New Astronomy 59 (2018) 21–27

Contents lists available at ScienceDirect

New Astronomy

journal homepage: www.elsevier.com/locate/newast

The distribution of infrared point sources in nearby elliptical galaxies

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HIGHLIGHTS

- An effective method for classification of IR point sources.
- Determination with accuracy whether sources are part of ellipticals or background.
- Devised method based on IR colours after thorough examination.

ARTICLE INFO

Article history:
Received 12 April 2017
Revised 28 June 2017
Accepted 27 August 2017
Available online 30 August 2017

Keywords:
X-rays: binaries
Infrared: general

ABSTRACT

Infrared (IR) point sources as observed by *Spitzer*, in nearby early-type galaxies should either be bright sources in the galaxy such as globular clusters, or they may be background sources such as AGNs. These objects are often counterparts of sources in other wavebands such as optical and X-rays and the IR information provides crucial information regarding their nature. However, many of the IR sources may be background objects and it is important to identify them or at least quantify the level of background contamination. Moreover, the distribution of these IR point sources in flux, distance from the centre and colour would be useful in understanding their origin. Archival Spitzer IRAC images provide a unique opportunity for such a study and here we present the results of such an analysis for four nearby galaxies, NGC 1399, NGC 2768, NGC 4365 and NGC 4649. We estimate the background contamination using several blank fields. Our results suggest that IR colours can be effectively used to differentiate between sources in the galaxy and background ones. In particular we find that sources having AGN like colours are indeed consistent with being background AGNs. For sources with non AGN like colours we compute the distribution of flux and normalised distance from the centre which is found to be of a power-law form. Although our sample size is small, the power-law index for the galaxies are different indicating perhaps that the galaxy environment may be playing a part in their origin and nature.

1. Introduction

The Infrared Array Camera (IRAC) on-board the *Spitzer* telescope provides a unique opportunity to study nearby galaxies. Space based observations of a number of regions in the sky provides a basis where different galaxies can be uniformly analysed i.e. with the same instrument and conditions. Apart from the primary objective of providing flux, light distribution and morphology of these galaxies in four Infrared (IR) bands (e.g. Rowan-Robinson et al., 2005; Hatziminaoglou et al., 2005; Labbé et al., 2005), *Spitzer* can also identify point sources within the galaxy. Thus it provides the IR flux colours of interesting objects identified in other wave-bands such as X-ray or optical. For example *Chandra* has detected many X-ray point sources in nearby galaxies (Schlegel and Pannuti, 2003; Swartz et al., 2004; Liu, 2011). While most of them are similar to standard X-ray binaries found in our own Galaxy, there are sources which are Ultra-luminous in X-rays (Colbert and Mushotzky, 1999; Makishima et al., 2000), whose nature is still debated. The IR counterpart of X-ray sources may be due to a globular cluster hosting the X-ray source providing information regarding its environment or could be associated directly with the X-ray binary providing crucial information regarding its nature. (Shalima et al., 2013) used *Spitzer* data to identify the IR counterparts of X-ray sources in the elliptical galaxy NGC 1399. They found that several of the X-ray sources had IR colours which are typically observed for AGNs. In particular, the ratio of the flux between 5.8 μm and 3.6 μm bands is larger than one for AGNs (Lacy et al., 2004) and for some of the X-ray sources in NGC 1399 this was found to be the case. More interestingly, for these sources the IR and X-ray flux were highly correlated, very similar to the tight correlation observed for AGNs (Krabbe et al., 2001; Lutz et al., 2004).

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http://dx.doi.org/10.1016/j.newast.2017.08.006
1384-1076/

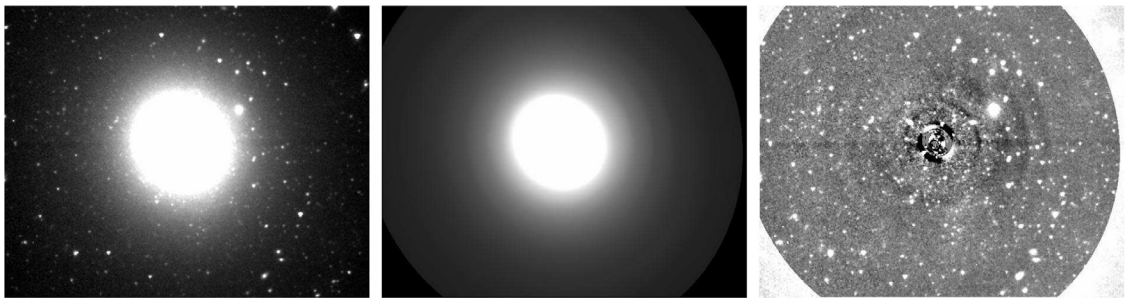

Fig. 1. The original *Spitzer* image of NGC 1399 (left panel), the image of the model galaxy (middle panel) and the subtracted image (right panel) which shows the IR points sources.

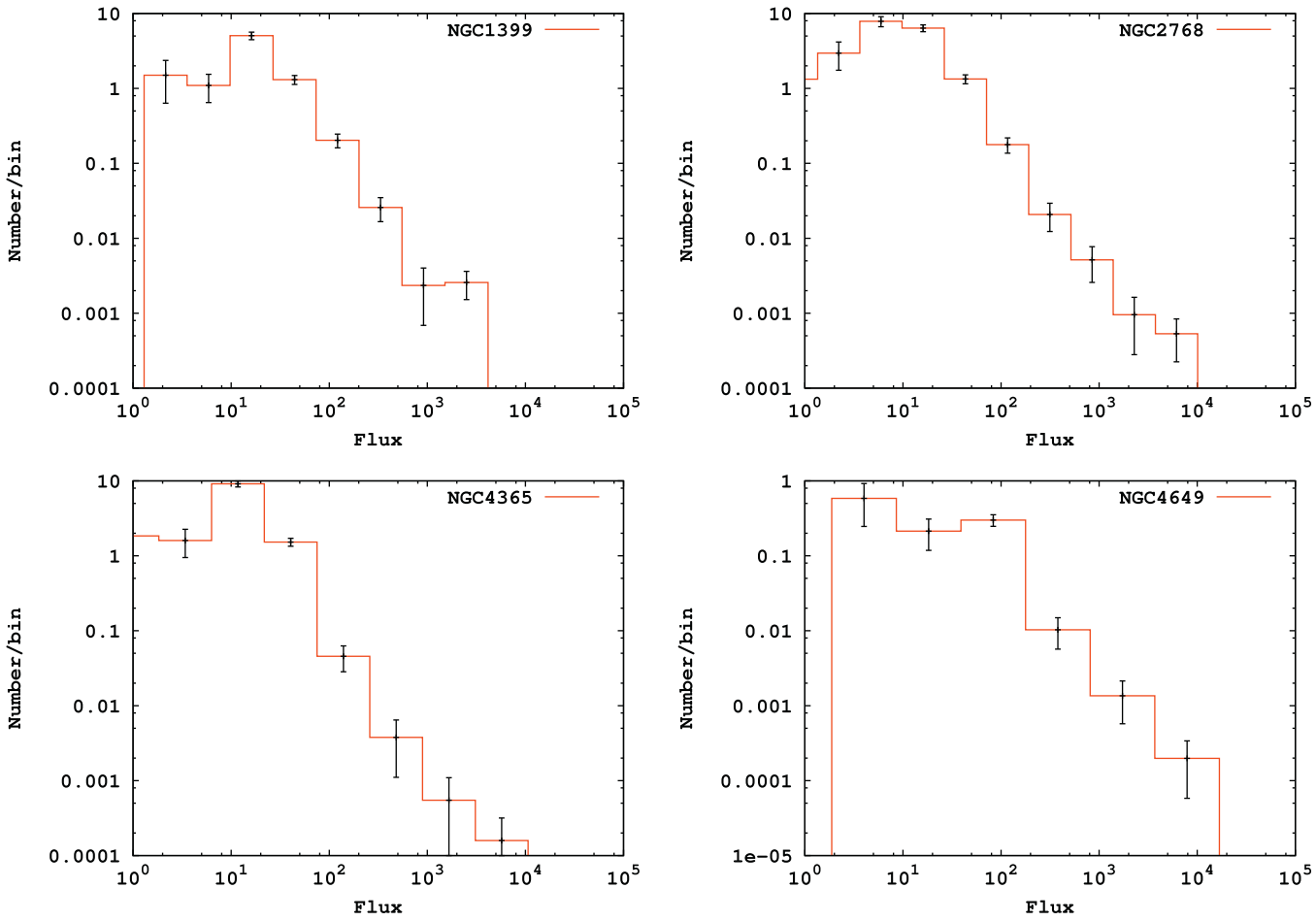

Fig. 2. Flux histogram for the 3.6 μm channel of the IR sources for the four galaxies. The distributions have a power-law form and show a turnover at ∼ 20 μJy, indicating perhaps the flux limit of the analysis.

The primary problem of such type of studies is that the source detected in different wave-bands may be a background one hence not associated with the galaxy. In the above example, if the sources with AGN like colours are indeed background AGNs, then it is no longer surprising that they have AGN properties such as the correlation between X-ray and IR fluxes. In the absence of spectral information, it is indeed difficult to ascertain whether a source belongs to a galaxy or is a background one. However, one can statistically infer how many background sources one expects in the image and their colour properties and this information can be used to infer if most of the sources being considered are background ones or not. In this work, we compare the distribution of point sources in nearby elliptical galaxies and compare the result from blank fields to infer the background contamination rate. We limit the analysis to bright and large nearby elliptical galaxies where we can model the IR continuum emission of the galaxy, subtract the model from the image and hence detect the point sources within.

Another motivation of this work is to obtain the distribution of the flux and distance from the centre of IR sources in the galaxies. At *Spitzer* resolution we expect that a significant number of these sources would be globular clusters and hence the results may shed light on the evolution of these clusters.

In the next section, we describe the sample selection and analysis. In Section 3 the background contamination is estimated and the distribution of the IR sources are computed. We discuss the results in the last section.