PHOTOMETRIC PROPERTIES OF KISO ULTRAVIOLET-EXCESS GALAXIES IN THE LYNX–URSA MAJOR REGION

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ABSTRACT

We have performed a systematic study of several regions in the sky where the number of galaxies exhibiting star formation (SF) activity is greater than average. We used Kiso ultraviolet-excess galaxies (KUGs) as our SF-enhanced sample. By statistically comparing the KUG and non-KUG distributions, we discovered four KUG-rich regions with sizes of ~10° × 10°. One of these regions corresponds spatially to a filament of length ~60 h⁻¹ Mpc in the Lynx–Ursa Major region (z ~ 9h–10h, δ ~ 42°–48°). We call this “the Lynx–Ursa Major (LUM) filament.” We obtained V(RI)c surface photometry of 11 of the KUGs in the LUM filament and used these to investigate the integrated colors, the distribution of SF regions, the morphologies, and the local environments. We found that these KUGs consist of distorted spiral galaxies and compact galaxies with blue colors. Their star formation occurs in the entire disk and is not confined to just the central regions. The colors of the SF regions imply that active star formation in the spiral galaxies occurred 10⁷–8 yr ago, while that in the compact objects occurred 10⁷ yr ago. Though the photometric characteristics of these KUGs are similar to those of interacting galaxies or mergers, most of these KUGs do not show direct evidence of merger processes.

Subject headings: galaxies: photometry — galaxies: starburst — galaxies: statistics — surveys

1. INTRODUCTION

Kiso ultraviolet-excess galaxies (KUGs) are a blue galaxy sample selected from photographic UGR three-color images taken by the Kiso Observatory 105 cm Schmidt telescope (Takase & Miyachi-Isobe 1993, and references therein, hereafter TM93). The survey selected galaxies if they had greater UV excess than A-type stars seen on the same plates. The KUG survey has been carried out mainly on the northern celestial hemisphere over ~5800 deg² and contains roughly 8200 objects. The depth of the survey is 17–18.5 mag in photographic magnitude. A second KUG survey is in progress. A general description of the survey method and the statistical properties of KUG objects is given in Takase (1980).

A galaxy that has experienced a star formation (SF) episode less than ~10⁸–⁹ yr ago (sub-Gyr) contains an elevated number of A stars and so can be identified by a bluer-than-average color. The so-called “Butcher-Oemler” galaxies are mostly in this category (Dressler & Gunn 1983). Photometric (Maehara et al. 1988), spectroscopic (Maehara et al. 1987, 1988; Augarde et al. 1994; Comte et al. 1994), and radio (Maehara et al. 1985, 1988) observations have revealed that KUGs as a class exhibit star formation. Thus, the KUG survey is a good sample of galaxies that have experienced periods of star formation within the recent sub-Gyr in the Local Universe. Tomita et al. (1997, hereafter TTUS97) have quantified the general characteristics of a large number of KUGs using optical color, morphology, and FIR data. Here we briefly summarize their results.

1. The KUG selection was originally based on a plate search, and the classification of galaxies into blue and nonblue ones proved to work well even in terms of the total color systems, but the boundary color is slightly redder than that of A stars; that is, 22% of the KUGs have the non-KUG colors, and the boundary color separating KUGs and non-KUGs is (U − V) = 0.1 mag.
2. KUGs are preferentially Sb or later type spiral galaxies. The KUG fraction changes linearly along the Hubble sequence: it is less than 10% for E/S0 and more than 50% for Sa/Sb.
3. KUGs are biased toward less luminous galaxies. At around the knee of the luminosity function (LF), where B-luminosity L_B ~ 10¹⁰ L☉, most of the KUGs are spiral galaxies. In the fainter L_B < 10⁹.5 L☉ regime, the dwarf population dominates.
4. The fraction of the blue population in a survey depends on the depth of the survey. If the survey is volume limited and deep enough to pick up the bulk of the dwarf population, the blue population fraction would be higher.

The distribution of KUGs is inhomogeneous, not only when compared with a uniform distribution but also in comparison with the ambient galaxy distribution. Consequently there are some “KUG-rich regions.” This inhomogeneity may be related to environmental effects. Some studies show that a dense environment activates star formation (e.g., Maia et al. 1994; Pastoriza et al. 1994). On the other hand, recent observational studies (e.g., Zabludoff et al. 1996, hereafter Z96) suggest that a low-density environ-
ment can enhance star formation. Therefore, the question is unsettled.

In this study we statistically analyzed the fraction of KUGs in the whole galaxy population and discovered four KUG-rich regions. Among them was a region that lies in the constellations of Lynx and Ursa Major (\(\alpha \sim 9^h-10^h, \delta \sim 42^\circ-48^\circ\)). In this region, there is a galaxy filament with a length of \(\sim 60 h^{-1}\) Mpc (we use \(H_0 = 100 h\) km s\(^{-1}\) Mpc\(^{-1}\) as the Hubble parameter throughout this paper). We call this structure the Lynx–Ursa Major (LUM) filament. We obtained \(V(RI)_C\) surface photometry of 11 KUGs in this region in order to make a quantitative analysis of the star formation properties and the effects of local environment on star formation.

This paper is organized as follows: §2 describes our statistical survey methods and the KUG-rich regions found; sample selection, observation, and data reduction of the \(V(RI)_C\) photometry of the 11 KUGs in the LUM filament are discussed in §3; §4 presents the results of our photometry; discussion based on the photometry is made in §5; and, finally, in §6, we present a summary of our results.

2. SURVEY

2.1. KUG-rich Regions

First we searched for regions in which the total galaxy population contains a large fraction of KUGs. A single Kiso Schmidt plate has a field of view (FOV) of \(6^\circ \times 6^\circ\). The previously noted variation in survey depth is caused by differences in plate quality. To avoid a bias caused by the variation of the photographic-plate depths, we required that our sample galaxies also be included in the magnitude-limited portion of the Catalogue of Galaxies and Clusters of Galaxies (Zwicky et al. 1961–1968, hereafter CGCG). This limited our sample to objects with \(m_B \lesssim 15.7\) mag (corresponding to \(m_B \lesssim 15.2\) mag; Kirshner, Oemler, & Schecter 1978) at \(\delta > -5^\circ\). Although the faint limit of the CGCG has some uncertainties (see, e.g., Takamiya, Kron, & Kron 1995), they do not affect our analysis. Hereafter we use the term KUG for galaxies listed in both the CGCG and KUG catalogs.

The KUG-population fraction, \(f_{\text{KUG}}\), was defined as \(f_{\text{KUG}} = k/n\) where \(n\) is the total number of CGCG galaxies on a plate and \(k\) is the number of KUGs on the same plate. We first formed this statistic for the individual \(6^\circ \times 6^\circ\) photographic plates. Using only this number, we found some tentative "KUG-rich" regions. We were still concerned, however, that these could be false effects caused by the different depth of each photographic plate. To check this, we recalculated \(f_{\text{KUG}}\) for same-size areas in an offset "tessellation" that was independent of the location of the original Kiso fields. Both methods yielded almost the same result, implying that the effects of the plate-quality difference were effectively suppressed by using the CGCG subsample. We also formed the \(f_{\text{KUG}}\) statistic for areas with sizes ranging between \(3^\circ \times 3^\circ\) and \(10^\circ \times 10^\circ\), again with no significant change in results. Figure 1 shows the distribution of \(f_{\text{KUG}}\) versus \(n\). Each symbol represents the \(f_{\text{KUG}}\) of a \(6^\circ \times 6^\circ\) area from the offset tessellation.

The next step was to determine the statistical significance of the KUG-rich regions. As shown in Figure 1, the mean KUG fraction has a value of \(\sim 27.7\%\), which is essentially independent of \(n\). We therefore assumed that \(p = 0.277\) represents the mean KUG fraction. The probability density of \(k\) with respect to \(n\), \(P(n, k)\), follows a binomial distribution given by

\[
P(n, k) = \frac{n!}{(n-k)!k!} p^k (1-p)^{n-k}
\]

\(k = 1, \ldots, n\).

The standard deviation, \(\sigma\), is

\[
\sigma = \sqrt{np(1-p)}.
\]

The probability \(P(n, \xi)\) that \(f_{\text{KUG}}\) has the value \(\xi\) in a population of \(n\) CGCG galaxies is

\[
P(n, \xi) = \frac{n!}{(n-\xi)!\xi!} p^\xi (1-p)^{n-\xi},
\]

\(0 \leq \xi \leq 1\).

Equations (2) and (3) give a standard deviation for \(\xi\), \(\sigma(\xi)\), of

\[
\sigma(\xi) = \sqrt{\frac{\xi(1-\xi)}{n}}.
\]

The smaller \(n\) is, the larger \(\sigma(\xi)\) becomes. This is well expressed in Figure 1, which shows confidence limits of 99.9\%, 99.99\%, and 99.999\% as long-dashed, dotted, and dashed lines, respectively. We define the KUG-rich regions as those in which \(f_{\text{KUG}}\) is greater than or equal to the 99.99\% confidence limit. The filled symbols in Figure 1 represent the KUG-rich regions. Eight filled symbols are plotted in Figure 1, but region B overlaps one of the Ds and region C overlaps one of the Es, making the number of filled symbols appear to be six. Circles with the same labels are regions adjacent to each other on the sky. The large extent of the regions and the high confidence limit both show that these regions are not mere products of chance.

An all-sky map containing the KUG-rich regions we discovered is shown in Figure 2. In this figure, the small dots represent the distribution of CGCG galaxies in KUG-survey regions and the black areas depict the KUG-rich regions. Their labels (A, B, C, D, and E) correspond to those labels in Figure 1. KUG-rich region E contains the galaxy cluster Zwicky 1615.8+3505. Unfortunately, this contains KUG area A0432 (center position: \(16^h 20^m, +35^\circ\)), which has been reported to contain a sizable fraction of nonblue galaxies that should not have been in the Kiso survey (Miyachi-Isobe, Takase, & Maehara 1997). The cluster itself has other interesting aspects, the details of which will be presented elsewhere (Tomita et al. 1999). The four other regions have no virialized galaxy structures; i.e., they are in the "field." Details about region A are presented in § 2.2. Region B seems to be a part of a filamentary structures of galaxies in proximity to the Canes Venatici void. Region C may also belong to a filament surrounding the Gemini void, and region D may be associated with a filament between the Leo and Coma voids that is connected to the Coma cluster (Fairall 1998). We summarize the parameters of these KUG-rich regions in Table 1. Column (1) gives the labels of KUG-rich regions presented in Figures 1 and 2. Their approximate positions are given in columns (2) and (3), and corresponding KUG field numbers are shown in column
**Fig. 1**—Distribution of the fraction of Kiso ultraviolet-excess galaxies (KUGs) $f_{KUG}$ relative to the number density of CGCG galaxies $n$. Each symbol represents $f_{KUG}$ in a $6^\circ \times 6^\circ$ area. The confidence limits of 99.9%, 99.99%, and 99.999% are also shown. The filled symbols, all outside the 99.99% contour, represent the KUG-rich regions. Eight filled symbols are plotted, but some of them (B and one of Ds, and C and one of Es) overlap, so the number of filled symbols appears to be six. The regions that have the same labels are adjacent to each other on the sky.

**Fig. 2**—All-sky projection map of the KUG-rich regions. The small dots represent the distribution of CGCG galaxies in KUG-survey regions, and the black areas depict the KUG-rich regions. The labels "A," "B," "C," "D," and "E" attached to the black regions correspond to the labels in Fig. 1.
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(4). Since the offset tessellation defines a grid centered differently from the original Kiso survey field blocks, the black regions in Figure 2 and the Kiso fields given in column (4) of Table 1 are at slightly different positions.

2.2. The Lynx–Ursa Major (LUM) Filament

Around region A, we found a filament structure of galaxies in the CfA survey (see, e.g., de Lapparent, Geller, & Huchra 1986). We name it “the Lynx–Ursa Major (LUM) filament” after the constellations within which it lies. This is an elongated and winding structure extending along the line of sight between $cz \sim 2000 \text{ km s}^{-1}$ and $8000 \text{ km s}^{-1}$ ($\sim 60$ $h^{-1} \text{ Mpc}$), at $\alpha \sim 9^\mathrm{h}\text{--}10^\mathrm{h}$, $\delta \sim 42^\circ\text{--}48^\circ$. The far end of the filament connects to the Great Wall (Geller & Huchra 1989). We note that, although “the Lynx–Ursa Major supercluster” named by Giovanelli & Haynes (1982) and the LUM filament are connected, these are actually distinct structures, and the former is much larger. Han, Gould, & Sackett (1995) studied the orientation of the spin vectors of galaxies belonging to a filamentary structure in this area. They named it “the Ursa Major filament.” Their filament is part of the left leg of the "CfA homunculus" and differs from our LUM filament. As mentioned above, region D is associated with Han et al.’s filament.

We summarize the parameters of the LUM filament in Table 2.

3. Observation and Data Reduction

3.1. The Sample

We obtained surface photometry of the KUGs in the LUM filament that met the following selection criteria: (1) an angular diameter $\geq 0.6$ and (2) a small inclination (axial ratio $\lesssim 2$). The first criterion was to ensure that the sample galaxies were large enough to allow the identification and analysis of their star-forming regions. The second criterion was to minimize the effect of internal extinction on the objects, the correction of which is uncertain (Buta & Williams 1995, hereafter BW95). Eleven objects met these criteria. We compile their names, positions, and basic properties in Table 3. Column (1) gives the serial number of the objects, and columns (2) and (3) give their KUG and CGCG names, respectively. Columns (4) and (5) give their positions (B1950.0 equinox), extracted from the NED. Columns (6) and (7) give their recession velocities and $B^\odot$ magnitudes, both from Third Reference Catalogue of Bright Galaxies (de Vaucouleurs et al. 1991, hereafter RC3). The recession velocities are Galacticentric. Column (8) gives the absolute $B$-magnitude of the objects calculated from $cz$ and $B^\odot$. All of the samples are IRAS point sources.

Next we examine whether or not our selected sample is fair. The LUM filament lies at $cz \sim 2000$–$8000$ km s$^{-1}$. Among the 11 sample KUGs, number 1 is the nearest, numbers 2, 3, 6, 7, 8, and 9 are located in the nearer half of

|TABLE 1| KUG-RICH REGIONS |
|---|---|---|
|Label | $\alpha$ (hr) | $\delta$ (deg) | KUG Field Number(s)* |
|A | 9–10 | 42–48 | 0286, 0287, 0288 |
|B | $\sim$ 12 | 36–42 | 0352, 0353, 0354 |
|C | 7–8 | 30–36 | 0405, 0406 |
|D | $\sim$ 13 | 18–24 | 0637 |

* These are the original Kiso fields corresponding to the KUG-rich regions. Thus their locations and areas are slightly different from those shown in Fig. 1.

|TABLE 2| LYNX–URSA MAJOR FILAMENT |
|---|---|---|
|Parameter | Value |
|Location ($\alpha$, $\delta$) (hr, deg) | 9–10, 42–48 |
|Projected area' (deg$^2$) | $\sim$ 90 |
|Velocity Range $cz$ (km s$^{-1}$) | 2000–8000 |
|Number of CGCGs (n) | $\sim$ 120 |
|Number of KUGs (k) | $\sim$ 70 |
|Fraction of KUGs ($f_{KUG}$) (\%) | $\sim$ 67 |

* The filament extends east and west from the $6^\circ \times 6^\circ$ region A. In the adjacent regions, KUG fractions are also significantly high at the $\gtrsim 99.9\%$ confidence level.

|TABLE 3| SELECTED KUGS AND THEIR BASIC PROPERTIES |
|---|---|---|---|---|---|---|---|---|
|Number | KUG Name | CGCG Name | $\alpha_{1950.0}$ (4) | $\delta_{1950.0}$ (5) | $cz^\ast$ (km s$^{-1}$) | $B^\odot$ (mag) (7) | $M_B$ (mag) (8) |
|1 | 0908 + 451 | 0909.0 + 4510 | 9 8 55.7 | 45 9 39 | 2638 | 12.14 | $-$ 19.96 |
|2 | 0908 + 468 | 0908.4 + 4651 | 9 8 18.0 | 46 50 42 | 4287 | 14.50 | $-$ 18.66 |
|3 | 0911 + 471 | 0911.6 + 4707 | 9 11 34.5 | 47 6 38 | 4242 | 14.20 | $-$ 18.94 |
|4 | 0919 + 474 | 0919.0 + 4727 | 9 19 5.0 | 47 27 28 | 9121 | 15.77 | $-$ 19.03 |
|5 | 0924 + 448 | 0925.0 + 4453 | 9 24 55.1 | 44 52 56 | 7717 | 14.18 | $-$ 20.26 |
|6 | 0944 + 468 | 0944.2 + 4651 | 9 44 7.1 | 46 50 31 | 4708 | 14.74 | $-$ 18.62 |
|7 | 0945 + 463 | 0945.5 + 4418 | 9 45 34.2 | 44 18 49 | 4786 | 13.30 | $-$ 20.10 |
|8 | 0947 + 455 | 0947.0 + 4432 | 9 47 1.8 | 44 31 43 | 4666 | 14.52 | $-$ 18.83 |
|9 | 0953 + 466 | 0953.6 + 4642 | 9 53 32.6 | 46 41 57 | 4681 | 15.15 | $-$ 18.20 |
|10 | 1007 + 461 | 1007.8 + 4612 | 10 07 48.4 | 46 11 49 | 7291 | 14.40 | $-$ 19.91 |
|11 | 1016 + 467 | 1016.0 + 4643 | 10 16 0.7 | 46 42 21 | 9169 | 14.10 | $-$ 20.71 |

* Galactocentric velocities based on the value taken from the NED.

$B^\odot$ magnitudes from RC3.

$M_B$ for $h = 1.0$. 

Note.—Units of right ascension are hours, minutes, and seconds, and units of declination are degrees, arcminutes, and arcseconds.
the filament, numbers 5 and 10 in the farther half, and numbers 4 and 11 at the farther end. Therefore our sample is not strongly correlated with redshift in the manner of the KUG and CGCG (see Fig. 7 of TTUS97). Next we check the galaxy luminosities. The LF of the KUGs show Schechter-like behavior (Schechter 1976), with a knee at $L_B \sim 10^{10} L_\odot$, corresponding to $M_B \sim -19.45$ mag (TTUS97). The brightest object is number 11 ($M_B = -20.71$ mag), and the faintest is number 9 ($M_B = -18.20$ mag). The others are distributed rather uniformly between the two. Our sample consists of slightly bright KUGs, but as a whole, it is not strongly biased toward brighter luminosities. We note that there are no active galactic nuclei in the sample.

3.2. $V(RI)_c$ Surface Photometry and Data Reduction

We obtained $V(RI)_c$ surface photometry using the 105 cm Schmidt telescope at the Kiso Observatory (hereafter Kiso). The nights were photometric and had seeing conditions of typically a few arcseconds. The observation log is given in Table 4. Column (1) shows the names of the sample KUGs. The observed date is presented in column (2). Column (3) gives the ID numbers of the obtained original CCD image frames at Kiso.

The optical system at the prime focus has a focal ratio of f/3.1. We mounted at the prime focus a single-chip CCD camera that uses a TI Japan TC215 frontside-illuminated 1000 $\times$ 1018 chip. One pixel corresponded to giving 0.032 arcsec. Nonlinearity was < 0.5% at < 25,000 counts, which is too small to give rise to any significant photometric error. We used broadband Johnson $V$ and Cousins $R_c$ and $I_c$ filters. The Kiso $V$, $R_c$, and $I_c$-band response functions are in good agreement with the standard filter transmissions, so we did not need any color corrections. The exposure time for all objects and filters was 900 s.

### Table 4

**Obervation Log**

| KUG Name  | Date     | Frame ID* |
|-----------|----------|-----------|
| 0908 + 451 | 1996 Nov 25 | 36782-36790 |
| 0908 + 468 | 1996 Nov 28 | 37087-37095 |
| 0911 + 471 | 1996 Nov 28 | 37099-37107 |
| 0919 + 474 | 1996 Nov 27 | 36971-36979 |
| 0924 + 448 | 1996 Nov 28 | 37061-37069 |
| 0944 + 468 | 1996 May 27 | 31375-31383 |
| 0945 + 443 | 1996 May 27 | 31387-31395 |
| 0947 + 445A | 1996 Jun 1 | 31622-31630 |
| 0953 + 466 | 1996 Nov 27 | 36959-36967 |
| 1007 + 461 | 1996 Nov 28 | 37111-37119 |
| 1016 + 467 | 1996 Jun 1 | 31634-31642 |

* Frame ID numbers of the objects used in our paper. The actual name is of the form “kcc36782,” and here we omit the prefix “kcc.” Quick looks of the raw data of our observations are available on the World Wide Web through the Mitaka-Okayaama-Kiso Data Archival System (MOKA) at http://www.moka.nao.ac.jp. MOKA is operated by the Astronomical Data Analysis Center, Okayama Astrophysical Observatory (National Astronomical Observatory of Japan) and Kiso Observatory (University of Tokyo) in cooperation with the Japan Association of Information Processing in Astronomy (Hoguchichi et al. 1994; Takata et al. 1995).

The basic data reduction consisted of a bias subtraction, flat fielding, and cosmic-ray elimination, using IRAF. The sky subtraction was accomplished via a polynomial-surface fit to the sky regions using SPIRAL (Hamabe & Ichikawa 1992). We made various tests to estimate the uncertainty of the sky subtraction, which turned out to be $\leq 1\%$.

Flux calibration was done by observing the equatorial photometric standard stars of Landolt (1992) throughout the night. The differences of the standard magnitudes from the original values of Cousins for our $V$, $R_c$, and $I_c$-bands are small enough (Menzies et al. 1991) to obviate any corrections. We obtained integrated magnitudes for each object from the asymptotic limit of a circular-aperture curve of growth after any stars were removed from the galaxy image. We used the template curve of growth provided by Kodaira, Okamura, & Ichikawa (1990) for testing the convergent value of the curve of growth. The reliability of this method is examined in Tomita et al. (1999). The total error induced by all procedures is typically $\sim 0.03$ mag.

In order to estimate the colors of the objects better, we corrected for differences caused by variations in the seeing and position between images taken in different bandpasses. We used IRAF and SPIRAL for this procedure. For the detailed color analysis, we used Interactive Data Language (IDL).

4. RESULTS

4.1. Total Magnitudes by Growth-Curve Fitting

We show the results of the photometry in Table 5. Column (1) gives the name of the galaxy. Columns (2), (3), and (4) give the apparent integrated $V$, $R_c$, and $I_c$-magnitudes, respectively. No correction for internal or external extinction has been applied for the apparent magnitudes. Columns (5), (6), and (7) give the derived total absolute magnitudes after correction for Galactic extinction. The Galactic extinction value at Lynx–Ursa Major, derived from the maps of Burstein & Heiles (1982), is $E(B-V) \sim 0.03$. This corresponds to $A_V \sim 0.09$ mag, $A_R \sim 0.07$ mag, and $A_I \sim 0.04$ mag when we apply $A_V = A_V/E(B-V) = 3.1$, using the extinction curve of Cardelli, Clayton, & Mathis (1989). Absolute magnitudes are dereddened by these values. We did not apply any correction for inclination. No attempt has been made to apply a $K$-correction because of the closeness of our sample.

These are the first photometric measurements for all but one of these objects, KUG 0953 + 466. This object is also Mrk 129 (Markarian et al. 1989), and has Johnson $V$- and $R$-band photometry from Huchra (1977, hereafter H77). Using 24" aperture photometry, the same aperture size as H77, we measured the $V$- and $R_c$-magnitudes for comparison. Then we converted his $R$-magnitudes to $R_c$. (We also use this conversion in § 5.2, where a detailed discussion of the conversion formula will be given.) Table 6 shows our results and shows that our measurements are identical with the values from H77, to within the errors.

4.2. Contour Maps

Figure 3 shows contour maps in the $V$- and $I_c$-bands of all 11 objects in our sample. They are shown from top to...
bottom in increasing order of right ascension, x. The contour interval is 0.5 mag. In this figure, north is up and east is to the right. The field of view is 2.5 × 2.5. A distance-scale bar of 10 h⁻¹ kpc is presented in the upper left-hand corner of each galaxy image. We comment on the morphological features of each galaxy. Unless otherwise noted, the morphological index is the T-type from the RC3.

4.2.1. KUG 0908 + 451 (NGC 2766, IRAS F09089 + 4509)

The morphological index is T = 5. This galaxy is quite knotty, with a large number of H II regions. This object has a globally distorted appearance and well-developed arms. The eastern arm is extremely blue. There are no companions in the FOV of the Kiso CCD (corresponding to ~100 h⁻¹ kpc × 100 h⁻¹ kpc).

4.2.2. KUG 0908 + 468 (Mrk 102, IRAS F09082 + 4650)

A morphological index is not given in the RC3 and cannot be accurately estimated. This is a featureless, spheroidal galaxy, with a slightly boxy isophote. It is isolated within ~160 h⁻¹ kpc × 160 h⁻¹ kpc.

4.2.3. KUG 0911 + 471 (UGC 4870, IRAS F09115 + 4706)

A morphological index is not given in the RC3. We estimate a value of T ~ 5. The disk is slightly warped. This galaxy has H II region knots in its peripheral region around the disk, which are not well presented in the smoothed contours. There are no galaxy companions within ~160 h⁻¹ kpc × 160 h⁻¹ kpc.

4.2.4. KUG 0919 + 474 (Mrk 109, IRAS F09190 + 4727)

A morphological index is not given in the RC3 and cannot be accurately estimated. This object has a compact and featureless appearance. It lies in a loose group of galaxies and has some companions.

4.2.5. KUG 0924 + 448 (UGC 5045, IRAS F09249 + 4452)

The morphological index is T = 5. This object is a triple-arm barred galaxy that suffers from global distortion. Its arms are knotty with many H II regions. It is isolated in a field of ~270 h⁻¹ kpc × 270 h⁻¹ kpc.

4.2.6. KUG 0944 + 468 (UGC 5237, IRAS F09441 + 4650)

The morphological index is T = 6. The object is asymmetric. The arm in the south is well developed with large blue knots. It is isolated in a field of ~160 h⁻¹ kpc × 160 h⁻¹ kpc.

4.2.7. KUG 0945 + 443 (UGC 2998, IRAS F09453 + 4418)

The morphological index is T = 5. This galaxy has extremely well-developed knotty arms. It lies in a loose group, and there is a faint irregular galaxy lying at 5' (~60 h⁻¹ kpc) to the east. They do not appear to be bridged or to have any features that imply interaction.

4.2.8. KUG 0947 + 445A (UGC 3009, IRAS F09470 + 4431)

A morphological index is not given in the RC3. We estimate a value of T ~ 4. This galaxy has four arms, with the one in the north being less developed than the others. The appearance is rather smooth with no prominent H II regions. It lies in a loose group and has small companions at almost the same redshifts, but without any tidal features.

4.2.9. KUG 0953 + 466 (Mrk 129, IRAS F09535 + 4641)

A morphological index is not given in the RC3 and cannot be accurately estimated. This object is a featureless, box-shaped compact galaxy. It is isolated within ~160 h⁻¹ kpc × 160 h⁻¹ kpc.

4.2.10. KUG 1007 + 461 (UGC 3192, IRAS F10078 + 4611)

A morphological index is not given in the RC3. We estimate a value of T ~ 5. Its arms are poorly developed. This galaxy has a companion in the northeast.

4.2.11. KUG 1016 + 467 (UGC 3191, IRAS F10159 + 4642)

The morphological index T = 4. This galaxy suffers from heavy distortion and has a companion to the west. There is an extremely blue tidal bridge between them, suggesting that they are interacting.

4.3. Colors

We give the total integrated V(RI) colors of the objects in Table 7. They are corrected only for Galactic extinction.

We then further divided each image into sections and derived colors by section in order to investigate the distribution of SF regions within each galaxy. An SF region
Fig. 3.—Contour maps in the V- and I-band of the objects in our sample. They are shown from top to bottom in increasing order of right ascension. Each contour interval is 0.5 mag. In this figure, north is up and east is to the right. The FOV of the contour maps is $2.5 \times 2.5$. A distance scale is presented in the upper left-hand corner of each galaxy image.
Fig. 3.—Continued
Fig. 3—Continued
that is 2–3 kpc diameter (which is typical of such regions) has an angular size of $\sim 7''$ at $cz \sim 9000$ km s$^{-1}$, the distance of the furthest galaxy in our sample. This angular size is much larger than the seeing disk of our images; therefore we can divide the most distant image into $7'' \times 7''$ squares without oversampling. For consistency we scaled the sample resolution applied to our nearer objects with redshift to match the same physical size of 3 kpc. Then, for the regions that have S/N $> 3$, we evaluated the colors. Figure 4 shows the partitioning of each galaxy. Color-color (C-C) diagrams of the sections in each galaxy are presented in Figure 5. The dominant error of the color estimation comes from the sky fitting. Points labeled “bulge” and “disk” are from those sections of each galaxy. For some representative regions in each galaxy, we have labeled its number from Figure 4 beside the corresponding point in Figure 5. The three broken lines on the C-C diagrams show starburst evolutionary tracks superimposed on an old stellar population (Bica, Alloin, & Schmidt 1990, hereafter BAS90). Detailed discussion about these tracks will be given in § 5.2.

5. DISCUSSION

5.1. Total Colors

We compare the total colors of our sample with those of galaxies listed in the RC3. We have taken our values for $(V - R)_T$ and $(V - I)_T$ from BW95. Their filters are the same as those of Kiso, Johnson $V$ and Cousins $R_c$ and $I_c$, so it was not necessary to apply a correction. However, they

| KUG Name   | $(V-R)_{T}$ | $(V-I)_{T}$ | $(R_c-I)_{T}$ |
|------------|-------------|-------------|---------------|
| 0908+451   | 0.51        | 0.86        | 0.35          |
| 0908+468   | 0.39        | 0.70        | 0.31          |
| 0911+471   | 0.46        | 0.86        | 0.40          |
| 0919+474   | 0.38        | 0.60        | 0.22          |
| 0924+448   | 0.45        | 0.85        | 0.41          |
| 0944+468   | 0.38        | 0.80        | 0.42          |
| 0945+443   | 0.42        | 0.84        | 0.42          |
| 0947+445A  | 0.48        | 0.92        | 0.45          |
| 0953+466   | 0.47        | 0.85        | 0.39          |
| 1007+461   | 0.39        | 0.71        | 0.31          |
| 1016+467   | 0.39        | 0.73        | 0.35          |
corrected the galaxy colors for internal extinction and inclination. To compare our results with the data from BW95, we applied a correction of $A_V \sim 0.15$ for internal extinction.

Figure 6 plots $\langle V-R \rangle_0^T$ versus $\langle V-I \rangle_0^T$ for the KUGs in the LUM filament together with those of a wider range in Hubble types from BW95. Open circles represent the mean color of each morphological type index $T$. The error bars give the standard deviation in each color across the galaxies belonging to each morphological type. Filled squares repre-

8 The shown indices are $-5, -4, -3, -2, -1, 0, 1, 2, 3, 4, 5, 6, {7, 8}$, 9, and 10, according to BW95.
represent the dereddened colors of our KUGs. The applied reddening correction vector is presented in the top left-hand corner of the diagram. The typical photometric error of our data is shown in the bottom right-hand corner. The reddening correction value is set to compare our photometry with that of BW95. The morphological $T$ index of each KUG is indicated. For the six objects without $T$ values in RC3, we use our own classification, or we label them “C” for compact morphology if we could not determine a $T$ value. The colors of our sample tend to deviate systematically blueward from the range of the 1 $\sigma$ strip of the Hubble sequence in $(V-I)_T$. Even though our sample consists of intermediate/late-type spiral and compact galaxies, they are scattered well outside the distribution of the BW95 sample. This is attributed not only to the blue-continuum emission from early-type stars but also to the strong emission lines from star-forming regions. The strong Hz line makes their $(V-R)$ colors redder, as is clearly seen in Figure 6.

A similar tendency has been reported for other UV-excess galaxy samples. Markarian galaxies are dispersed more widely on a $(U-B)-(B-V)$ diagram than are field galaxies (H77). Barth, Coziol, & Demers (1995, hereafter BCD95) have mentioned that their Montreal Blue Galaxy (MBG) sample shows a larger dispersion than normal galaxies on the $(B-V)-(V-R)$ and $(B-R)-(V-I)$ planes. The MBG is a blue galaxy sample selected by a similar but more restricted method than that of the KUG survey (Coziol et al. 1993, 1997, and references therein). Larson & Tinsley (1978) pointed out that interacting galaxies show a large scatter on C-C diagrams. Therefore, BCD95 have suggested a link between active star formation in MBG and galaxy-galaxy encounters, since the behavior of interacting galaxies is similar to behavior observed in their samples. Our analysis, however, shows that the blue color of KUGs is not necessarily connected to interactions (see § 5.3).

5.2. Distribution of SF Regions

Figure 5 clearly shows that all the spiral KUGs of our sample have bulges redder than their disks, like normal galaxies. This means that the LUM-filament KUGs are not starburst nucleus galaxies (SBNGs), a fact consistent with the KUG morphological types given in the original catalog. This is in contrast to the fact that the most MBGs are SBNGs (Coziol et al. 1993, 1997). A detailed discussion of morphology is in § 5.3. The rest of our sample turns out to be compact galaxies. These compact galaxies are not too distant to judge their morphology ($cz \sim 5000$ km s$^{-1}$) and are in reality featureless. Their properties are similar to those of the so-called “blue compact dwarf galaxies” (“BCDGs”), but our compact KUGs have log $L_B > 9.5$ ($M_B < -18.2$ mag), brighter than BCDGs. This is consistent with the global properties of the whole KUG survey (TTUS97, and references therein).

A comparison of the starburst evolution models with the color distribution in Figure 5 provides an estimate of the onset of star formation in each object. As previously noted, we used evolution tracks from BAS90, which describe the spectral evolution over $3 \times 10^8$ yr of a starburst in low-metallicity gas, superimposed on an older stellar population. Their models combine elements from star cluster and galaxy spectral libraries. A star cluster of a given age defines the starburst spectral signature while a red galaxy nucleus represents a typical old metal-rich underlying population.

The flux proportions for combining the spectra are dictated by three burst-to-galaxy mass ratios of 10%, 1%, and 0.1%. In Figure 5, the solid, short-dashed, and long-dashed lines represent 10%, 1%, and 0.1% burst masses, respectively.

BAS90 calculated Johnson $BVR$ colors from their synthesized spectra. We converted their starburst colors into the Cousins system via the following two formulae:

$$(V-R)_{BC} = \frac{1}{1.40} [(V-R)_B - 0.028], \quad (V-R)_{BC} < 1.0 \quad (5)$$

$$(V-I)_{BC} = \frac{1}{1.36} [(V-I)_B - 0.013], \quad (V-I)_{BC} < 2.0 \quad (6)$$

(Cousins 1976), and

$$(V-R)_{BC} = 0.73(V-R)_I - 0.03, \quad (V-R)_I < 1.0 \quad (7)$$

$$(V-I)_{BC} = 0.778(V-I)_I - 0.03, \quad (V-I)_I < 2.0 \quad (8)$$

(Bessell 1979). The converted colors derived from these two formulae agree to within 0.01 mag. The tracks on Figure 5 are the converted evolutionary loci. Furthermore, we need to estimate the internal extinction for comparison. As with Figure 6, an applied reddening vector of $A_V = 0.1$ is shown in the upper left-hand corner.

Figure 5 shows that most of the partial colors of our sample KUGs are located on the BAS90 model tracks, affirming the validity of applying this model to our measurements. We emphasize that the models are of a starburst superimposed on an old population, instead of the evolutionary models of the starburst component alone. Though we should keep in mind that the galaxy color is sensitive to the burst-mass fraction (BAS90) and metallicity of the gas (Leitherer & Heckman 1995), both of which are rather uncertain, the important fact is that most of our sample KUGs have a young ($\lesssim 10^{7-8}$ yr) stellar component within their old disks; i.e., the star formation is taking place in the disks of the KUGs, not in their central regions.

We next examine the color distribution of the individual KUGs.

5.2.1. KUG 0908 + 451

This is a giant grand-design spiral galaxy. The partial colors of the disk distribute around the $10^8$ yr phase of the 10% burst mass track, or $10^7$ yr phase of the 1% burst mass track. The symbol labeled “12” corresponds to the bulge of this galaxy. Clearly, the color of the bulge is red, implying a lack of a young population. The arm of the galaxy (labeled “23” in Fig. 5) is abundant in H$\alpha$ regions and turns out to be very blue in color, corresponding to a stellar age of less than $10^7$ yr for a 10% burst mass.

5.2.2. KUG 0908 + 468

This galaxy is compact with the same color throughout. Comparison with the tracks indicates that the stellar ages of the burst component are $<10^8$ yr and the ratio of the burst mass to the total baryonic mass is high (greater than a few percent); i.e., ongoing starburst activity occurs over the whole galaxy.

5.2.3. KUG 0911 + 471

This galaxy belongs to the giant spirals. The disk color is located around the $10^8$ yr phase of the 10% burst mass track. The symbol labeled “6” represents the color of the
Fig. 5.—Color-color (C-C) diagrams of each square section of each galaxy shown in Fig. 4. The data points labeled “bulge” and “disk” represent the color of bulge and disk sections of the object. The three lines on the C-C diagrams are the model starburst evolutionary tracks superimposed on an older stellar population, given by Bica et al. (1990).
KUG 0908+468

Av = 0.1

10% burst mass

1.0% burst mass

0.1% burst mass

Fig. 5.—Continued
Continued
KUG 0924+448

Av = 0.1

10% burst mass

1.0% burst mass

0.1% burst mass

7 * 10^6 yr

5 * 10^7 yr

10^7 yr

3 * 10^9 yr

Bulge

Disk

Fig. 5.—Continued
KUG 0944+468

Av = 0.1

10% burst mass

1.0% burst mass

0.1% burst mass

4 Bulge

Disk

5 * 10^7 yr

10^7 yr

3 * 10^9 yr

7 * 10^6 yr

FIG. 5.—Continued
KUG 0947+445A

![Graph](image)

**Figure 5.—Continued**

- $Av = 0.1$
- $10^7$ yr
- $5 \times 10^7$ yr
- $7 \times 10^6$ yr
- $3 \times 10^9$ yr

Legend:
- Solid line: 10% burst mass
- Dashed line: 0.1% burst mass
- Dotted line: 1% burst mass

10% burst mass
Disk
Bulge
KUG 0953+466

$V - R$

$V - I$

$Av = 0.1$

$7 \times 10^6$ yr

$5 \times 10^7$ yr

$10^7$ yr

$3 \times 10^9$ yr

$10\%$ burst mass

$1.0\%$ burst mass

$0.1\%$ burst mass

$3$

Fig. 5.—Continued
KUG 1007+461

Fig. 5.—Continued

Av = 0.1

10% burst mass

1.0% burst mass

0.1% burst mass

10^7 yr

5 * 10^7 yr

7 * 10^6 yr

3 * 10^9 yr

9 Bulge

Disk

Bulge

Continued
KUG 1016+467

Fig. 5.—Continued
Fig. 6.—\((V - R) - (V - I)\) diagram, comparing the dereddened total colors of our KUGs in the Lynx-Ursa Major filament with those covering the galaxy morphology sequence. Open circles represent the mean color of each morphological type index \(T\). The shown indices are \(-5, -4, -3, -2, -1, 0, 1, 2, 3, 4, 5, 6, 7, 8, 9,\) and \(10\), from Buta & Williams (1995), and some are labeled to show the trend. Error bars show the standard deviation of the color of galaxies in each morphological type. Filled squares represent the dereddened color of our KUGs. A vector showing the effect of the applied \(A_v \sim 0.15\) reddening correction is presented in the top left-hand corner of the diagram. A typical photometric error of our data is shown in the bottom right-hand corner. The numbers beside the filled squares are the morphological type indices of the KUGs. We give the symbol "C" instead of the \(T\) index for compact galaxies. Our sample tends to deviate from the range of the \(1 \sigma\) strip of the Hubble sequence.
bulge, which has a normal color for an old stellar population.

5.2.4. **KUG 0919+474**

This galaxy is compact and, like KUG 0908+468, has the same color throughout. The color of this galaxy can be explained only with a very high burst-mass ratio, \( \sim 10\% \). The implicated burst time is very recent \((10^{8.7} \text{ yr})\).

5.2.5. **KUG 0924+448**

This is a giant spiral galaxy with a variety of colors in the disk. Most of the disk color clusters around the \(10^8\) yr phase of the \(1\%-10\%\) burst mass tracks. Some other parts show colors corresponding to younger stellar populations. As with other giant spiral KUG samples, the bulge of this galaxy (labeled "20") is red.

5.2.6. **KUG 0944+468**

This is also a giant spiral galaxy, though it looks small in size because of its rather low surface brightness. Its bulge (labeled "4") is bluer than comparable KUG samples, but its disk parts are still bluer than the bulge. The color corresponds to a burst more recent than \(10^8\) yr on the \(1\%-10\%\) tracks.

5.2.7. **KUG 0945+443**

This is also a giant spiral galaxy. The dispersion of colors across the galaxy is large, implying that the ages of the SF regions on the disk range from \(5 \times 10^7\) yr to \(10^9\) yr. The most crowded domain on the C-C diagram corresponds to the \(10^8\) yr phase of the \(10\%\) or \(1\%\) burst mass tracks. Its bulge (labeled "12") is red, as expected from an old stellar component.

5.2.8. **KUG 0947+445A**

This galaxy is a spiral but has a rather strange shape consisting of four separate arms or two arms with a bar crossing between them. In addition, it is as small as a compact galaxy. Despite its morphological peculiarity, its disk parts have rather old stellar colors, corresponding to the several \(\times 10^8\) yr phase of the \(1\%-10\%\) burst mass tracks. Its bulge (labeled "5") has the same color as its disk parts, though the color is not so blue that it would be regarded as a nuclear starburst.

5.2.9. **KUG 0953+466**

This is a compact galaxy with a large dispersion in \((V-I)_r\). Its bursts correspond to a stellar age of \(\sim 10^{8.7}\) yr with a burst mass fraction of several \(\times 0.1\%). The partial colors are well explained by this burst mass and mass fraction, so the age dispersion may be also small as those of other compact KUG samples.

5.2.10. **KUG 1007+461**

This is a giant spiral galaxy. Its bulge (labeled "9") is slightly bluer than those of other spiral galaxy samples, and its disk components are distributed around the domain of a very young stellar population. The suggested stellar age is around \(10^{7.8}\) yr.

5.2.11. **KUG 1016+467**

This is the only interacting galaxy pair in our sample. The parent or larger one is a giant spiral galaxy. We show only the partial colors of the parent galaxy in Figure 5. This galaxy has a large color dispersion across its disk, corresponding to a stellar population with an age of \(10^7\) to several \(\times 10^9\) yr superimposed on an old background population. Its bulge (labeled "13") is also somewhat blue.

5.3. **Morphology**

We have described the individual morphologies of the LUM-filament KUGs in § 4.2. In addition, the KUG catalog gives original morphological classifications as follows (TM93): "Ic" is an irregular galaxy with clumpy H II regions, "Ig" is an irregular galaxy with a conspicuously giant H II region, "Pi" is a pair of interacting components, "Pd" is a pair of detached components, "Sk" is a spiral galaxy with knots of H II regions along its arms, "Sp" is a spiral galaxy with a peculiar bar and/or nucleus, "C" is a compact galaxy, and "?" is unclassifiable. The morphological properties of the objects in this study, as well as the originally cataloged KUG morphology and star formation properties, are summarized in Table 8. Column (1) shows the KUG names. Column (2) presents the RC3 T indices for each KUG. For the galaxies for which RC3 T values are not given, we give our assigned indices instead. Unclassifiable compact galaxies are labeled "C." We show the KUG morphological classification in column (3). The star formation properties are presented in columns (4), (5), and (6); column (4) gives the location where star formation occurs within the galaxy; column (5) gives the derived ages of the superposing stellar population; and column (6) gives the burst-to-galaxy mass ratios of our samples. We note their morphological features in columns (7), (8), and (9). Our LUM-filament KUG sample is roughly divided into two classes, knotty spirals ("Sk") and compact galaxies ("C"). This is consistent with the morphological analysis based on our CCD images.

Despite the variety of morphologies, some general points are apparent.

1. Our sample KUGs are divided into two classes, giant spiral systems and compact galaxies.
2. Most of the giant-spiral KUGs show disk distortion.
3. Giant-spiral KUGs have highly developed arms and knotty appearances due to giant H II regions.
4. In spite of points 2 and 3, roughly one-half of the objects in of our sample are isolated, and the other one-half have some companions or lie in groups of galaxies.
5. Only one of our sample galaxies (KUG 1016+467) shows explicit interaction features. This galaxy is an interacting system of a giant spiral and a small amorphous satellite.

One of the main conclusions of TTUS97 is that, in terms of stellar population, the late-type KUGs are mostly normal galaxies and the early-type KUGs often turned out to be peculiar galaxies. The color difference between the KUGs and non-KUGs is significant for \( T < 5\) and indicates that the early-type KUGs have a young stellar population for their morphologies. Compact galaxies tend to be included in the early-type galaxy classification as peculiar early types and are thus not really a proper member of the class. On the other hand, though the spiral KUGs in our sample have young stellar populations in their disks, making their appearance quite knotty, they are rather normal for their morphology. This is also consistent with the above result of TTUS97. The spiral KUG samples have no active nuclei or...
circumnuclear starbursts. Therefore they are “active normal spirals.”

5.4. Correlation between Various Properties of Our Samples

Here we examine the relation between the colors, ages, morphologies, and environments of our samples. Many authors have claimed a close connection between active star formation and morphological distortion. For example, BCD95 performed a quantitative morphological analysis of their MBG starbursts by Fourier transforming the isophotes of sample galaxies. They concluded that the star formation regions are associated with isophotal twists. Such a distortion or twist from symmetry is also found in our KUG sample in the LUM filament. 296 discovered that a significant fraction of their “E + A” sample exhibits tidal features. However, as BCD95 pointed out, the morphological distortion is not a direct evidence of galaxy-galaxy interaction. One-half of our sample consists of isolated galaxies. Only one has a tidally connected companion. Thus, we cannot attribute the star formation in our sample to distortion features, though galaxy encounters might be responsible for some of the starbursts.

We next consider the relations between stellar ages implied by the color distribution and other properties. A clear morphological relation exists. Compact galaxies that have featureless appearances have very young superposing stellar components (10^6 – 7 yr), i.e., on-going starbursts, spread over the whole of each galaxy. In contrast, giant spiral galaxies that have well-developed arms have more aged stellar components (10^7 – 8 yr) in their disks, and their bulges are old. The age scatter is large in each spiral sample, but there is an exception, KUG 0947 + 445A, which is a spiral galaxy with a small dispersion of partial colors. We note that this is a physically small galaxy, as we saw in 5.2. The color dispersion appears to correlate with galaxy size, with larger galaxies having a greater dispersion.

Finally we look into the relation between stellar age and the existence of companions. The most active star-forming galaxy is KUG 0919 + 474, which is a compact galaxy in a group having a burst age of 10^6 – 7 yr. Isolated compact galaxy KUG 0908 + 468 also has rather young starbursts, but they are not as young as those of KUG 0919 + 474. Another isolated compact galaxy, KUG 0953 + 466, has a burst age of 10^6 – 7 yr, with a small burst mass fraction (~ several x 0.1%) implied. Spiral galaxies have similar stellar ages. Some KUGs in a group or with companions, such as KUG 1007 + 461 and KUG 1016 + 467, have rather younger stellar ages. In contrast, other KUGs with companions, such as KUG 0945 + 443 and KUG 0947 + 445A, have superposing stellar components consistent with intermediate ages. Thus, there is no clear relation between the superposing stellar age and the existence of companions.

6. SUMMARY

We have focused on the collective star formation enhancement of galaxies and searched for regions where such phenomena have occurred using the Kiso Ultraviolet-Excess Galaxy (KUG) Catalog as an SF-enhanced galaxy sample. Through our survey we found four KUG-rich regions, one of which turned out to be associated with a filamentary structure. We named it “the Lynx–Ursa Major filament” after its location on the sky (x ~ 98°–109°, δ ~ 42°–48°). We then investigated the star formation properties of the KUGs in the LUM. Our results are as follows.

1. The 11 KUG objects we examined in the LUM filament proved to be generally blue by CCD photometry, and they show much larger scatter on C-C diagrams than do normal galaxies. This is similar to results of other UV-excess galaxy surveys, such as the Markarian survey or the MBG survey.

2. The spiral subset of the sample has conspicuous H II region knots in their arms. The rest are compact galaxies with no structure and extremely blue colors. We suggest that the former corresponds to the KUG subset of “normal late-type spiral galaxies” and the latter corresponds to the “peculiar early-type galaxies” proposed by TTUS97.

3. Star formation in our sample KUGs occurs in the whole disk and is not concentrated in the central regions. This is different from star formation in those SBNGs that are the main constituent of the MBG survey. None of our sample KUGs have nuclear activity. The age of their young stellar population is 10^7–8 yr. Compact samples have

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**Table 8**

Summary of Morphology and Star Formation Characteristics

| KUG Name | Type | Agea | Burst | Appearance | Distortion | Environment |
|----------|------|------|-------|------------|------------|-------------|
| 0908 + 451 | Sk Disk | 10^7 | 1–10 | Knotty | Yes | Isolated |
| 0908 + 468 | C Whole | 10^7 | 10 | Featureless | … | Isolated |
| 0911 + 471 | Sk Disk | 10^7 | 10 | Knotty | Yes | Isolated |
| 0919 + 474 | C Whole | 10^7 | 10 | Featureless | … | In a group |
| 0924 + 448 | Sk Disk | 10^7 | 1–10 | Knotty | Yes (tripled-armed) | Isolated |
| 0944 + 465 | Sk Disk | 10^7 | 1–10 | Knotty | Yes | Isolated |
| 0945 + 443 | Sk Disk | 10^7 | 10 | Knotty | … | In a group |
| 0947 + 445A | Sp Disk | 10^7 | 1–10 | Smooth | … (four-armed) | In a group |
| 0953 + 466 | C Whole | 10^7 | 1–10 | Featureless | … | Isolated |
| 1007 + 461 | Sk Disk | 10^7 | 10 | Smooth | … | Companion |
| 1016 + 467 | Pi Disk | 10^7 | 10 | … | Yes (tidal feature) | Inteacting |

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a Location where active star formation occurs on the galaxy.
b Burst-to-galaxy mass ratio based on Bica et al. 1990.
c Not given in RC3, and has featureless compact morphology.
d Not given in RC3. Assigned by us.
very young superposing stellar components \((10^6-7 \text{ yr})\) spread over the whole galaxy, while giant spiral samples have moderately aged stellar components \((10^7-8 \text{ yr})\) in their disks and older bulges. The age scatter is large in each spiral sample. Star formation properties of giant spiral samples and compact samples are clearly different, implying that the star formation is regulated by the inner galaxy environment.

4. Only one KUG exhibits an explicit interaction feature, although half of the galaxies in our sample have some companions. However, most of the spiral subset of our sample show distortions or isophotal twists. This indicates that a weak encounter may have activated the star formation, though we should note that their morphological distortion is not necessarily due to external forces.

5. The age and strength of star formation in an individual sample has no relation to the existence of companions, implying that star formation may not be activated by the local environment.

We should also note that there are no extremely peculiar galaxies in this region. A detailed spatial distribution of KUGs and non-KUGs in the LUM filament should be investigated in order to study further the effects of environment. Now in progress is a redshift survey to study the detailed spatial distribution of KUGs, the results of which will appear in Takeuchi et al. (1999).

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