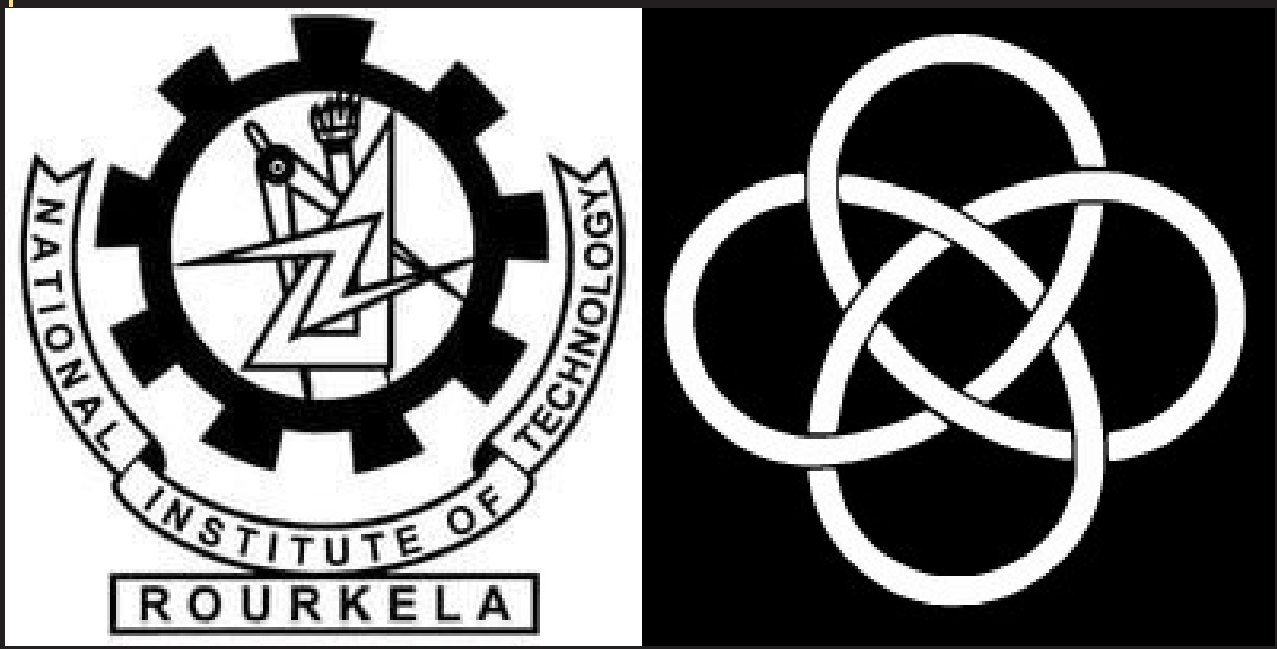


# Multi-wavelength study of galaxies in Bootes Void

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## Introduction - Background

- ▶ Voids represent an under dense region present in the universe formed by the hierarchical clustering of galaxies around primordial density fluctuations processes. It provides a secular environment to study formation and evolution of galaxies. Region of spaces in voids contains lesser number of galaxies than average.
- ▶ We obtain photometric observations a sample of galaxies in the Bootes void which lies in the direction of Bootes constellation. The existence of Bootes void was first proposed by Robert Kirshner in 1987. The void is centered at  $RA = 14^h 50^m, Dec = +46^\circ$ , with redshift range of  $z = 0.041$  to  $z = 0.062$  corresponding to a spherical region of radius 42 Mpc ( $H_0 = 75 \text{ km s}^{-1} \text{ Mpc}^{-1}$ ).
- ▶ By studying the galaxies across the electromagnetic spectrum, we can get a more complete understanding of objects in space. Light from each part of the spectrum brings us unique information about the properties of object.

## Methods

- ▶ **Data Acquisition**
  - ▶ Our sample consists of galaxies present in Bootes void in a total field of view size  $2^\circ \times 2^\circ$  approximately.
  - ▶ We obtained imaging data from SDSS DR12 in *ugriz* wavelength band having mean wavelength of 355.1nm , 468.6nm, 616.5nm, 748.1nm and 893.1nm respectively.
  - ▶ In order to study properties of galaxies in near infrared filter, we acquire imaging data in J, H and Ks band with effective wavelength J-band (1.235 m), H-band (1.662 m) and Ks-band (2.159 m) from Two-Micron All Sky Survey.
  - ▶ Our study also comprises of imaging data from **The Ultraviolet Imaging Telescope (UVIT)** in **Far Ultraviolet (FUV)** and **Near Ultraviolet (NUV)** filter. The wavelength pass band fro FUV and NUV is 130-180 nm, 180-300 nm respectively. Observation information: OBSID = G07077T019000001306  
OBSERVER = kanak
- ▶ **Data Reduction**
  - ▶ Aperture photometry has been performed using for SDSS *ugriz* and 2MASS J, H and Ks band images. The aperture in all bands is set by the profile of the galaxy in the r band alone. Profile of galaxy in r band is determined using Kron photometry. Further, to compensate for loss of flux, aperture correction has been performed. Source Extractor is used for photometric estimations.
  - ▶ Classification between stars and galaxies is based on the CLASS STAR parameter given by Source extractor. In addition, classification was done using (J-K) versus (g-i) color to separate galaxies from stellar locus.
  - ▶ Color and magnitude used for analysis are corrected for atmospheric extinction and reddening. K-correction done to obtain color of galaxies in rest frame.

## Results

- ▶ In the following section, we compare the color magnitude distribution of void galaxies with a magnitude limited ( $z < 0.09, m_r < 17.77$ ) sample of SDSS galaxies. Our sample represents a significant range of colors, having nearly equal representation from early type and late type galaxies.

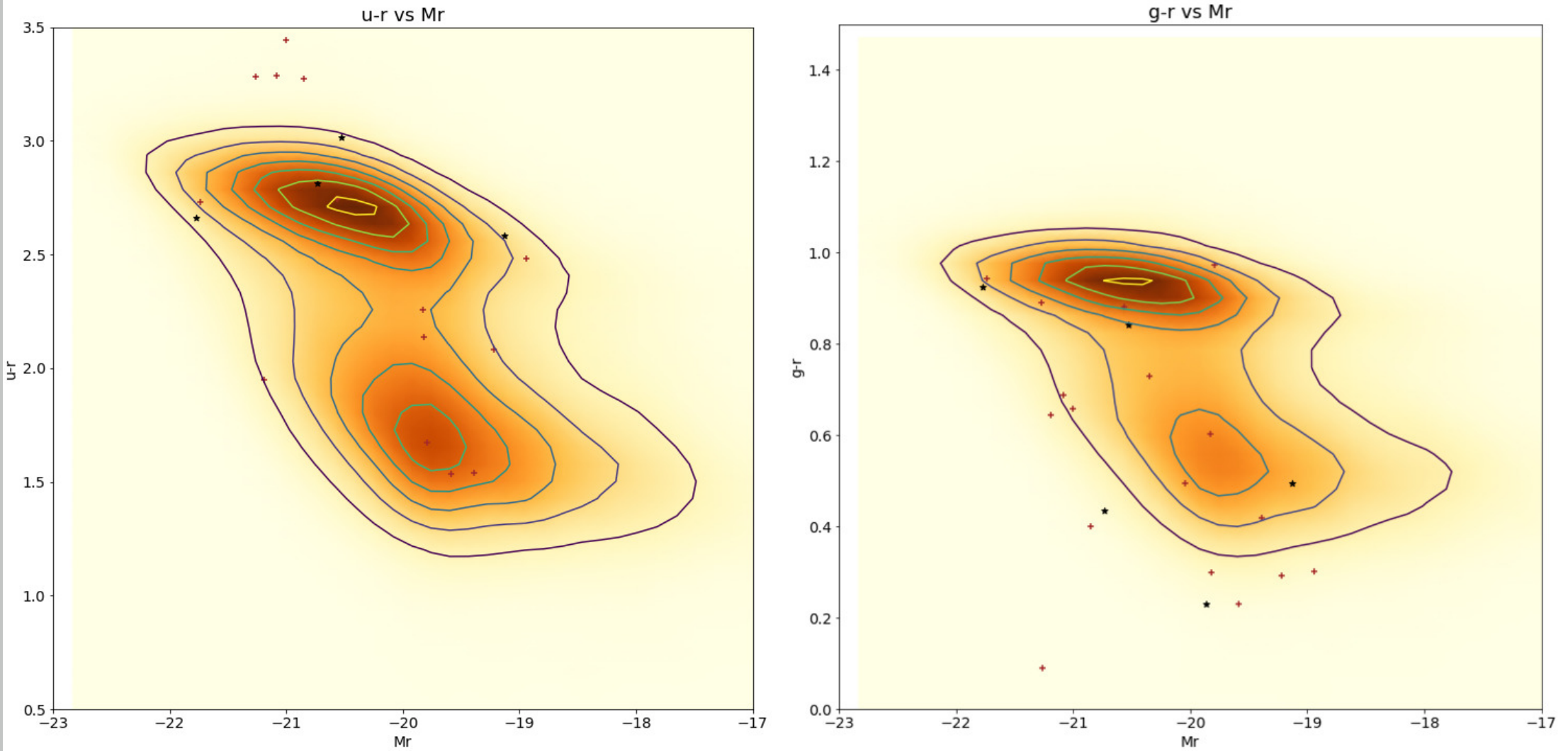


Figure 1: Colormagnitude diagram of the void galaxies (brown-black) compared with a magnitude-limited sample of galaxies from SDSS.

- ▶ Total number of 20 galaxies are reported here. Figure 2 illustrates a selection of galaxies in SDSS *r* filter.

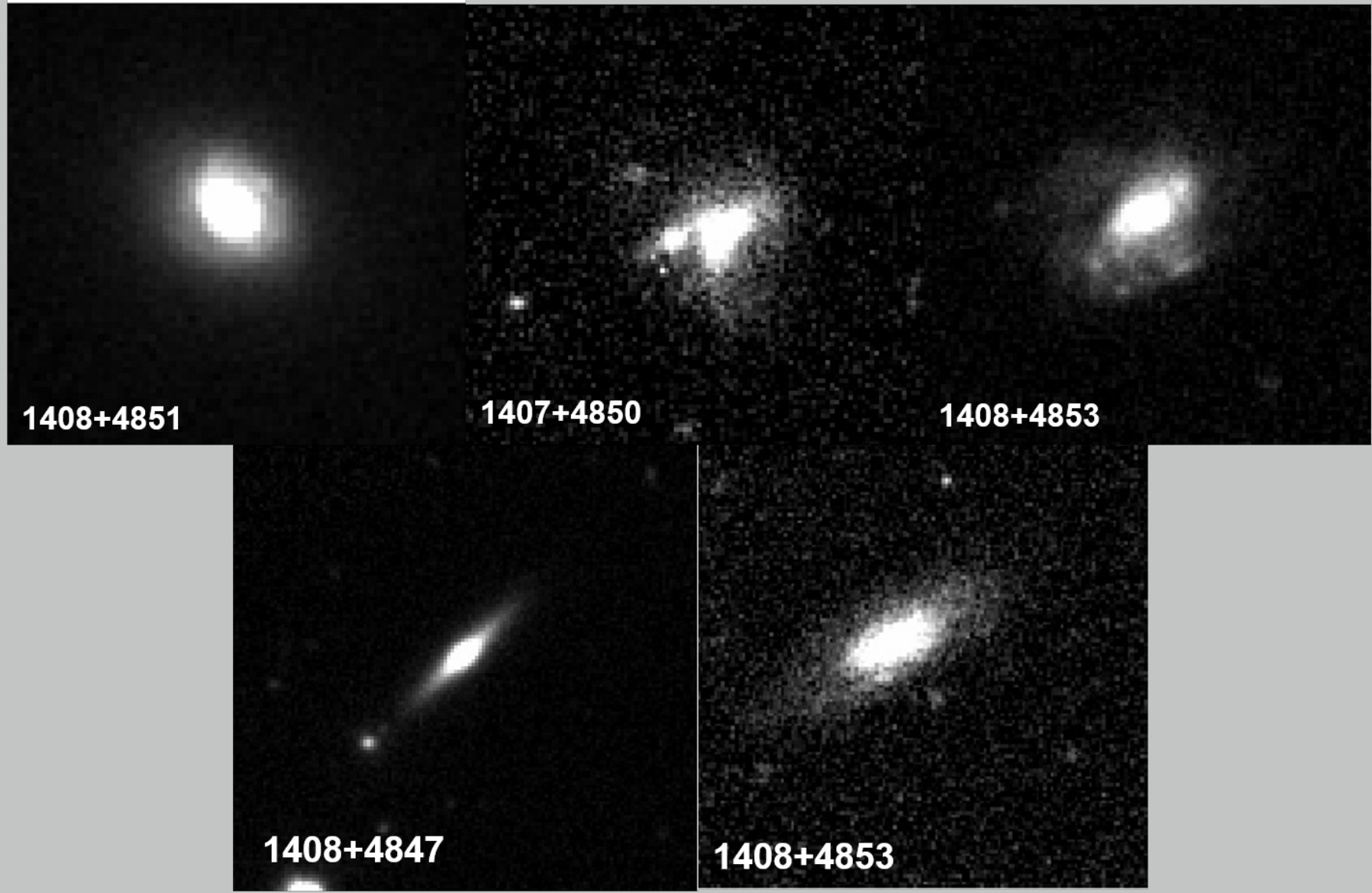


Figure 2: A selection of void galaxies (black) sample are observed in SDSS *r* filter.

- ▶ Figure 3 illustrates RGB composite images of the same selection of galaxy after combining SDSS *r* filter, UVIT NUV and UVIT FUV filter respectively. Figure shows that UVIT imaging data has added details to the components of galaxy observed by SDSS. These galaxies (black) are represent in color magnitude diagram in figure 1.

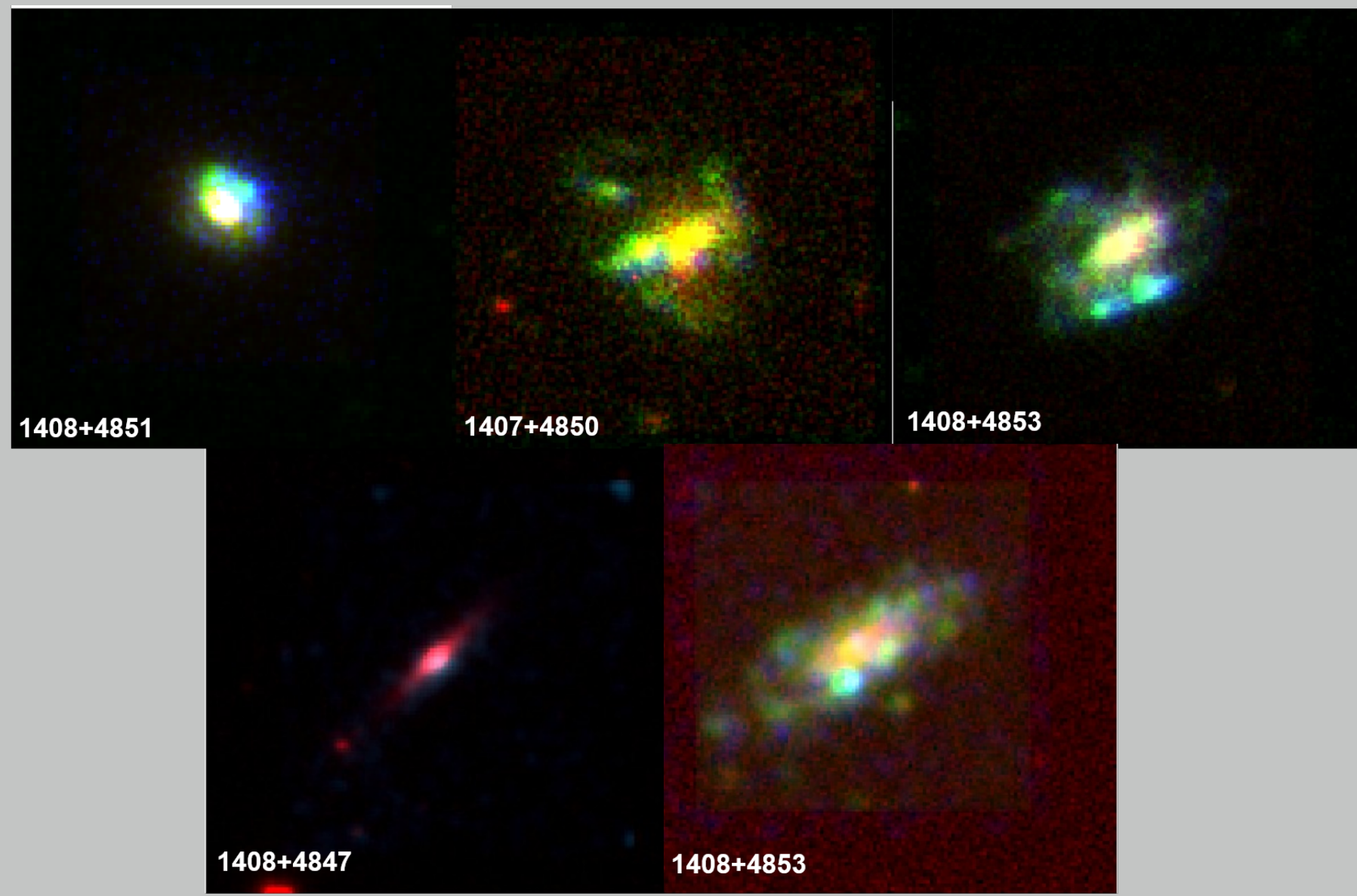


Figure 3: A selection galaxies from our sample. These RGB images are produced from combining SDSS *r* band, UVIT NUV and UVIT FUV filter images respectively.

## Conclusions and Future work

- ▶ We observe that galaxies present in void significantly lie in population of early type and late type galaxies. Galaxy mergers, spiral and elliptical structure have been reported in our sample of galaxies.
- ▶ For future prospects, we aim to obtain a catalog of galaxies present in Bootes void using UVIT imaging data and to derive integrated Spectral energy distribution (SEDs) of these galaxies to estimate their properties.
- ▶ Study of galaxies in low density environment enable us to understand the effect of environment on evolution of galaxies and formation of large scale structures.