



Giulia Boscolo<sup>1</sup>, Riccardo Ravagnan<sup>2</sup>, Gloria Tiozzo<sup>2</sup>

<sup>1</sup>Liceo G. Veronese, sez. Classico, Chioggia

<sup>2</sup>Liceo G. Veronese, sez. Scientifico Brocca, Chioggia

**Abstract.** We studied the photometry of the two galaxy groups 2MASXJ14391186+1415215 and 2MASX J14530794+25554327 using 5 bands (u, g, r, i, z). This study allowed us to determine when a group is compact and isolated, using Hickson's criteria.

## 1. Introduction

Groups of galaxies are the smallest aggregates of galaxies. They typically contain less than 50 galaxies in a diameter of 1 to 2 megaparsecs (Mpc). For example the group which contains our galaxy, the **Milky Way**, is called the **Local Group** and contains more than 40 galaxies. For this analysis we chose the galaxies with the same characteristics: size, brightness intensity and relative distance. This study allowed us to determine when a group is compact and isolated, using Hickson's criteria. Hickson established three criteria to define groups of galaxies.

1. the population: the group must be composed of at least four members;
2. the compactness: the galaxies have to be included in a limited field;
3. the isolation: the members of a galaxy group have to be distant from other galaxies.

## 2. Observational Data

We used images extracted from the public archive of the Sloan Digital Sky Survey (SDSS). SDSS is a project that provides optical images covering more than a quarter of the sky and a tridimensional map containing about one million galaxies and 120000 quasars. SDSS used a 2.5 m telescope, at Apache Point in New Mexico. For the photometric survey, five filters have been used; every filter can select only a determined range of the electromagnetic spectrum of visible light. The five filters (u, g, r, i, z) and their average wavelengths are:

u	g	r	i	z
3551 Å	4686 Å	6165 Å	7481 Å	8931 Å

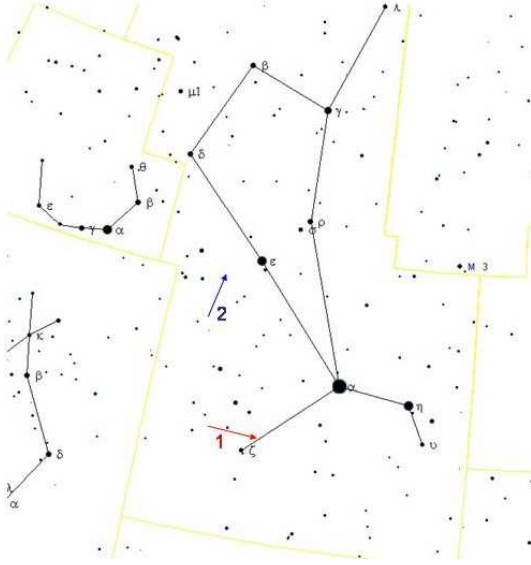


**Fig.1.** Group of galaxies 2MASX J14391186+1415215

Our study was focused on the analysis of the photometric properties of galaxies around two X-ray sources: 2MASX J14391186+1415215 and 2MASX J14530794+2554327, in order to understand if they can be candidates galaxy groups. Since we do not have spectra for these galaxies, we cannot determine their redshift and therefore we are forced to use photometry.

Object	2MASX J14391186+1415215
Right Ascension	14h39m11.8s
Declination	+14d15m22s
Constellation	Bootes

Object	2MASXJ14530794+2554327
Right Ascension	14h53m07.9s
Declination	+25d54m33s
Constellation	Bootes



**Fig. 2.** Bootes constellation

### 3. Work description

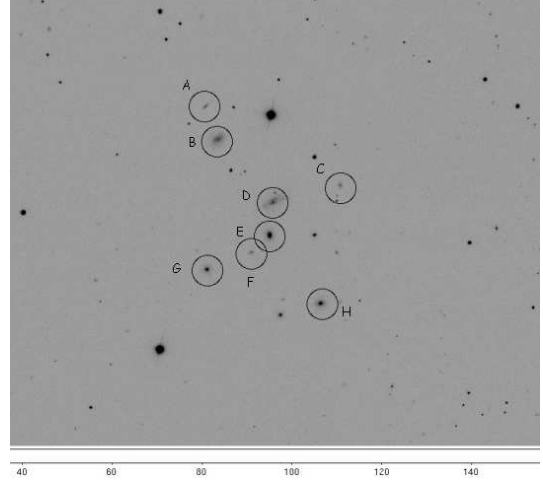
We used the program IRAF (Image Reduction and Analysis Facility) to analyse the images: each pixel in the image has a value in counts that is proportional to the flux of photons that collected by the telescope. By using this program we can measure the light that galaxies send to us. We took five images. Every image was taken by the telescope using different filters (u, g, r, i, z). To understand if a group of galaxies is isolated or not, we performed the following operations.

We started displaying the images, then we selected the galaxies that appeared to belong to the same group for size, brightness and their reciprocal proximity. We numbered and put a circle around each of them to easily identify them.

We searched for the centers of the galaxies and found their coordinates. We enclosed each galaxy in a circle with the smallest possible radius in which we calculated the photometry (the centre of the circle corresponds to that of the galaxy). Then we traced a larger concentric circle around the previous one, including each galaxy, in which we estimated the sky brightness which have to be subtracted.

A	B	C	D
1559.3815	1594.0983	1920.0506	1738.7517
1735.8606	1650.9973	1519.8449	1481.2707
E	F	G	H
1731.0368	1682.819	1565.1676	1562.434
1394.4786	1350.1182	1305.7579	1737.536

With IRAF we calculated the magnitude of each galaxy, called instrumental magnitude ( $m_s$ ). Using the



**Fig. 3.** The group 2MASX J14391186+1415215

photometric constants provided by SDSS ( $m_0$ ,  $k$ ,  $X$ ) we converted instrumental into calibrated magnitudes. For the second group of galaxies, we got 2 sets of constants, because the galaxies were distributed in two different frames: We used the following formula:  $m = m_0 + m_s - k \cdot X$ , where  $m_s$  is the instrumental magnitude,  $m_0$  the photometric zero-point,  $k$  the atmospheric extinction coefficient and  $X$  the airmass. To analyse the properties of the candidate groups we used only the r filter. In order to determine the compactness, we needed to calculate the surface brightness of all the galaxies together. First, we converted the calibrated magnitude of each galaxy into intensity:

$$m = -2.5 \log I \rightarrow I = 10^{\frac{m}{2.5}} \quad (1)$$

Then we measured the radius of the smallest possible circle containing the group of galaxies. This radius was originally in pixel, but we converted them into arcsecs knowing that each pixel of the image is a square covering an area of the sky corresponding to  $0.4'' \times 0.4''$ . For the first group we obtained  $315 \text{ px} = 126''$ , and for the second group  $153 \text{ px} = 61''$ . We calculated the surface intensity of each group summing the intensities of each galaxy and dividing by the area of the circle:

$$I = \sum \frac{I_g}{\pi R^2} \quad (2)$$

where  $R$  represents the radius of the circle that contains the group of galaxies.

The sum of the intensity of the first group is  $11.2334 \cdot 10^{-5}$ . The surface intensity of the first group is:

$$I = \frac{11.2334 \cdot 10^{-5}}{\pi \cdot 15876} = 2.25 \cdot 10^{-9} \quad (3)$$

Then we were able to calculate the surface brightness of each group of galaxies:

$$\mu = -2.5 \log(2.25 \cdot 10^{-9}) = 21.62 \text{ mag/arcsec} \quad (4)$$

Since these two values are lower than  $26 \text{ mag/arcsec}^2$ , the Hickson's limit, we can assert that both galaxy groups are compact.

Finally, we had to define if the groups were isolated or not. To do this we drew a concentric circle to that having the smallest radius containing the galaxies, but with the radius three times larger. If we find other galaxies within this new circle having magnitudes similar or even brighter than those of the studied groups, they cannot be considered isolated. In both cases our galaxy groups satisfy the isolation criterion proposed by Hickson.

#### 4. Results

According to the experimental data, we can say that we have identified candidate compact groups of galaxies. They satisfy the three criteria proposed by Paul Hickson in 1982. It is clear that only from their spectra and redshifts we can be sure that these groups of galaxies are physically connected.

#### References

- Antonucci, R.R.J & Miller, J.S. 1985, ApJ, 297, 612  
Antonucci, R. 1993, ARA&A, 31, 473  
Cid Fernandes, R., et al. 2004, ApJ, 605, 105  
Cid Fernandes, R., Mateus, A., Sodré, L., Stasińska, G., & Gomes, J. M. 2005, MNRAS, 358, 363