Structural Analysis of early-type galaxies-Near IR observations

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Abstract— Photometric structural parameters and their correlations are significant in understanding the formation and evolution of galaxies. Our sample includes nearby early type galaxies with the presence of ionized gas. The sample galaxies have a wide range of velocity dispersion and their red shifts are less than 5500 km/s. Most of our galaxies are from low density environments. 2MASS (Two Micron All Sky Survey) K-band images were used for photometric analysis. The galaxy components are extracted by two dimensional fitting using the code GALFIT. Structural analysis suggests the presence of significant exponential disc component in our sample galaxies. Average value of B/T is 0.425 and the standard deviation is 0.145.

Key Words — Bulge disc decomposition, B/T ratio, Early-type galaxies, Sérsic index, Secular evolution, Pseudo bulges, r_e/h ratio.

1 INTRODUCTION

THE basic understanding of the early-type galaxies is that they are very quiescent systems. Improved resolution of imaging and spectroscopic technologies reveals that early-type systems are multicomponent systems and have a significant fraction of star formation. The study of structural analysis of galaxies leads to the understanding of formation and evolution of these systems. Different morphologies of galaxies indicate different formation scenarios which result from variation of components, environments [1], presence of gas, dust etc. The early-type galaxies contain central spheroidal bulge and large or an intermediate sized exponential disc. Studies of the presence of bulge and disc present in early-type galaxies are among the active research area, which help to understand the mystery about different formation and evolution mechanisms behind systems [2], [3].

The quantitative analysis of light distribution in galaxies was correctly interpreted by using fitting functions. In one dimensional fitting the information regarding difference in morphology and complexities in the structures of galaxies may be lost. So the accuracy of analysis in the qualitative and quantitative study of galaxies using two dimensional methods is more suitable. Two dimensional decomposition methods are different from each other by their specific solution of problems [4],[5],[6],[7]. Each of these methods is functioned by number of semiautomatic codes written in computer based programs.

Ellipticals and some early-type galaxies are known to be gas free or with presence of very little gas. Recent studies reveal that the complex interstellar medium present in the early-type systems contains multiphase gas components. The hot X-ray ($T = 10^6$ K) emitting gas halos are found in luminous elliptical galaxies [8]. A warm ($T = 10^4$ K) component known as ionized gas [9] seen in nearby galaxies was detected by optical emission lines [10]. Cold atomic and molecular gases and dusts are found in early-type systems [11].

Extraction of structural components and their correlations are used to interpret the formation mechanism of galaxies. From our earlier analysis, we reported [12] the correlations between the bulge effective radius and the mean surface brightness with in this radius known as Kormendy relation. We reported another relation between bulge effective radius and disc scale length which predicts that the galaxies having larger bulge reflect larger disc [12]. Large fractions of early-type galaxies that are more massive systems are found mostly in cluster environments. Chances are high for the presence of disc in these types of systems. The hot and dense regions of the galaxies may affect their formation and evolution. The evolutionary studies of early-type galaxies mainly depend on the presence of bulge and disc in them. The bulges present in the galaxies may be pseudo bulges or classical bulges depending on the formation mechanism of secular evolution or hierarchical merging [13]. The probability of formation of disc by major merger process is very low in early-type galaxies found in low density regions. Many of the possible mechanisms for the formation of disc in early-type systems in the field are already reported [14], [15]. But clear suggestions of the presence of discs in field galaxies are still a debating issue. Recent studies [16] reported that the field early-type galaxies exhibit different disc sizes ranging from a smaller nuclear disc to large discs extending beyond the bulge.

In this paper, we studied the importance of dominant exponential disc in nearby early-type galaxies and relevance of Bulge to Total luminosity (B/T) ratio, Bulge effective radius to Disc scale length (r_e/h) ratio and the Sérsic index in the formation of bulges present in the galaxies.

2 DATA AND DATA REDUCTION

2.1 Data

Images used for our analysis were taken from Two Micron All Sky Survey (2MASS) observations. Samples were selected on the basis of the presence of ionized gas [17]. Chosen samples showed emission line features from different observations of IRAS 100 μm, X-Ray emission, radio emission, neutral hydrogen emission or carbon monoxide emissions. Sample consists of 54 early-type galaxies belonging to the Revised Shapely Ames (RSA) catalog [18] and most of them reside in low density regions which have a wide range of velocity dispersions and red shift less than 5500 km/s. The red shift of each of these galaxies is measured directly from

their spectra.

2.2 Data Reduction

Quantitative analysis of light distribution in galaxies is done by using the two dimensional bulge disc decomposition method. This method uses entire galaxy image rather than the major axis profile. So this technique will improve the fitting of non axisymmetric component present in the samples. We assume that our samples contain multiple components. The central spheroidal bulge component is modelled by using the Sérsic law [19], and expressed in terms of bulge effective parameters as

$$I_b(r) = I_e \exp\left[-b_n[(r/r_e)^{1/n} - 1]\right]$$

Where r_e is the effective radius enclosing half of the total luminosity, and I_e is the intensity at this half light radius. The value of b_n is evaluated as the root of an equation involving the incomplete gamma function and can be approximated to a linear function of the Sérsic index n. The approximate value of b_n is 2n-0.32 [20]

The extended disc light is modeled by exponential law [21] and is defined as

$$I_d(r) = I_0 \exp(-r/h)$$

Where I_0 is the central light intensity and h is the disc scale length respectively.

The bulge and disc structural components of our samples are measured using the code GALFIT [22]. Structural parameters of each of the galaxies are initially measured by fitting elliptical isophotes to the original image using the ELLIPSE task in IRAF/STSDAS. The rough models of the galaxies are created and are subtracted from the original image. The bad pixels and unwanted sources are masked out while doing the ellipse fit [23]. The initial approximations of the bulge and disc parameters obtained from the ellipse fit are given to the code GALFIT. The position angle, ellipticity, shape parameter n and sky are given as free parameter during the first iteration. From this iteration we get the bulge, the disc and the sky values. The sky value thus obtained was fixed in next iterations until better chi square values are achieved.

3 Results

3.1 Bulge to Total Luminosity Ratio

Figure 1 represents the histogram of bulge to total luminosity ratio. The lesser values of the B/T suggest the dominance of exponential component in our samples. The value of B/T > 0.5 are pure bulge systems and B/T < 0.5 are two component systems [24]. In an early-type system with less B/T luminosity ratio, the bulges may be formed by secular evolution process. These bulges in early- type systems are formed from the already existing discs and are called pseudo bulges. The larger value of B/T is primarily seen in massive and early-type systems. The average value of B/T is 0.425 ±0.145

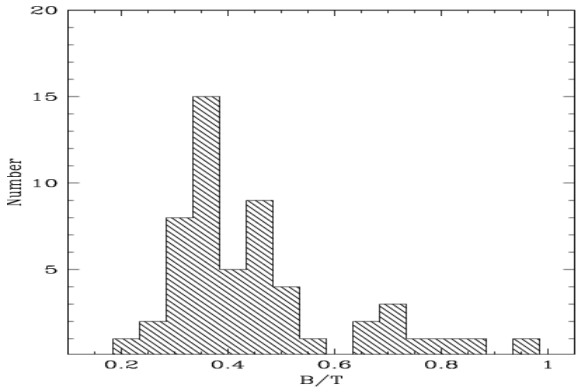

Fig. 1. Histogram of Bulge to Total luminosity Ratio (B/T)

3.2 r_e/h ratio

Figure 2 represents the histogram of ratio of bulge effective radius to the disc scale lengths. Low values re/h (r_e/h < 0.4) indicates that majority of our samples may contain pseudo bulges. Some of the values are higher because our selected samples are early-type systems and thus mostly contain the classical bulges. The bulge effective radius and disc scale lengths of galaxies do not correlate to the galaxies with classical bulges [25].

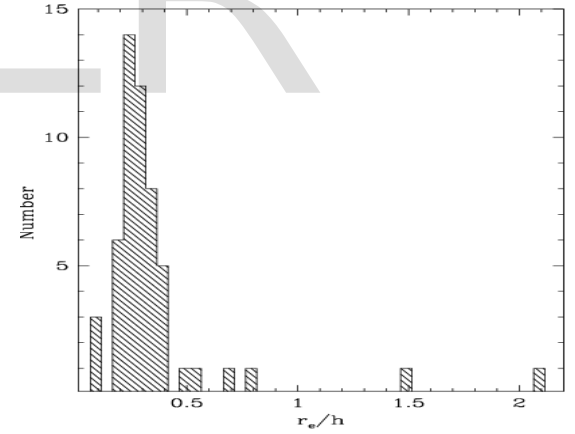

Fig. 2 Variation of r_e/h.

3.3 Variation of Sérsic index n

Figure 3 represents the value of bulge Sérsic index n varies as the function of Hubble type. This value of Sérsic index n is related to the properties of bulges present in the galaxies. Sérsic index of bulge is one of the tools for identifying the nature of bulges present in the galaxies. Lesser value of Sérsic index (n < 2) usually shows the presence of pseudo bulges in galaxies [26]. The formation of pseudo bulges may be due to various mechanisms such as secular evolution, gas inflow to the galaxies etc.

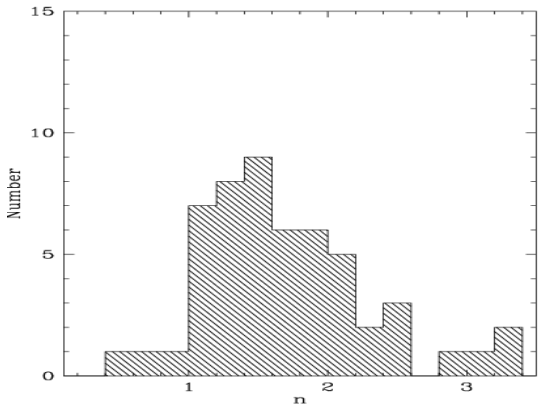

Fig. 3. Variation of Sèrsic index.

6 Conclusion

We studied the structural parameters of bulge and disc components of 54 early-type galaxies. The structural parameters were extracted by performing the two dimensional bulge disc decomposition algorithms. Early-type galaxies contain central bright bulge component and the exponential disc. We modelled these two components by fitting Sérsic and exponential functions. From this ongoing study of morphological analysis, we identified that our samples shows the dominant disc component. Compared to the optical band, the attenuation by dust is lower in near Infra-red (IR) wavelengths. 2MASS images of galaxies observed in near IR wavelengths are dominated by stellar light and baryonic component in galaxies. Because of the advantage of near IR wavelength the contribution of light from the inner region of galaxies was also detected. So the undetected disc component is dominated in this wavelength. Further, we intend to study the multi wavelength analysis of bulge and disc present in the samples and expect to get more idea about the formation and evolution of these systems.

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