Forming Blue Compact Dwarf Galaxy (BCD) through Mergers

MNRAS: 520, 4, (4953 – 4960), 2023. https://doi.org/10.1093/mnras/stac3700

Daya Nidhi Chhatkuli[1], Sanjaya Paudel[2], Rajesh Kumar Bachchan[3], Binil Aryal[1]

[1]*Central Department of Physics, Tribhuvan University, Kirtipur, Kathmandu, Nepal*

[2]*Department of Astronomy, Yonsei University, Seoul, 03722, Republic of Korea*

[3]*Patan Multiple Campus, Tribhuvan University, Lalitpur, Nepal*

Abstract

It has long been speculated that Blue Compact Dwarf galaxies (BCDs) are formed through the interaction between low-mass gas-rich galaxies, but a few candidates of such systems have been studied in detail. We study a sample of compact star-forming dwarf galaxies that are selected from a merging dwarf galaxy catalog. We present a detailed study of their spectroscopic and structural properties. We find that these BCDs looking galaxies host extended stellar shells and thus are confirmed to be a dwarf-dwarf merger. Their stellar masses range between $8 \times 10^7 M_\odot$ and $2 \times 10^9 M_\odot$. Although the extended tail and shell are prominent in the deep optical images, the overall major axis light profile is well modeled with a two-component Sérsic function of inner compact and extended outer radii. We calculate the inner and outer component stellar-mass ratio using the two-component modeling. We find an average ratio of 4:1 (with a range of 10:1 to 2:1) for our sample, indicating that the central component dominates the stellar mass with an ongoing burst of star-formation. From the measurement of H_α equivalent width, we derived the star-formation ages of these galaxies. The derived star-formation ages of these galaxies turn out to be in the order of a few 10 Myr, suggesting the recent ignition of star-formation due to events of satellite interaction.

1. Motivation

a. **Formation of BCD through the merger.**
b. **The evolution of many dwarf galaxies via their merging history is yet to be explored in detail.**
c. **Provides insights into the early universe and the formation of the first galaxies.**

2. Objectives

a. **To study a sample of six nearby Blue Compact Dwarf galaxies (BCDs) concerning their structural parameters and star-formation activities.**
b. **To study the formation of BCD-type galaxies through the merger.**
c. **To model galaxy images with Sérsic function to decompose the merger remnant to its progenitor.**

3. Methods

We specifically chose six compact merging dwarf candidates with an obvious tidal characteristic to investigate the origin and evolution of BCD-type galaxies. Our sample galaxy collection comes from Paudel et al. (2018) of merging dwarf galaxies.

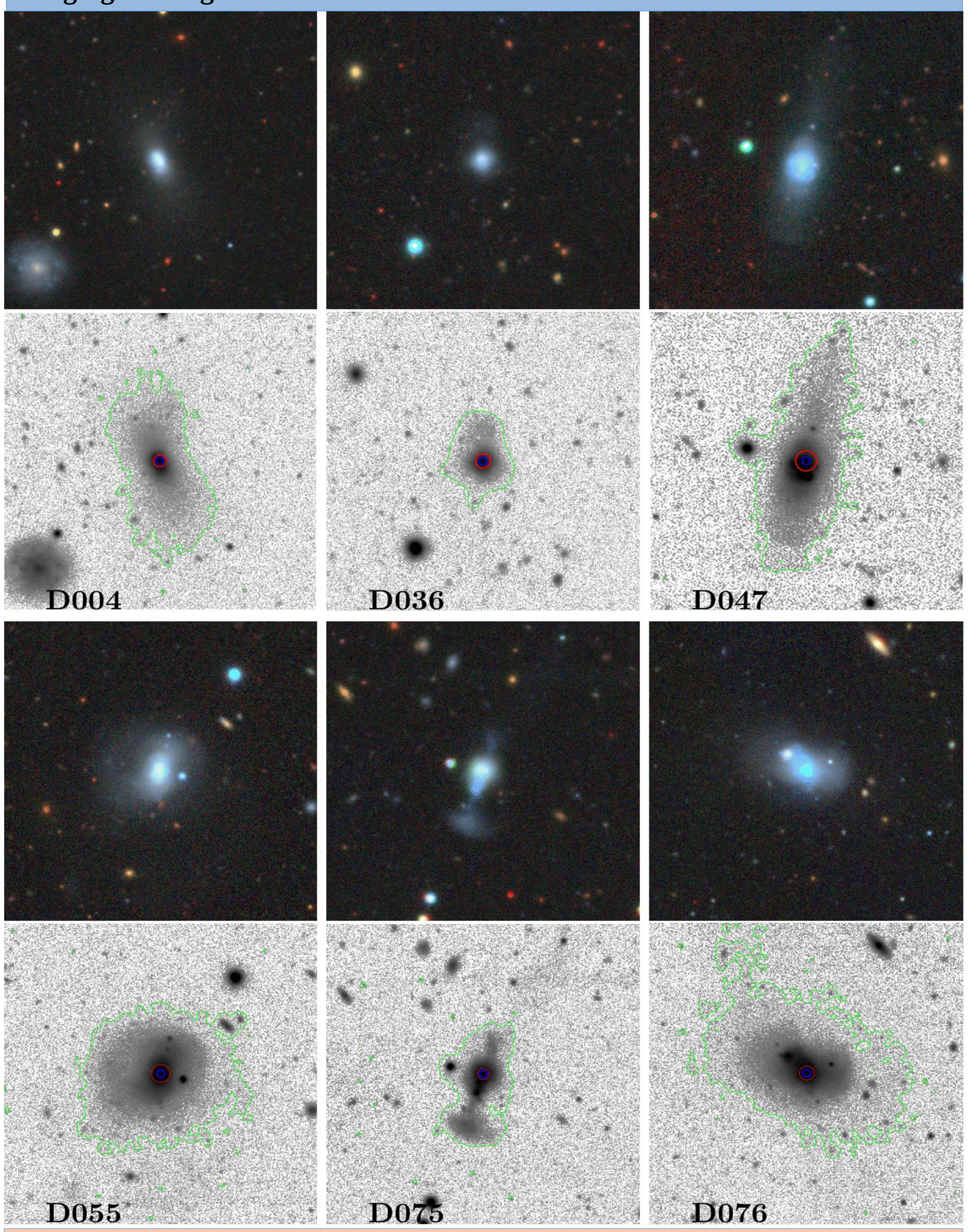
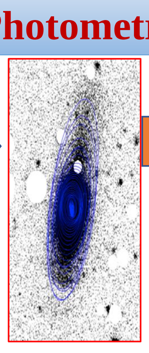
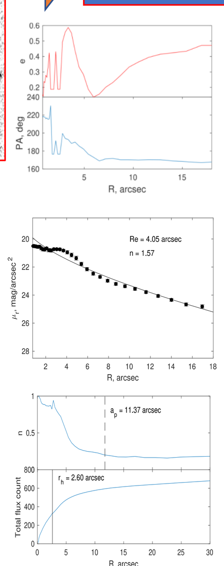


Figure 1: The *g*-, *r*-, and *z*-band tri-color image is a cutout of the Legacy sky-server images (Dey et al., 2019). The lower panel is the gray-scale *g*-band images. We also show the size of the measured half-light radius with a red circle and a blue circle representing the SDSS fiber position. In each grey scale image, we draw a green contour representing a surface brightness level of 27 mag-arcsec^{-2} at the *g* −band.

A. Photometric Analysis

CG 0315
Image Source: Legacy survey sky-server.

IRAF Ellipse Task Jedrzejewski (1987) →  → Ellipse Parameters → Radial Profile → Galaxy Size → Parametric / Non-Parametric → Size (R_e & r_h)



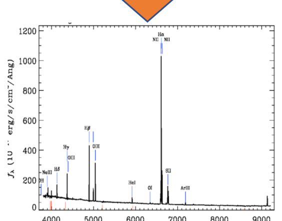
$$I(R) = I_e \exp\left[-b_n\left\{\left(\frac{R}{R_e}\right)^{\frac{1}{n}}\right\} - 1\right]$$

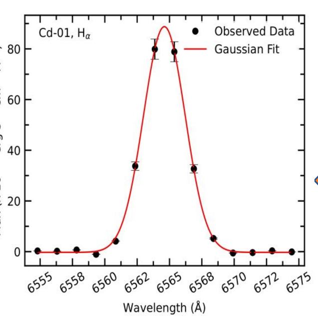
$$n(R) = \frac{\mu(R)}{\langle\mu(R)\rangle}$$

a_p is setup when n = 0.2

B. Spectroscopic Analysis

Galaxy from Catalog (z = 0.0024 – 0.0144) → Download FITS File → Download SDSS Data → Plot Spectrum → Gaussian Fits of Emission Lines → Tabulate Gaussian Parameters → Calculate SFR & Metallicity





$$12 + \log(O/H) = 8.743 + 0.462 \times \log(NII/H_\alpha)$$

$$SFR\ (M_\odot year^{-1}) = 7.9 \times 10^{-42} \sum L(H_\alpha) \quad (ergs\ s^{-1})$$

4. Results and Discussion

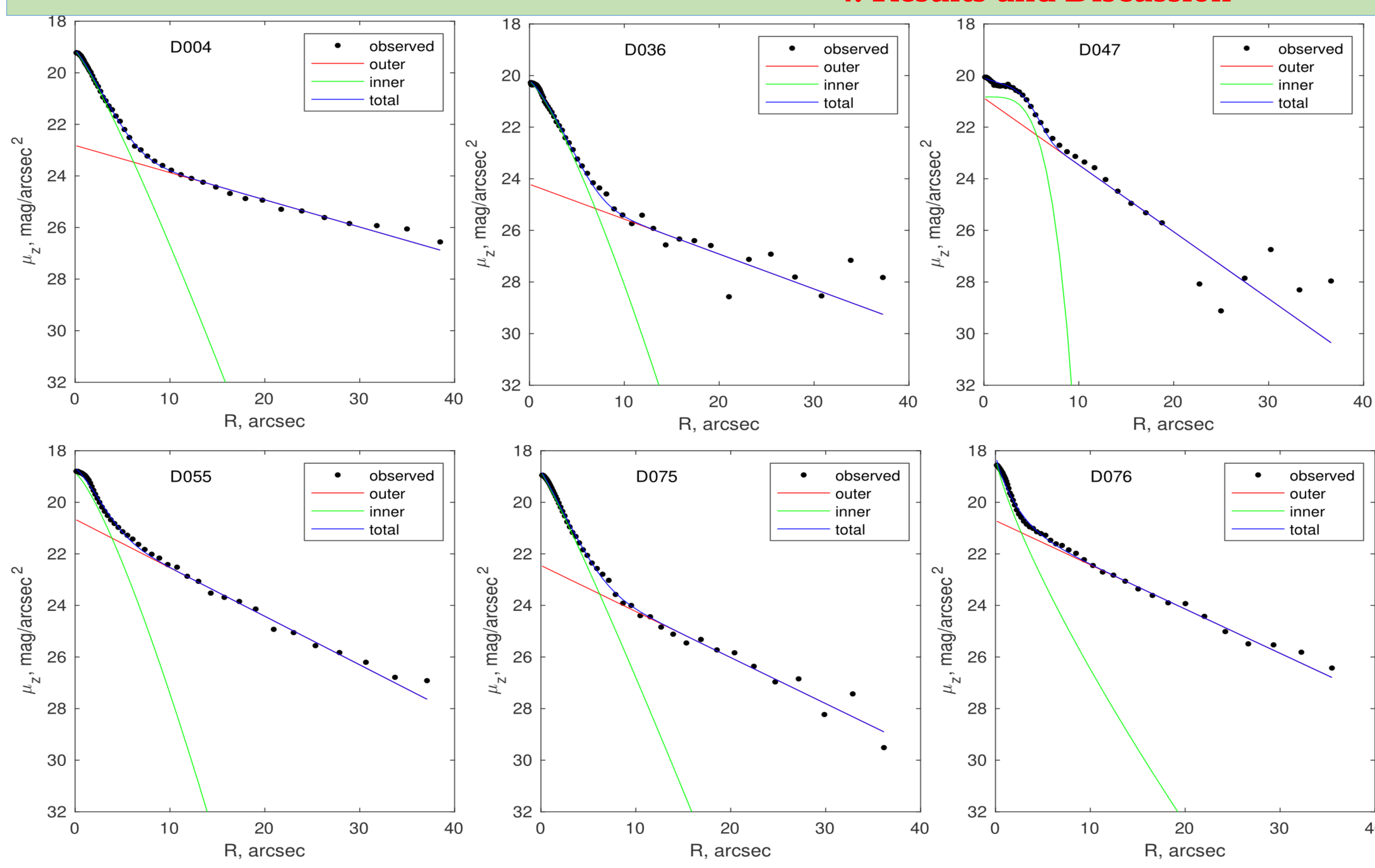


Figure 2: Multicomponent S´ersic modelling of observed one-dimensional light profile. The black dots represent the observed data points. We show the inner and outer best fit S´ersic function in green and red lines respectively. The blue line represents a combination of both the inner and outer best-fit models.

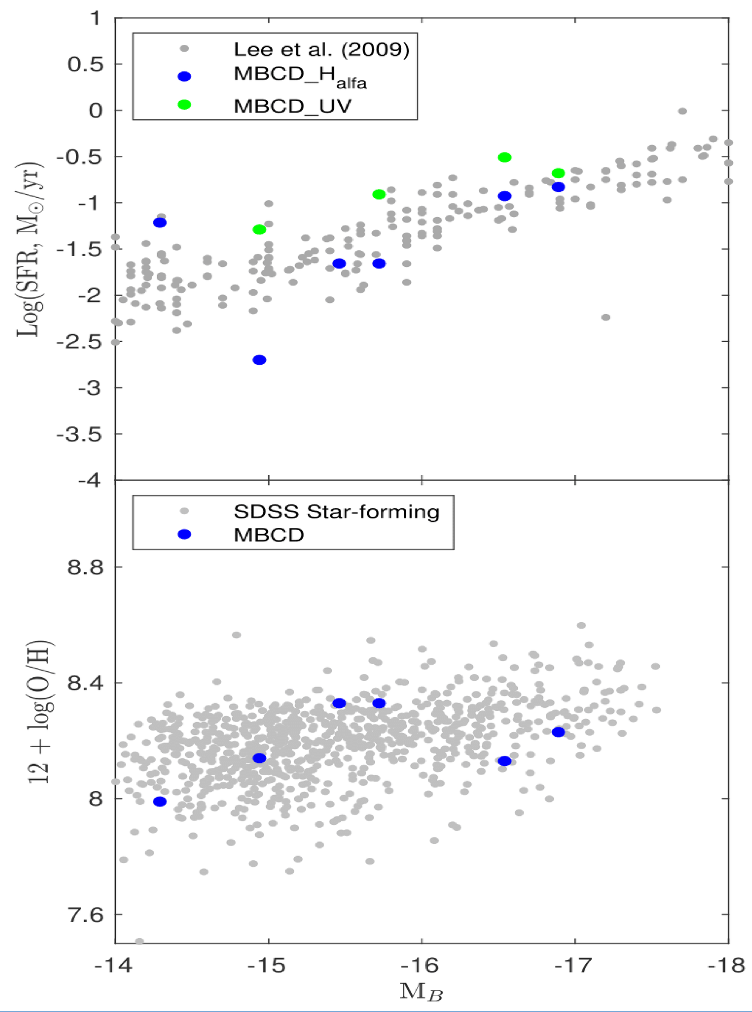


Figure 3: Top : Relation between B-band absolute magnitude and log (SFR). There are no UV data for galaxies D036 and D076. Bottom : emission line metallicity and B-band absolute magnitude relation.

Table 1: Derived properties of the sample galaxies.

Galaxy ID	R. A. (◦)	Dec. (◦)	*c*	*Z* (dex)	*SFR* ($M_\odot$/yr)	R_a (″)	R_i (″)	n_i	R_o (″)
D004	028.9989	− 0 .1855	4.62	8.33	0.022	2.841	2.490	0.8	17.1
D036	144.5608	19 .7111	3.34	8.33	0.022	2.101	2.751	0.8	19.4
D047	150.3099	37 .0709	3.27	8.14	0.002	4.234	1.212	0.3	06.1
D055	157.4553	16 .1809	3.56	8.23	0.148	3.162	2.481	0.7	10.0
D075	177.0757	− 1 .6399	2.98	8.13	0.118	2.659	2.358	0.9	10.4
D076	177.5113	15 .0231	3.26	7.99	0.061	1.998	2.067	1.2	10.5

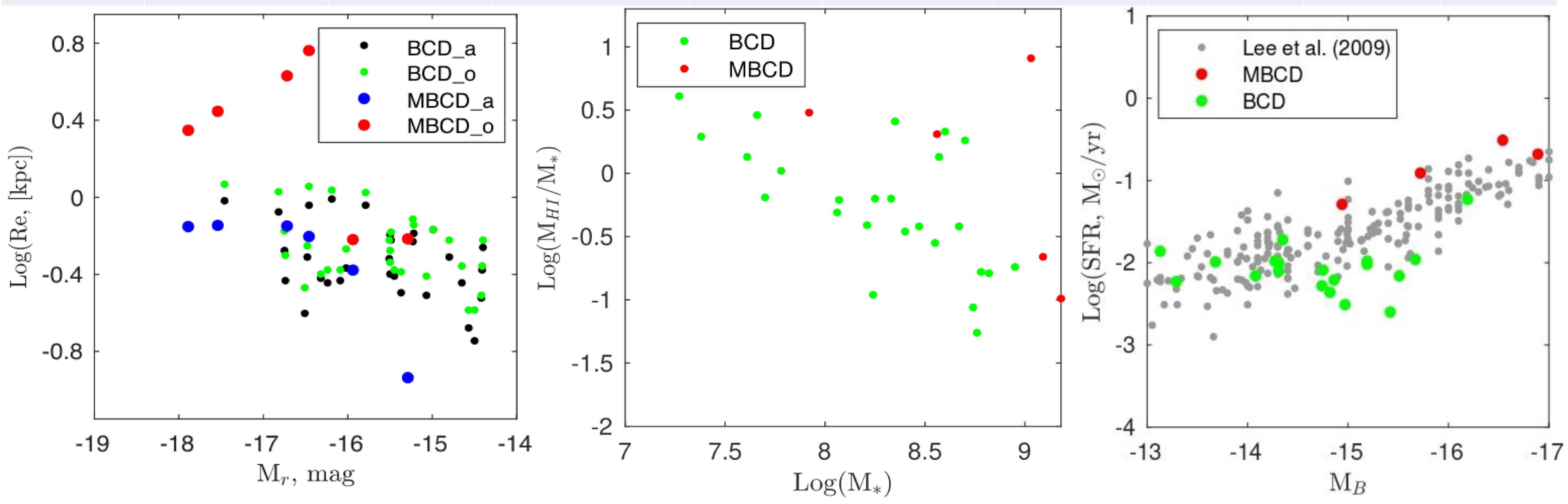


Figure 4: Comparison of physical and star-formation parameters between merging BCDs and Virgo cluster BCDs. For the Virgo cluster BCDs, we used Meyer et al. (2014) photometric measurement.

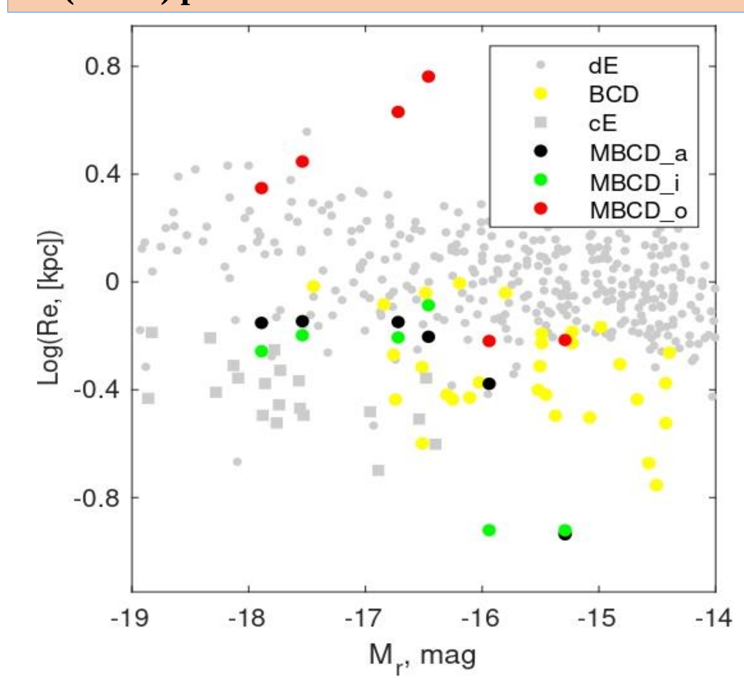


Figure 5: Scaling relation between log (R_e) and magnitude. Sample dE, cE and BCD are taken from Janz & Lisker (2008), Chilingarian et al. (2009) and Meyer et al. (2014) respectively.

5. Conclusions

a. **We measured galaxies' sizes, SFR, metallicity and so on and found that they are significantly compact and are formed by the merger.**
b. **The inner and outer component stellar-mass ratio is an average of 4:1 for our sample, indicating these galaxies might have suffered a recent accretion of small dwarf galaxies, which triggers the starburst in the center of the galaxies.**
c. **Several physical properties such as color, metal content, and star-formation rate are fairly similar to a typical BCD.**
d. **The half-light radii of our sample galaxies range from 0.23 kpc to 0.56 kpc, proving that our selected sample dwarf galaxies are compact dwarfs in general.**

Acknowledgements

DNC acknowledges the University Grants Commission of Nepal for financial support (Ph. D. -75/76-S & T-13). SP acknowledges support from the New Researcher Program (Shinjin grant No. 2019R1C1C1009600) through the National Research Foundation of Korea. This study is based on the archival images and spectra from the Sloan Digital Sky Survey (the full acknowledgment can be found at https://www.sdss.org/collaboration/acknowledgements).

References

1. Ahn C. P. et al., 2012, ApJS , 203, 21
2. Jedrzejewski R. I., 1987, MNRAS , 226, 747
3. Kennicutt R. C. Jr, 1998, ARA&A , 36, 189
4. Sersic J. L., 1968, Atlas de Galaxias Australes, Observatorio Astronomico, Cordoba, Argentina

chhatkulidn@gmail.com