Search for Dwarf Galaxy Candidates in M 106

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Abstract

We present preliminary results of a search for dwarf galaxy candidates in the 24′ x 24′ field of view around M 106 galaxy. Total of 107 images were taken in the V-band with the new 1.4m Milanković telescope (Serbia, near Prokuplje) and 27 images in the L-band. We confirm presence of the satellites from previous studies and find new candidate galaxies.

Introduction

Nearby galaxies offer unique possibility to study their local environment in unprecedented details. Addressing the "missing satellites" problem, systematic study of the low surface brightness objects is needed. Observations carried out using amateur telescopes with hours-long exposures revealed plethora of dwarf galaxies in the Local Volume (Karachentsev et al. 2015). If galaxies grow trough accretion, they should be surrounded by diffuse stellar halos. Dragonfly Nearby Galaxies Survey probed stellar halos in many nearby galaxies and often found prominent tidal streams (Merritt et al. 2016) and unfold giant low surface brightness stellar disks spread out as the HI disks (Zhang et al. 2018).

There are numerous low surface brightness objects in the vicinity of nearby galaxies yet to be discovered by long exposures using modest-sized telescopes. To that end, we have imaged one nearby galaxy M 106, searching for the possible low surface brightness satellite candidates.

Observations

We carried out observations in two wavelength bands (V and L) on tree nights (11, 20 and 23 April 2018) using Apogee U42 camera mounted on 1.4m Milanković telescope. With our small field-of-view (FOV, hereafter) of 8.3′ × 8.3′, we created a mosaic of 3 × 3 images centered on the galaxy, getting 24′ × 24′ area around M 106 galaxy. In each small FOV we took 10 images dithered slightly (by 0′.3). And on the other nights, 27 images were taken in V- and L-band, respectively. Regarding the L-band, the number of 27 exposures of 180 s across such a wide FOV wasn't enough to reduce the noise sufficiently. Finally, we have used only 80 images in the V-band of 180 s exposure each.

Data reduction was done in `IRAF`, following the standard procedure. Astrometric solution was obtained using `Astrometry` software (Lang et al. 2010). The mosaic creation was done using *mscred* package in `IRAF`, based on the astrometric solution. Objects were extracted from individual stacked small FOVs, 10 images each using Sextractor (Bertin and Arnouts 1996).

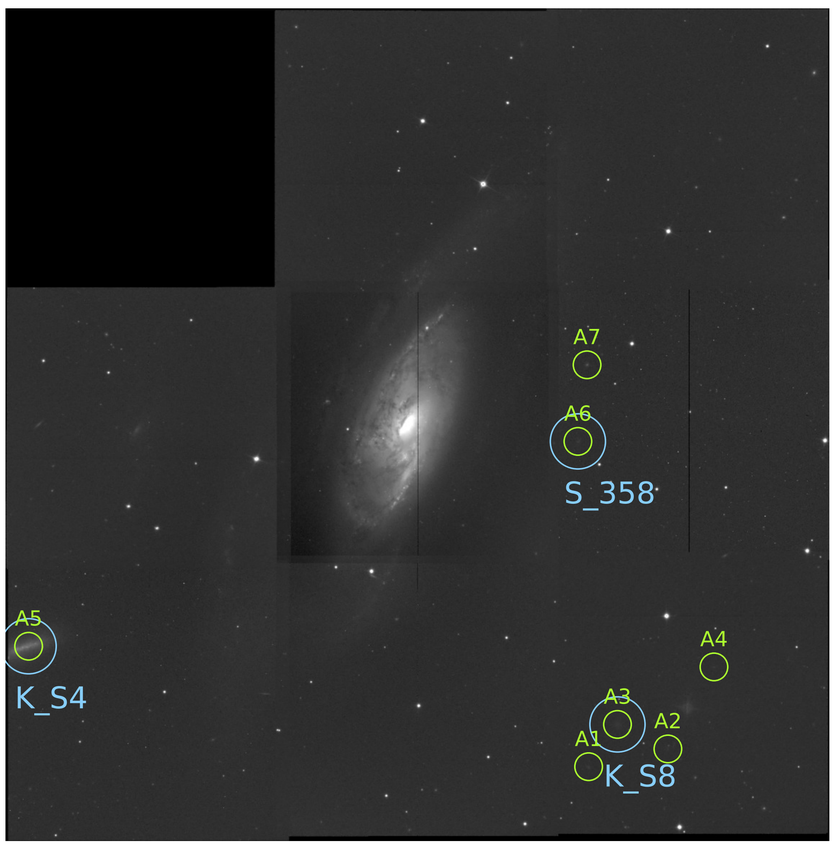

Figure 1: Potential satellite galaxies are marked with smaller green circles. Larger blue circles correspond to the previously known and confirmed satellites.

Results

Celestial coordinates provided by Sextractor were cross-matched against SDSS DR14 photometric catalog to get $g - r$ color. The color cut was performed with $g - r < 0.8$ for galaxies at redshift $z = 0$ (Fukugita et al. 1995). Another cut was required regarding the size of the potential satellites. The Petrosian radii R_{90} in the r-band were required to be larger then 5″. Given the distance to M 106 galaxy, 5 ″ ≈ corresponds to 184 pc, which is about the size of the smallest half-light radius of the classical Milky Way dwarf galaxies. Although Petrosian radius is larger then half-light radius, we believe that distance uncertainties allow for this overestimation. In this way, the potential list of candidates was downsized to 7 objects. All candidates are marked in the Fig 1. with green circles. The blue circles mark objects that were found before: K_S4 and K_S8 are dwarves from Kim et al. (2011) and S_358 is a dwarf galaxy reported by Spencer et al. (2014).

Comparison

Since M 106 galaxy is at a distance of only 7.6 Mpc (Humphreys et al. 2013), it was well studied before. Kim et al. (2011) imaged a large area (1.7° × 2°) around M 106 galaxy in the search for dwarf galaxy satellites. They found 16 candidates and 5 probable satellite candidates (13 of which was previously known), but overlapping with our mosaic (24′ × 24′) only two and they are labeled as K_S4 and K_S8. K_S4 is NGC 4248 and was known to be a satellite already. K_S8 was spectroscopically confirmed as a probable satellite in Spencer et al. (2014). They also had larger FOV, but overlapping with our FOV, except for K_S8, there was no other objects to be matched.

Since the M 106 galaxy is so close to us, we would expect to resolve some stars in the candidate galaxies or they should be extended and extremely faint. These are precisely objects we were looking for. The final seven candidates were examined by the eye and they all resemble objects with such characteristics and they are listed in Table 1.

Object	RAJ2000 [h:m:s]	DECJ2000 [d:m:s]	SDSS-DR14 objID	$R_{90}['']$	g-r
A1	12:19:28.045	47:28:19.56	1237661434308329731	6.6	0.49
A2	12:19:41.887	47:27:50.55	1237661434308329632	6.4	0.25
A3	12:19:33.184	47:27:05.92	1237661434308329605	17.7	0.52
A4	12:19:50.121	47:25:27.18	1237661434308330070	6.5	0.49
A5	12:17:49.84	47:24:33.13	1237661434308198442	58.2	0.87
A6	12:19:27.353	47:18:43.93	1237661434308329730	8.0	0.4
A7	12:19:29.290	47:16:28.28	1237661357007503592	6.4	0.33

Table 1: Galaxy candidates data: (1) Object label same as in the Fig 1., (2, 3) Celestial coordinates, (4) objID from SDSS DR14 photometric catalog, (5) Petrosian radius R_{90} in arcseconds in the r-band and (6) g-r color from SDSS DR14 photometric catalog.

Conclusions

- Total of seven possible dwarf galaxy candidates are found, tree of which have spectroscopic confirmation.
- Meter-sized telescopes with hour-long exposures can detect diffuse structure around nearby galaxies.

Forthcoming Research

It would be interesting in the future to obtain spectroscopic confirmation of candidate dwarf galaxies and to expand the FOV to at least half of the M 106 virial radius, where most of the satelites should reside (Moore et al. 1999). From the photometric field of view, when imaging such a field at least two filters are needed to apply a color-cut to downsize the sample of possible satellites for the following spectroscopic observations.

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