New Cosmological Data and the Values of the Fundamental Parameters
IAU Symposium, Vol. 201, 2005
Anthony Lasenby and Althea Wilkinson, eds.

The Local Group Dwarf Spheroidal Galaxies: A Key to Building Blocks in the Universe

Hiroyuki Hirashita and Naoyuki Tamura

Department of Astronomy, Faculty of Science, Kyoto University, Sakyo-ku, Kyoto 606-8502, Japan

Tsutomu T. Takeuchi

Division of Particle and Astrophysical Sciences, Nagoya University, Chikusa-ku, Nagoya 464-8602, Japan

Abstract. Recent studies have been revealing the properties of dwarf spheroidal galaxies (dSphs). Their low mass indicates that the dSphs may provide a clue to physical properties of the building blocks in the hierarchical structure formation. We select the Local Group dSphs as a sample. To obtain the information on the star formation history of dSphs, we investigate the relation between their metallicity and virial mass. According to our scenario, the star formation efficiency of the dSphs is low because of strong regulation. This is consistent with their high mass-to-light ratios. We also comment on the environmental effects on the dSphs.

1. Introduction

Recent studies have been revealing the physical properties of dwarf spheroidal galaxies (dSphs). Their low mass ($\sim 10^7$–$10^8 M_\odot$) indicates that the dSphs may provide a clue to physical properties of the building blocks in the hierarchical structure formation. In this scenario, the collapse of such low-mass objects is considered to form the first luminous objects and their formation epoch depends on the cosmological parameters. Thus, in the context of the cosmological structure formation, it is important to consider what determines the physical properties of dSphs. We select the Local Group dSphs as a sample. To obtain the information on the star formation history of dSphs, we investigate the relation between their metallicity and virial mass. Environmental effects on the dSphs are also mentioned.

2. Metallicity–Mass Relation

The relation between the metallicity and the virial mass for the Local Group dSphs is examined (Tamura, Hirashita & Takeuchi 2000 for the details). According to the relation between their virial mass ($M_{\rm vir}$) and luminosity, Hirashita, Takeuchi & Tamura (1998) divided the dSphs into two classes: low-mass ($M_{\rm vir} < 10^8 M_\odot$) and high-mass ($M_{\rm vir} > 10^8 M_\odot$) groups. For the low-mass group, Hirashita et al. (1998) proposed that their gas is blown away once they form stars actively.

https://doi.org/10.1017/S0074180900216719 Published online by Cambridge University Press

According to Mateo (1998), the metallicity of the low-mass dSphs lies in the range of $-2.5 < [Fe/H] < -1.5$. Such a low-metallicity range for the low-mass group is consistent with the low star formation efficiency due to the blow-away. Moreover, Nishi & Tashiro (2000) showed that if the metallicity of a cloud is less than $\sim 10^{-2} Z_{\odot}$, its star formation is strongly regulated by photodissociation of H_2. So we suggest that the low-mass dSphs are objects with extremely low star formation efficiency due to the strong regulation and the blow-away. On the other hand, the dSphs in the high-mass group has [Fe/H] larger than -1.5. This is consistent with the suggestion in Hirashita et al. (1998) that the high-mass dSphs sustained gas after the first active star formation occurred.

3. Environmental Effects

The properties of Local Group dSph may have been affected by the giant galaxies (the Galaxy and M31). We have considered two effects: the wind from the giant galaxies and the tidal force exerted by the giant galaxies.

Hirashita, Kamaya & Mineshige (1997) showed that the ram pressure force by the Galactic wind exceeds the gravitational binding force of a dwarf galaxy if it is located within 100 kpc from the Galaxy. This means that dwarfs within 100 kpc from the Galaxy were stripped of gas and their star formation was terminated in the early epoch of the universe. Their estimate is consistent with the correlation between the star formation history and the Galactocentric distance of the satellite dwarf galaxies (van den Bergh 1994).

Tamura & Hirashita (1999) examined whether tidal force exerted by the Galaxy or M31 have an influence on the Local Group dSphs. They focused on the surface brightness profiles of the dSphs, especially their core radii, because it had been suggested that tidal disturbance can make the core radii extended. They examined the correlation between the distances from their parent galaxy and the "compactness" introduced newly by them. Consequently, they found no significant correlation. This means that there is no evidence that the tidal force significantly affected the structure of the dSphs.

Acknowledgments. H. H. was supported by the Research Fellowship of the Japan Society for the Promotion of Science for Young Scientists.

References

Hirashita, H., Kamaya, H. & Mineshige, S. 1997, MNRAS, 290, L33
Hirashita, H., Takeuchi, T. T. & Tamura, N. 1998, ApJ, 504, L83
Mateo, M. 1998, ARA&A, 36, 435
Nishi, R. & Tashiro, M. 2000, ApJ, 537, 50
Tamura, N. & Hirashita, H. 1999, ApJ, 525, L17
Tamura, N., Hirashita, H. & Takeuchi, T. T. 2000, ApJ, submitted
van den Bergh, S. 1994, ApJ, 428, 617