P22

The “missing” satellite problem: Implications from the Milky Way satellites recently discovered by Hyper Suprime-Cam

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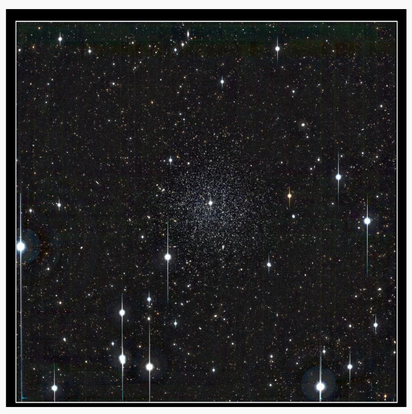
Summary

- Dwarf galaxies that survive around the Milky Way (MW) are key to test **galaxy formation and cosmology**
- We search for the new candidates with **Hyper Suprime-Cam (HSC)** mounted on the Subaru telescope
- **Main Sequence Turn Off stars (MSTOs)** are used to effectively search for new dwarf galaxies
- We have discovered **a new dwarf galaxy candidate with $r_{\mathrm{half\text{-}light}}$ ~ 432 pc**
- Spectroscopic follow-up campaign is ongoing to derive dynamical mass and chemical abundance

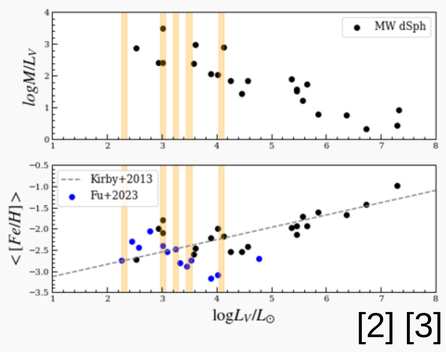
Introduction

○ Dwarf galaxies : Unique stellar systems to test **galaxy formation in the early universe and cosmology**



Dwarf galaxy (Leo II) [1]

Fainter dwarf galaxies are metal-poor and dark matter rich?



[2] [3]

M : Dynamical mass (including stars and dark matter)
L : Luminosity (only from stars)
→ **M/L** ~ **1000** (in solar unit)

<Fe/H> : Mean number density ratio of stellar Fe to H normalized by that of the Sun

&

Observed dwarf galaxies are less? = missing satellite problem

Simulation based on ΛCDM model

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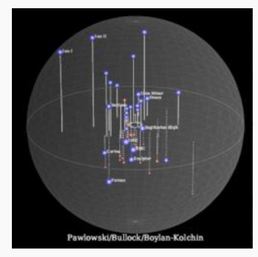


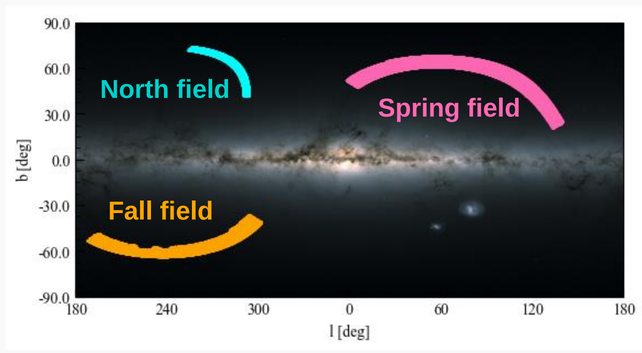
Observation [4]

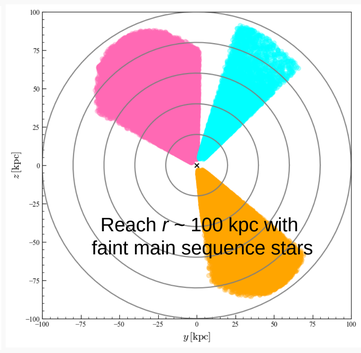
▶ **Detection of ultra faint dwarf galaxies (UFDs)** can strongly constrain on both science cases

Data

○ HSC Subaru Strategic Program (HSC-SSP)

Wide (~1,100 deg^2) & Deep (i-band < 26.5) photometry



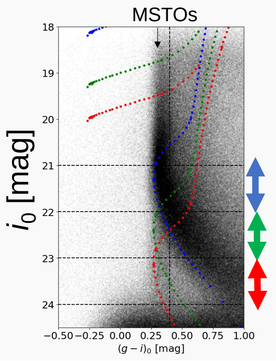


[5] [6] [7]

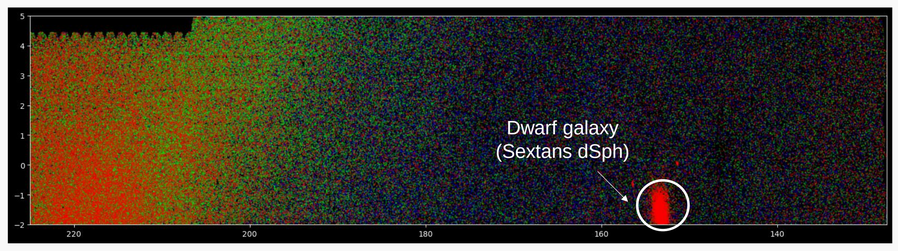
Method

○ Traces: near MSTO stars : $0.25 < (g\text{-}i)_0 < 0.4$

We can obtain stars at a certain distance from the Sun, $D_\odot$



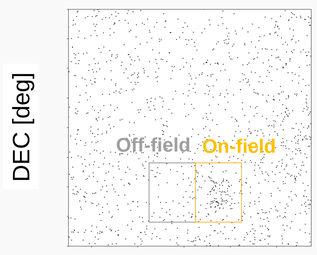
$30 < D_\odot < 50$ kpc　$50 < D_\odot < 70$ kpc　$70 < D_\odot < 120$ kpc



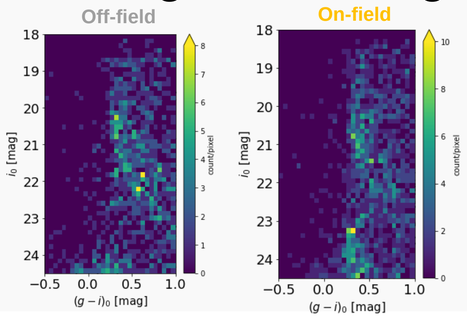
Tomographic view of the MW toward the Spring field

Results

Spatial distribution



Color Magnitude Diagram



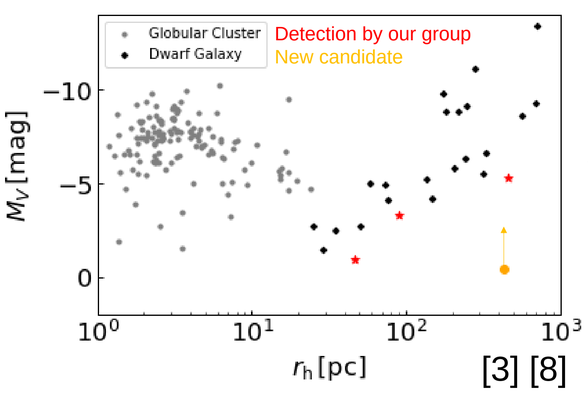
○ Physical parameters

Age (Gyr) : 11.5 ± 0.26
[M/H] (dex) : -0.997 ± 0.018
r_h (pc) : $432.32^{+64.35}_{-55.82}$

Preliminary

▶ **Discovery of a new candidate of old and metal-poor system!**

Discussion & Conclusion



[3] [8]

GC or UFD?

- GC → r_h ~ a few pc (compact)
- UFD → r_h ~ 100 pc

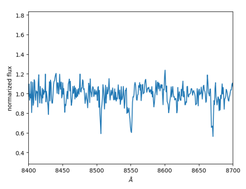
∴ **Our candidate is dwarf galaxy from morphology.**

※ M_V is mainly influenced by bright stars (*i.e.*, RGB stars), resulting in a large uncertainty

Ongoing spectroscopic follow-up campaign [9]

Observation	PI	Target	instrument	remarks
S17B (1.0 night)	M. Chiba	Cetus III	DEIMOS (Keck)	bad weather
S18A (1.5 night)	M. Ishigaki	Virgo I	FOCAS (Subaru)	snowstorm totally cloudy
S18B (1.0 night)	M. Ishigaki	Cetus III	DEIMOS (Keck)	good
S19A (2.0 night)	M. Ishigaki	Virgo I	FOCAS (Subaru)	good
S20A (1.5 night)	M. Ishigaki	Virgo I/BootesIV	FOCAS (Subaru)	bad weather
S24A (4.0 nights)	Y. Suzuki	Bootes IV	FOCAS (Subaru)	5/12(**ToO**), 5/14, 6/6 (**ToO**), 7/12, 7/13, 7/14
S24B (1.0 night)	Y. Suzuki	Cetus III New candidate	FOCAS (Subaru)	9/6, 11/4 (**ToO**)
S25A (1.0 night)	Y. Suzuki	Virgo I/ Bootes IV Sextans II/ Virgo III	FOCAS (Subaru)	4/20

① Identify member stars (for M_V)
② Derive radial velocity v_r
③ Derive of metallicity <[Fe/H]>
④ Derive its dynamical mass $M \propto \sigma^2_{v_r}$



Na I @8194 Å and Ca II Triplet @ 8498 Å, 8542 Å and 8662 Å absorption lines are key to distinguish member stars from field halo stars.

References

[1] https://www.subarutelescope.org/old/Pressrelease/2007/11/28/fig01_h.jpg
[2] Kirby, E. N., Cohen, J. G., Simon, J. D. et al., ApJ, 838, 83K
[3] McConnachie, A. W., 2012, AJ, 144, 4M
[4] Bullock, J. S. & Boylan-Kolchin, M., ARA&A, 55, 343B
[5] Miyazaki, S., Komiyama, Y., Kawanomoto, S., et al. 2018, PASJ, 70S, 1M
[6] Aihara, H., Arimoto, N., Armstrong, R., et al. 2018, PASJ, 70S, 4A
[7] Komiyama, Y., Obuchi, Y., Nakaya, H., et al. 2018, PASJ, 70S, 2K[
[8] Harris, W. E., 1996, AJ, 112, 1487H
[9] Wolf, J., Martinez, G. D., Bullock, J. S., et al. 2010, MNRAS, 406, 1220W