 6.1, we found that UGC 5272 A and UGC 5340 are closer and UGC 6456 is more distant than previously thought. In order to re-asses their isolation (see section 2), we investigated the distribution of galaxies in KK along the line-of-sight toward
these galaxies. There are no galaxy groups or massive galaxies at the new distances, with 
which these sample galaxies could be associated.

Apart from the isolation of our sample galaxies from massive neighbors, we also 
have to investigate proximity to other low-mass galaxies, in particular since dwarf-dwarf 
interactions have been considered as star-formation triggers in dwarf galaxies. We note that 
UGC 8320 is actually located near UGC 8308 (Im V), UGC 8331 (Im IV) and UGC 8215 
(Im V); UGC 8760 could form a group of dwarfs with UGC 8833 (Im pec) und UGC 8651 
(Im IV), and UGC 5272 A with UGC 5272 B and UGC 5340 (all sample galaxies). This 
suggests that in our sample, only UGC 6456 is a truly isolated field galaxy.

Having re-discussed the relative isolation of our sample galaxies, we compared several 
of their global properties with those of other galaxy samples. Let us note at the onset that 
we are dealing with highly uncertain results in this section, owing to our small sample size, 
the sometimes ill-known parameters being compared, and the fact that comparison samples 
were compiled from the literature.

6.3.1. Effects of Massive Neighbors

Structural types of massive, luminous galaxies are well known to vary as a function 
of their environmental galaxy density. The debate over whether this difference is due 
to instrinsic conditions or environmental factors, such as galaxy-galaxy interactions, 
currently seems to favor the latter. We ask whether there is any effect of environment 
on the structural parameters of dIs. The structural parameters of the sample galaxies 
were previously compared with those of Virgo Cluster dwarfs by Hopp (1994). He showed 
that the same correlation of scale length with $B_T$ holds for field and cluster galaxies. 
In other words, the stellar components of isolated galaxies show no obvious structural
differences from the Virgo Cluster members at least with respect to size. We compared the structural parameters $SB(0)_B$ and $\alpha^{-1}_B$ of our sample galaxies (see Table 3) with those derived by Vennik et al. (1996) for galaxies distributed over a large range of absolute blue magnitudes and situated in groups, sheets and voids. The structural parameters of our sample galaxies overlap with, and form a smooth extension of, the low-luminosity end of the structural-parameter distributions derived for those galaxies. In terms of size and central surface brightness, our sample galaxies show no difference from them. The conclusion is that apparently, some structural parameters of dIs such as their stellar-disk sizes are insensitive to the environment.

Another issue related to structural parameters of the sample galaxies (but not their environment) is their classification. We noted repeatedly that some of the dIs in our sample have a BCD designation in the literature (UGC 5272 A, UGC 5340, UGC 6456) and we mentioned the lack of a clear dI vs. BCD classification criterion. Recently, Meurer (1998) suggested that a line of demarcation could be drawn on the basis of blue central surface brightness, with objects showing $SB(0)_B$ brighter than about $22''/\text{arcsec}^2$ being BCDs and objects fainter than about $22''/\text{arcsec}^2$ being dIs. While in our sample, UGC 5340, listed as a type Im/BCD in the catalog of Binggeli et al. (1990), has $SB(0)_B$ close to $22''/\text{arcsec}^2$, UGC 5272 A and UGC 6456 are somewhat fainter. However, inspection of Meurer’s Fig. 3 suggests that there is actually some overlap between the dI and BCD galaxy types in the 21.5-23.5''/\text{arcsec}^2 region, and our sample galaxies happen to fall with their $SB(0)_B$ exactly into this overlapping region.

The global colors of dIs reflect their populations and recent star-formation histories. As a group, Irregular galaxies are the bluest of the normal galaxies, with average colors of $U-B=-0.3$, $B-V=0.4$ (Hunter & Gallagher 1986). Note that among the IGs there may be an effect of bluer colors occurring among galaxies of low luminosity, i.e., the dIs. Gallagher &
Hunter (1985, 1987) used broad-band, total galaxy colors to compare the stellar populations and star-formation rates of a sample of Virgo Cluster IGs with a sample of IGs in the field (note, these samples comprise not just dIs, but contain more luminous Irregulars as well). They found that Cluster members are, on average, redder, U-B≈-0.13, than galaxies in the field sample, U-B≈-0.33. In Figure 35, we compare the total U, B, V, R colors of our sample galaxies (cf. HS) with those of the samples studied by Gallagher & Hunter (1986, 1987). Our galaxies tend to be found in the blue portion of the distributions, with an average U-B=-0.35. Our sample galaxies show colors that resemble those of the dIs or BCDs, and of IGs found in the field. Since our sample was chosen to comprise dIs in low-density regions, the dependence of IG colors on both galaxy luminosity and environmental density affect the result – are these galaxies blue because all dIs have blue colors, or are they blue because they are located in the field? Maybe these two issues are not independent of one another.

In the Local Group, for instance, the numbers increase and the ages of the dominant populations of low-mass galaxies decrease, with increasing distance from the center (van den Bergh 1994). We conclude that the blue total colors of our sample galaxies indicate that vigorous star formation does occur in isolated dIs, i.e., in the absence of external triggering by massive galaxies.

In the previous section, various indicators for young and old populations were employed in an attempt glean some limited insight into the star-formation histories of the sample galaxies. All of the galaxies show HII regions and resolve into blue stars, hence all of them are actively forming stars at the present epoch. However, where the star-formation histories are concerned, there appears to be some variety both in the amount and in the time-scales over which stars have been forming. This is rather similar to results found for the Local Group dIs. Their star formation took place at different times and with different intensities as well (Grebel 1997). It is possible that the data quality and our understanding of the CMDs, as well as our knowledge of the history of interactions, is not yet sophisticated
enough to enable us to discern the role of environmental effects on star-formation histories of dIs. Perhaps the stellar population differences between cluster and field dIs, if they exist, are subtle, otherwise we would classify the galaxy as something else, such as, e.g., a dSph.

In order to continue actively forming stars, a galaxy needs to have available a reservoir of material from which to form stars. Huchtmeier et al. (1997) compared the $M_{HI}/L_B$ ratios (considered an indicator for the star-forming potential of a galaxy) for a sample of dwarf galaxies in voids, with other dwarf galaxy samples, including that of dwarfs in the sample of nearby galaxies (KK) and of Virgo cluster dwarfs. They find a tendency for isolated galaxies to show larger values of $M_{HI}/L_B$ compared to the other samples, and suggest that this may be due to a smaller chance for galaxy-galaxy interactions for the void galaxies. We have taken the ratio of HI-mass-to-blue-luminosity for our galaxies from the compilation Schmidt & Boller (1992). The value of the mean $M_{HI}/L_B$ of our sample galaxies is 1.98 (in units of $M\odot$ and $L\odot$) and the scatter is $\pm$ 1.94. Hence, our sample galaxies possibly also show an elevated $M_{HI}/L_B$ ratio compared to samples of dwarfs in denser environments. The conclusion is that the environment of our sample galaxies is in principle favorable for fueling continuing star formation in the future.

In spite of their isolation, our sample galaxies exhibit globally very blue colors and have large HI masses for their blue luminosities, indicators for current and potential future high levels of star formation. With the caveats outlined at the beginning of the section, our results indicate that interactions with massive galaxies are unimportant as a trigger of star-formation in the sample galaxies. But, just how much the star-formation histories of field vs. cluster dIs differ as a result of different interaction histories remains unclear. It is suggested that one difference between galaxies in high-density and low-density environments might be their gas reservoirs. This could result in isolated dIs evolving more slowly, although that will also depend on how they recycle, acquire, or lose ISM.
6.3.2. Effects of Low-Mass Neighbors

In the absence of massive neighbors, what may trigger the star formation in dwarfs? Among the possibilities discussed in the literature are the hypothesis of self-propagating star-formation, interaction with low-mass neighbors, or the accretion of HI gas until a critical threshold is exceeded (see section 1).

Two pieces of information on our sample galaxies appear relevant. First, HII regions and young associations can be spread out over an entire galaxy. This may present a problem for the self-propagating star-formation scheme. How and why are such widely distributed regions of a galaxy all forming stars at the same time, when the self-propagating star-formation hypothesis rather envisions star formation to migrate with time from one active site of a galaxy to an adjacent site?

Second, several galaxies show outlying associations of blue stars or outlying HII regions (Table 4). An interesting question that arises is the following: when should we call an object and outlying HII region/association of a given dI and when a dI in its own right? This needs to be disentangled in the context of the hypothesis that dwarf-dwarf encounters trigger star formation in dIs. An educational example is provided by UGC 5272 A,B. Hopp & Schulte-Ladbeck (1991) called one outlying association of stars UGC 5272 B and thought of it as a companion galaxy. Another star cluster, however, was described as an outlying association rather than a companion galaxy, due to its greater proximity to UGC 5272 A. Note that Taylor et al. (1993) comment that UGC 5272 A and B are too close to one another to be separated on their HI maps. Another instructive example is that of the BCD SBS 0335-052 which also exhibits an “outlying HII region”; this region is demonstrated to be included within the HI envelope of the galaxy (Lipovetsky et al. 1996). Where should one draw the line between an outlying association and a dI companion? And if the interaction with an HI cloud triggers star formation in the dI, shouldn’t it also trigger
star-formation in the HI cloud it is interacting with (but see Chengalur et al. 1995)?

The presence of the outlying associations shows that star formation in dIs is taking place in regions of a galaxy that are quite far from other regions of the same galaxy which have previously been forming stars; again, this would seem to present a problem for the self-propagating star-formation hypothesis. If any one mechanism is to explain the triggering of star formation in isolated dIs, it will have to account for the range of morphologies seen in the distribution of star-forming sites, as well as for the variety in star-formation histories.

7. CONCLUSIONS

We presented and discussed the morphology and nature of resolved stars in 10 dIs which are generally more distant than galaxies previously resolved into single stars. We also discussed the character of the underlying, extended light distributions of the unresolved stars of these galaxies.

Whereas the shape of the underlying light distributions can be modeled by ellipses, the distribution of the bright, resolved stars is frequently clumpy. HII regions and associated blue stars are present in all of the sample galaxies, sometimes scattered across the entire face of the parent galaxy, sometimes clustered in distinct regions only.

Several cases of HII regions and young stellar associations were pointed out that are located outside of the main body of resolved stars of the parent galaxy, but not outside of the Holmberg radius. The question of where to draw the dividing line between an “outlying association” and a “companion dI” was raised. This problem has obvious implications regarding the hypothesis that encounters with other dwarf galaxies or HI clouds trigger star formation in dIs. On the other hand, the self-propagating star-formation hypothesis implies that star-forming regions in dIs should be found within some proximity of one another,
rather than isolated. Why then do we see single aggregates of young stars in remote regions of dIs? It should be interesting to compare the stellar content of such outlying associations with that of more centrally located star-forming regions.

The general picture that emerged is that while all sample galaxies are presently experiencing star formation, their histories were quite diverse, with differences in star-forming intensity and duration from galaxy to galaxy. A similar result has been derived for the dIs of the Local Group. With current knowledge about the star-formation histories of dIs it is not possible to distinguish any differences in evolution between dIs in high- and low-density environments.

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FIGURE CAPTIONS

Fig. 1.— Illustrative template CMDs constructed from data in Schmidt-Kaler (1965). The range of spectral types is from O9.5 to M4. Between B0 and M0, data were considered in intervals of 0.5 subtypes. The luminosity classes used were Ia, III, and V. The template CMDs are plotted to the same scale as the CMDs of the sample galaxies. Overlaying the templates onto the sample CMDs serves as an indicator for the envelope of brightest stars in the galaxies.

Fig. 2.— The brightness-coded position of all sources detected in the B-filter. The areas on the chip assumed to include stars in the galaxy vs. stars in the foreground are separated by a dashed line.

Fig. 3.— The color-coded position of all sources detected in the B- and R-filters. Three symbol sizes are used. In order of decreasing size the symbols indicate B-R<0.0, 0.0≤B-R<1.0, and B-R≥1.0. This provides a rough separation of the stellar types into OB, AF, and GKM stars.

Fig. 4.— The panels on the left-hand side show B vs. B-R CMDs, whereas the panels on the right-hand side show R vs. B-R CMDs. The two top panels include all stellar sources detected in the B- and R-filters.

Fig. 5.— The I-filter image of UGC 4459 is shown on the bottom, the Hα-I filter image is shown on the top.

Fig. 6.— The brightness-coded position of all sources detected in the B-filter. The areas on the chip assumed to include stars in the galaxy vs. stars in the foreground are separated by a dashed line.
Fig. 7.— The color-coded position of all sources detected in the B- and R-filters. Three symbol sizes are used. In order of decreasing size the symbols indicate B-R<0.0, 0.0≤B-R<1.0, and B-R≥1.0. This provides a rough separation of the stellar types into OB, AF, and GKM stars.

Fig. 8.— The panels on the left-hand side show B vs. B-R CMDs, whereas the panels on the right-hand side show R vs. B-R CMDs. The two top panels include all stellar sources detected in the B- and R-filters.

Fig. 9.— The I-filter image of UGC 7559 is shown on the bottom, the Hα-I filter image is shown on the top.

Fig. 10.— The brightness-coded position of all sources detected in the B-filter. The areas on the chip assumed to include stars in the galaxy vs. stars in the foreground are separated by a dashed line.

Fig. 11.— The color-coded position of all sources detected in the B- and R-filters. Three symbol sizes are used. In order of decreasing size the symbols indicate B-R<0.0, 0.0≤B-R<1.0, and B-R≥1.0. This provides a rough separation of the stellar types into OB, AF, and GKM stars.

Fig. 12.— The panels on the left-hand side show B vs. B-R CMDs, whereas the panels on the right-hand side show R vs. B-R CMDs. The two top panels include all stellar sources detected in the B- and R-filters.

Fig. 13.— The I-filter image of UGC 8024 is shown on the bottom, the Hα-I filter image is shown on the top.

Fig. 14.— The brightness-coded position of all sources detected in the B-filter. The areas on the chip assumed to include stars in the galaxy vs. stars in the foreground are separated
by a dashed line.

Fig. 15.— The color-coded position of all sources detected in the B- and R-filters. Three symbol sizes are used. In order of decreasing size the symbols indicate B-R<0.0, 0.0≤B-R<1.0, and B-R≥1.0. This provides a rough separation of the stellar types into OB, AF, and GKM stars.

Fig. 16.— The panels on the left-hand side show B vs. B-R CMDs, whereas the panels on the right-hand side show R vs. B-R CMDs. The two top panels include all stellar sources detected in the B- and R-filters.

Fig. 17.— The brightness-coded position of all sources detected in the B-filter. The areas on the chip assumed to include stars in the galaxy vs. stars in the foreground are separated by a dashed line.

Fig. 18.— The color-coded position of all sources detected in the B- and R-filters. Three symbol sizes are used. In order of decreasing size the symbols indicate B-R<0.0, 0.0≤B-R<1.0, and B-R≥1.0. This provides a rough separation of the stellar types into OB, AF, and GKM stars.

Fig. 19.— The panels on the left-hand side show B vs. B-R CMDs, whereas the panels on the right-hand side show R vs. B-R CMDs. The two top panels include all stellar sources detected in the B- and R-filters.

Fig. 20.— The brightness-coded position of all sources detected in the B-filter. The areas on the chip assumed to include stars in the galaxy vs. stars in the foreground are separated by a dashed line.

Fig. 21.— The color-coded position of all sources detected in the B- and R-filters. Three symbol sizes are used. In order of decreasing size the symbols indicate B-R<0.0, 0.0≤B-
R<1.0, and B-R≥1.0. This provides a rough separation of the stellar types into OB, AF, and GKM stars.

Fig. 22.—The panels on the left-hand side show B vs. B-R CMDs, whereas the panels on the right-hand side show R vs. B-R CMDs. The two top panels include all stellar sources detected in the B- and R-filters.

Fig. 23.—The I-filter image of UGC 5340 is shown on the bottom, the Hα-I filter image is shown on the top.

Fig. 24.—The brightness-coded position of all sources detected in the B-filter. The areas on the chip assumed to include stars in the galaxy vs. stars in the foreground are separated by a dashed line.

Fig. 25.—The color-coded position of all sources detected in the B- and R-filters. Three symbol sizes are used. In order of decreasing size the symbols indicate B-R<0.0, 0.0≤B-R<1.0, and B-R≥1.0. This provides a rough separation of the stellar types into OB, AF, and GKM stars.

Fig. 26.—The panels on the left-hand side show B vs. B-R CMDs, whereas the panels on the right-hand side show R vs. B-R CMDs. The two top panels include all stellar sources detected in the B- and R-filters.

Fig. 27.—Hα image of UGC 6456.

Fig. 28.—The brightness-coded position of all sources detected in the B-filter. The areas on the chip assumed to include stars in the galaxy vs. stars in the foreground are separated by a dashed line.

Fig. 29.—The color-coded position of all sources detected in the B- and R-filters. Three symbol sizes are used. In order of decreasing size the symbols indicate B-R<0.0, 0.0≤B-
R≤1.0, and B-R≥1.0. This provides a rough separation of the stellar types into OB, AF, and GKM stars.

Fig. 30.— The panels on the left-hand side show B vs. B-R CMDs, whereas the panels on the right-hand side show R vs. B-R CMDs. The two top panels include all stellar sources detected in the B- and R-filters.

Fig. 31.— Hα image of UGC 8320.

Fig. 32.— The brightness-coded position of all sources detected in the B-filter. The areas on the chip assumed to include stars in the galaxy vs. stars in the foreground are separated by a dashed line.

Fig. 33.— The color-coded position of all sources detected in the B- and R-filters. Three symbol sizes are used. In order of decreasing size the symbols indicate B-R<0.0, 0.0≤B-R<1.0, and B-R≥1.0. This provides a rough separation of the stellar types into OB, AF, and GKM stars.

Fig. 34.— The panels on the left-hand side show B vs. B-R CMDs, whereas the panels on the right-hand side show R vs. B-R CMDs. The two top panels include all stellar sources detected in the B- and R-filters.

Fig. 35.— Two-color diagrams comparing the total, intrinsic galaxy colors for our sample galaxies (filled squares) with the colors of IGs from Gallagher & Hunter (1986) (small filled dots), dIs in the field (filled triangles) and Virgo cluster IGs (open triangles) from Gallagher & Hunter (1987). The colors of the sample galaxies are noticeably blue.