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A STUDY OF DWARF GALAXIES EMBEDDED IN A LARGE-SCALE H I RING IN THE LEO I GROUP

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ABSTRACT

A large-scale neutral hydrogen (H I) ring serendipitously found in the Leo I galaxy group is 200 kpc in diameter with $M_{\rm H\,I} \sim 1.67 \times 10^9 {\rm M}_\odot$, unique in size in the Local Universe. It is still under debate where this H I ring originated - whether it has formed out of the gas remaining after the formation of a galaxy group (primordial origin) or been stripped during galaxy-galaxy interactions (tidal origin). We are investigating the optical and H I gas properties of the dwarf galaxies located within the gas ring in order to probe its formation mechanism. In this work, we present the photometric properties of the dwarfs inside the ring using the CFHT MegaCam u^*, g', r' and i'-band data. We discuss the origin of the gas ring based on the stellar age and metal abundance of dwarf galaxies contained within it.

Key words: ISM: clouds - Galaxies: dwarfs, evolution, formation, and photometry

1. INTRODUCTION

The Leo I galaxy group is the nearest group containing both bright spirals (M95 and M96) and a bright elliptical (M105) (Pedersen 2000). What makes this group distinct is a large-scale atomic hydrogen (H I) ring serendipitously found by Schneider et al. (1989). There are two competing scenarios for the origin of this large-scale H I ring; primordial gas left behind after the formation of a galaxy group (e.g. Castro-Rodriguez et al. 2003; Thilker et al. 2009) vs. tidally stripped gas pulled out during the gravitational interactions between galaxies (e.g. Pierce & Tully 1985; Bot et al. 2009; Bekki et al. 2005; Michel-Dansac et al. 2010).

While its origin is still under debate, a number of independent H I blobs have been recently discovered along the H I ring by by Stierwalt et al. (2009), some of which have optical counterparts. Using the optical and H I properties, we aim to investigate the origin of the large-scale H I ring as well as the formation history of the dwarfs associated with it. In this study, we present the photometric properties of a sample of dwarf galaxies which are located along the Leo ring. We also present the result of our analysis using the single stellar population synthesis model (Bressan et al. 2012) to constrain the age and metallicity of our dwarf galaxy sample. By comparing their optical colors with those of dwarfs located near the ring, we discuss the origin of the dwarf galaxies in the large-scale H I ring.

2. OPTICAL PHOTOMETRY

We present the result of the optical photometry of dwarf galaxies inside the Leo H I gas ring. We use the deep g', r' and i'-band images from Michel-Dansac et al. (2010) obtained using MegaCam on the Canada-France-Hawaii Telescope (CFHT). The u^*-band image was taken by us in March 2014. Photometry and galaxy identification were done using SExtractor. For comparison, we also analyze the photometric data of the dwarfs located in the Leo I group but outside the gas ring. This sample is included in our CFHT u-band observations but not covered by Michel-Dansac et al. (2010). Therefore, we use the Sloan Digital Sky Survey (SDSS) g', r' and i' data for the sample of dwarfs outside the ring. The SDSS magnitudes have been converted to the CFHT magnitude system using the relation from Smith et al. (2002). In Figure 1, the RGB color image (g', r' and i') of the region which covers the H I ring is presented. The silhouette of the H I gas ring is shown in blue. The zoom-in CFHT and SDSS color images of individual dwarfs are presented on the right.

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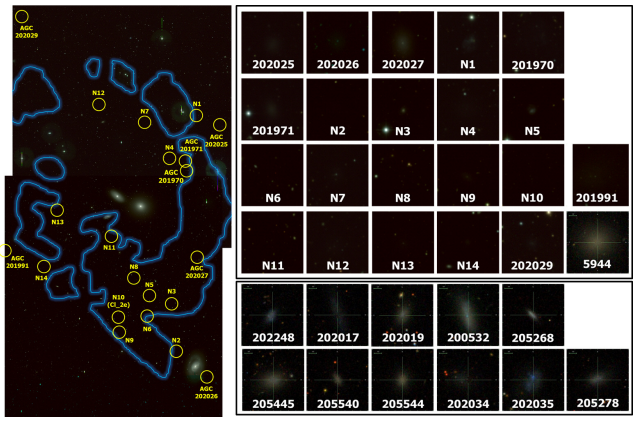

Figure 1. [Left] RGB color image (g', r', i') of the region where the large-scale H I ring is present in the Leo I group. The optically identified dwarf galaxies in this area are indicated by yellow circles. A thick blue line represents the overall shape of the H I gas ring. [Upper right] CFHT color images of optically identified dwarfs. Each box is the size of $80'' \times 80''$. [Lower right] SDSS color images of dwarfs located outside the gas ring. The size of individual images is same as above.

3. COLOR-MAGNITUDE DIAGRAM AND COLOR-COLOR DIAGRAM

We explore the color-magnitude relation of the dwarfs inside the ring and compare it those outside the ring. On the left of Figure 2, we show the color-magnitude diagram (CMD) of $(u^* - r')$ and r'. Due to the different depths between the CFHT and SDSS images, we do not find any dwarfs which are as faint as the ones inside the ring. Aside from this, however, there is no significant difference in color between the two samples, covering a similar $(g' - i')$ vs. $(u^* - i')$ and $(r' - i')$ vs. $(u^* - r')$ range.

In the color-color relations, the ring dwarfs are indistinguishable from the non-ring dwarfs. What is intriguing however, is that most of the non-ring dwarfs are found along the simple stellar models (SSP models) with a few exceptions, while the ring dwarfs deviate significantly from the model in most cases. This may imply that the ring dwarfs have different (likely more complicated) evolution histories from the non-ring dwarfs, possibly the result of experiencing episodic star formation.

4. DISCUSSION

We have investigated the photometric properties of the dwarf galaxies associated with a large-scale H I ring located in the Leo I group and those of neighboring dwarf galaxies. Using SSP models, we have constrained the stellar age of the sample. We do not find any significant differences in color between the dwarfs inside the ring and those located outside the ring. Although they are all found in similar color ranges, most non-ring galaxies can be explained by single stellar population models with a range of metallicities and ages, while the ring

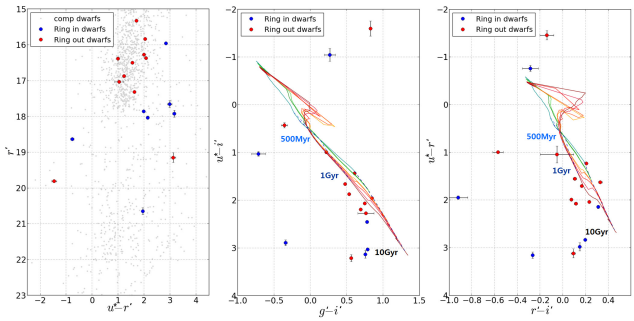

Figure 2. [Left] Color $(u^* - r')$-magnitude (u^*) diagram (CMD) of the sample. Blue dots represent the dwarfs in the ring and red dots represent dwarfs outside the ring. Grey dots are local $(0.001 < z < 0.005)$ dwarf galaxies. [Middle and Right] The color-color relations and the results of SSP analysis.

galaxies deviate significantly from the SSP models. This indicates that the ring dwarfs are likely to have gone through more sporadic star formation compared to the non-ring dwarfs. The biggest difference between the two populations is the presence of the large-scale ring, which might be responsible for the more episodic star formation history of the ring dwarfs. In order to better probe the star formation histories of the dwarfs and the origin of the gas ring, we plan to include NIR data in our color analysis in the future. In addition, we are now investigating the EVLA H I data to study the kinematics and the dark matter content of the ring dwarfs.

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