Identifying Unique Stellar Systems In Imaging Surveys With Citizen Science

Swapnaneel Dey[1], Michael Jones[1], David Sand[1]

1Astronomy Department, Steward Observatory, University of Arizona
933 N Cherry Ave, Tucson, AZ 85719, USA

Abstract

We present new examples of a novel class of stellar system identified in the Virgo galaxy cluster (~16.5 Mpc) through a citizen science search conducted on the Zooniverse platform. These systems feature blue, irregular and clumpy morphology with strong UV emission, suggesting a young stellar population. These “blue blobs” are isolated, often > 100 kpc away from the parent galaxy. They have low stellar masses (~10^4 $M_\odot$) and high metallicity. Zooniverse volunteers searched through optical/UV images from the Next Generation Virgo Survey (NGVS[1]), the Dark Energy Camera Legacy Survey (DECaLS), and NASA's Galaxy Evolution Explorer (GALEX) to find more of these rare objects. Radio observations confirm that some are exceptionally gas-rich, while other appear to be gas-poor. Here we present the full sample to date, including their distribution within the cluster and an overview of their properties.

What is a blue blob?

Characteristics:

- Blue, irregular, and clumpy objects.
- Embedded in the hot Intracluster Medium (ICM) of the Virgo Cluster[2].
- ~ 16.5 Mpc away with a redshift range of - 400 km/s to 4000 km/s.
- Typically >100 kpc from any plausible parent galaxy.
- Strong UV emission indicates presence of young, hot stars.
- Low stellar mass ($M_\star \sim 10^4$ $M_\odot$).
- High metallicity ($8.29 < 12 + \log(O/H) < 8.73$).

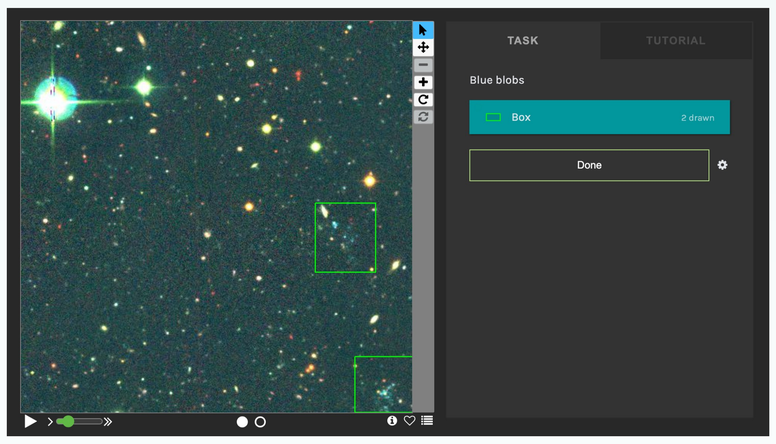
Origin hypothesis:

- High metallicity of blue blobs suggests that they have formed from stripped gas of galaxies. Ram pressure stripping is a phenomenon that could explain the young stellar population, high metallicity, and isolation observed in the blue blobs, due to the high speed at which the stripped gas travels.

We have identified around **30** of these objects to date.

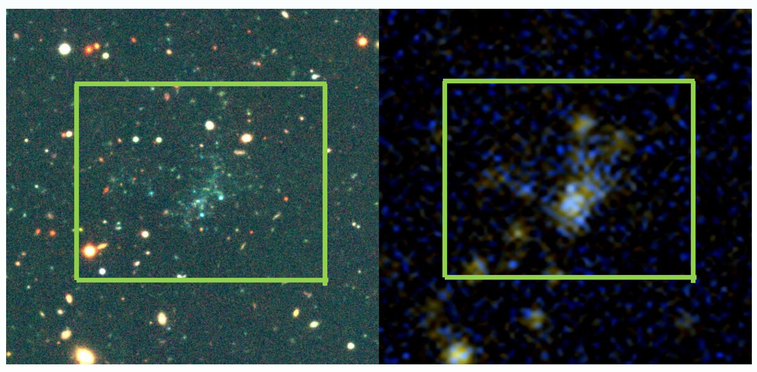
How do we find them?

Manual identification of faint and irregular blue blobs was facilitated via the Zooniverse citizen science platform, engaging > 1500 participants. Volunteers inspected paired optical and GALEX images to detect potential candidates. Each image was viewed by 10 different viewers. Criteria for candidate selection included the presence of blue irregular clumps in the optical image and strong UV emission in the corresponding GALEX image. Each blue blob candidate (BC) classified by at least 3 volunteers was subsequently evaluated and ranked by the research team.

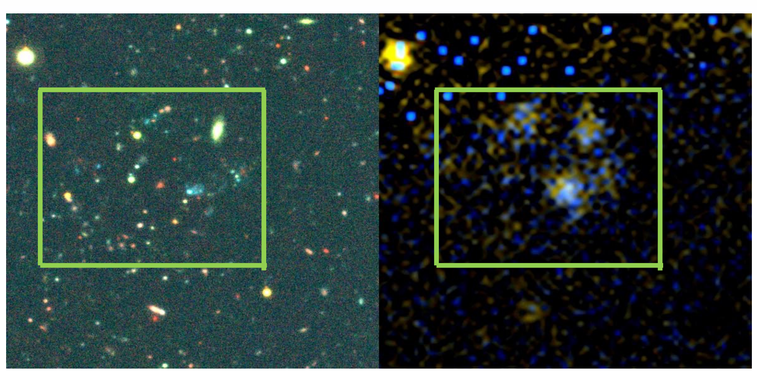


Zooniverse platform used to find blue blobs.

A few confirmed blue blobs

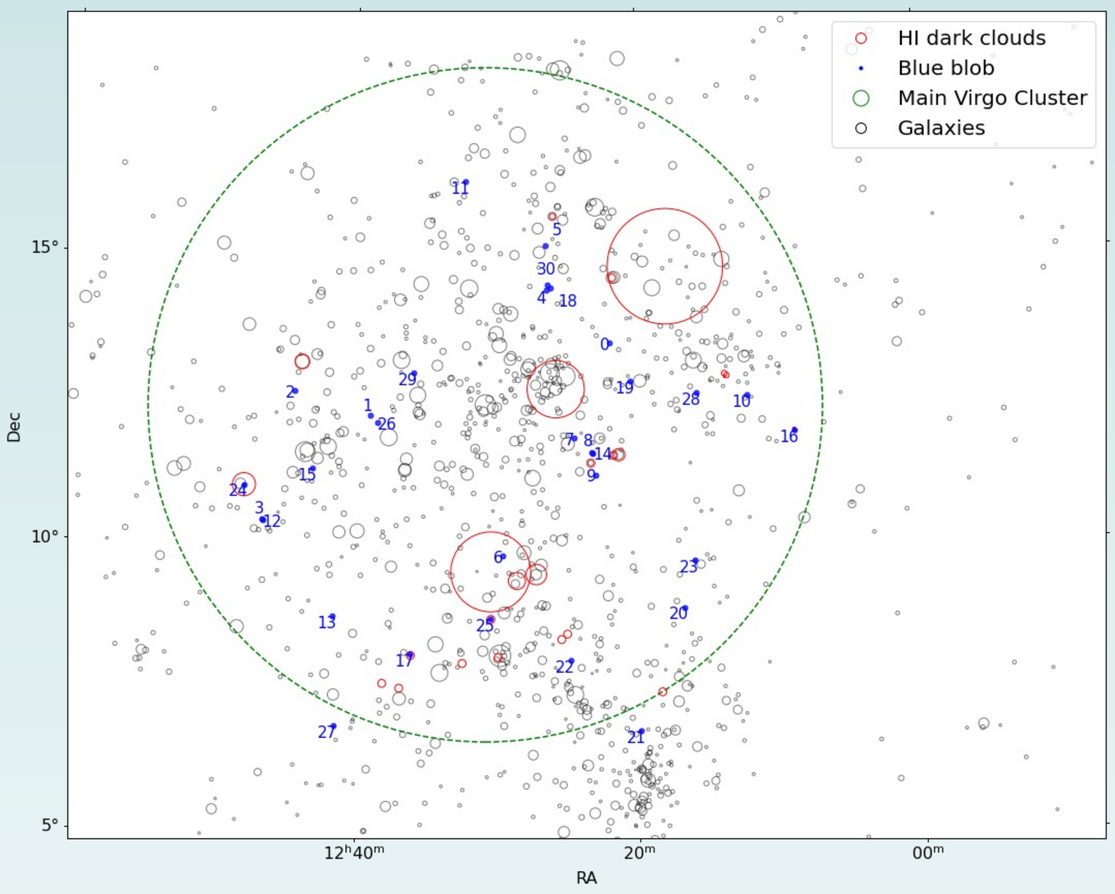


One of the first blue blob candidates, BC1. In the NGVS cutout (left) there are clear presence of blue clumps inside the box drawn. The clumps also have strong UV emission as seen in the GALEX cutout (right).



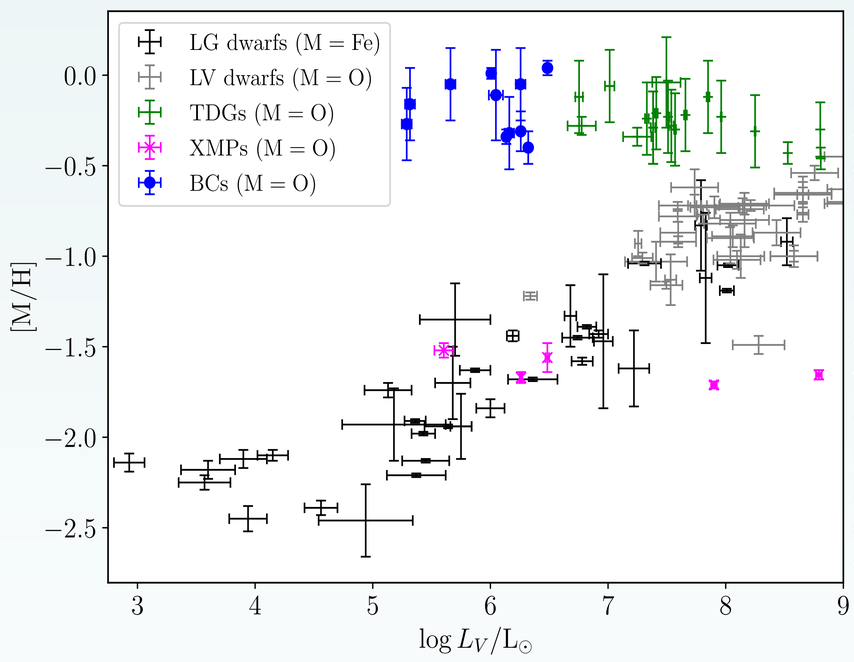
BC6[3] NGVS image (left) GALEX image (right). It is one of the unique blue blobs with a recent paper published on it. It is a stellar counterpart of what was previously thought to be a dark HI cloud for 17 years. **It is the most gas-rich star-forming object ever discovered** (Jones et al, 2024, S. Dey Co-author)

Distribution of blue blobs in Virgo



This plot shows the positions of all of the blue blobs found to date in the Virgo Cluster whose main area is enclosed in the green dashed line. HI optically dark clouds[4] are enclosed in the red circles. The black circles are the known galaxies in the Virgo cluster[5]. Blue dots are the blue blobs found in the Zooniverse search.

Metallicity of blue blobs



Metallicity vs V-band Luminosity plot[6] of a few blue blobs (BCs), local dwarfs galaxies, tidal dwarf galaxies and extremely metal-poor galaxies.
BCs tend to have a higher metallicity compared to LDGs and XMPs , but have the same metallicity as TDGs. However BCs have significantly lower stellar mass than TDGs. This hints towards RPS as a cause of origin for these objects.

Future work

- We are sorting through the objects classified by the volunteers.
- We will perform photometry and estimate stellar mass and SFRs for all the candidates.
- We have an extensive follow up program with GBT, ALMA, HET, and HST to perform detailed analysis of our candidates.
- We will use the distribution of blue blobs within the Virgo Cluster to understand their points of origin and formation pathways.
- In Dey et al. (in prep) we will present the full catalog of blue blob candidates in the Virgo cluster.

References

1 Ferrerase et al. 2012 ApJ 200, 4F
2,6 Jones et al. 2022, ApJ 935, 51
3 Jones et al 2024 (arXiv:2402.14909)
4 Rhys Taylor et al 2020 AJ 159 218
5 Binggeli et al 1985 AJ 90, 1681

BC6 paper!

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