Two and Three Dimensional Shape Distribution of Elliptical Galaxy NGC 315 Using Photometry

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***Abstract* - The three dimensional shapes of the light distribution of elliptical galaxies can be determined by addng the photometric data profiles which is taken from the literature. We have used triaxial models which is sum of different models. In this paper, ensembles of models are used to make the shape estimates model independent. The methodology used was as described in Statler (1994), Chakraborty et al. (2008), Chakraborty et al. (2011), Singh (2011), Singh (2015) and Singh (2019) using flat prior and Singh & Diwakar (2020). In this paper a modified prior is applied to determine the shape of NGC 315. This paper shows that how the parameters get constrained at short to long axial ratios at very small and at very large radii, and the absolute value of the triaxiality difference are well constrained shape parameters. The three dimensional shape of elliptical galaxy NGC 315 is determined using a flat prior. The above three dimensional shape distribution can also be determined using modified prior. These results are compared with the previous estimates which are determined by using flat prior. The plot shows the intrinsic shapes distribution of the NGC 315 as a function of (q0,q∞,|Td|) for three dimensional shapes, where q0 and q∞ are the short to long axial ratios at small and at very large radii and |Td| is the absolute values of the triaxiality difference, defined as |Td| = |T∞-T0 |. The probability is shown by the plot of dark grey region; darker is the region it means that higher is the probability.**

***Index Terms* - Distribution and Elliptical Galaxies, Triaxial Models, Intrinsic Shapes, Photometry and Triaxial Models.**

I.INTRODUCTION

Three dimensional shape determination of the individual elliptical galaxies have been determined by Binney (1985), Statler (1994a, b), Bak and Statler (2000), Statler et al (2001), Chakraborty (2004), Chakraborty et al (2008) and Singh & Chakraborty (2009), Singh (2011), Singh (2015) and Singh (2019) using flat prior and Singh & Diwakar (2020). The authors mentioned involved in this work have used the kinematical data and the photometric data. I have used the triaxial models which is defined with the density distribution $\rho = \rho(m^2)$, where $m^2 = x^2 + y^2/p^2 + z^2/q^2$ with axial ratios *p* and *q* remains constant. Photometric data alone has been used to determine the shape of individual elliptical galaxies.

In this paper, I find that short to long axial ratios at very small and at very large radii, and the absolute value of the triaxiality difference are well constrained shape parameters for galaxy NGC 315 and also for other samples of elliptical galaxies. Using a flat prior, the shapes of elliptical galaxies are reported by Chakraborty et al (2008) and Singh & Chakraborty (2009), Singh (2011), Singh (2015), Singh (2019), Singh & Diwakar (2020). I now find the distribution in shape and recalculate the shape of the individual elliptical galaxies by using modified prior.

II. MODEL

The model used is the triaxial generalizations of the spherical gamma (γ) models of Dehnen (1993), with density ρ given by

$$\rho(r) = \frac{(3-\gamma)Lbr^{-\gamma}(b+r)^{-4+\gamma}}{4\pi PQ} \quad (1)$$

Where L is the luminosity of the model, and $0 \le \gamma < 3$. b is the scale length. The models shows cusp at the centre, and the density decreases as r^{-4} at large radii, and has a cusp rising as $r^{-\gamma}$ at small radii.

I use the modified fgh model shown by equation (2) and the M^2 model which is shown by the equation (3), which is the triaxial generalization of the above equation (1) and is represented by the following equations (2) and (3).

$$\rho = f(r) - [g(r) + g_1(r)]Y_2^0 + [h(r) + h_1(r)]Y_2^2 \quad (2)$$

and

$$P^{-2} = \frac{\beta b^2 p_0^{-2} + M^2 p_\infty^{-2}}{\beta b^2 + M^2} \quad (3)$$

respectively. Similar expression for Q^{-2} is given in terms of (q_0, q_∞). where, $\beta > 0$ is a parameter. The parameter alters the values of (P,Q) in the intermediate region.

III. METHODOLOGY

The likelihood used to obtain the observed data by using the model which is given by

$$L(O_{ob}, O_{cal}) = N\exp - \sum_{j=1}^{N} \left(O_{ob}^j - O_{cal}^j\right)^2 / 2\sigma_j^2$$

where N is called as the normalization factor, and σ_j is define as the error in o^j_{ob}. The probability also called as posterior

The probability also called as posterior density which is defined as probability of obtaining the data and is given by the product of the likelihood and the parent distribution also called as prior density.

To make the probability relatively insensitive to the parent distribution, It is necessary that the likelihood must be a very sharpe peak. This is called a `likelihood-dominated' posterior density.

The photometric data of galaxy NGC 315 is obtained from Peletier et al (1990). The required condition for this is that the profiles of ellipticity and position angles are largely monotonic and the R_{in} and R_{out} are sufficiently small and large distances. The selected models for this work also reproduces profiles of ellipticity and position angle which are largely monotonic.

First the intrinsic shape of individual elliptical galaxy has been determined using flat prior. After collecting the sample of galaxies, their likelihood are used to get modified prior.

The shapes $P(q_0,q_\infty,T_d)$ as recalculated by using a modified prior to obtain the distributions as shown in Singh & Chakraborty (2009).

IV. OBSERVATION and RESULTS

The photometric data source of this galaxy is Peletier et al (1990). The effective radius is 68".0. The ellipticity ϵ in inner side is 0.284 at R_{in} = 15".0 and in outer side is 0.226 at R_{out} = 69".0. The position angle difference is 1º.3. We present the plot of MPD as a function of (q_0, q_∞), summed over (T_0, T_∞) in figure 1 and figure 2 by using flat and modified prior respectively and the 3-dimensional shape $P(T_0, T_\infty, |T_d|)$ is presented in figure 3 and figure 4 for both flat and modified prior. The expected values of the shape are $<q_0> = 0.58$, $<q_\infty> = 0.82$, $<|T_d|> = 0.32$, while the most probable values are $q_{0P} = 0.48$, $q_{\infty P} = 0.93$, $|T_{dP}| = 0.03$. We find that NGC 315 is flatter inside and rounder outside.

A. *Tables and Figures*

Figure 1 & 2 represents two dimensional shapes distribution of elliptical galaxy and figure 3 & 4 represents the three dimensional shape distribution distribution of elliptical galaxy NGC 315. The two and three dimensional distribution of these galaxy is determined both by using flat prior and j modified prior.

Table 1 represent the observation data of galaxy NGC 315. Table 2 and Table 3 represents the axial ratios q_0 at inner side of the galaxy and q_∞ represents the axial ratios at outer side of the galaxy. In table 2 and table 3 the observation are taken for first iteration and also for the second iteration. Results obtained by both iterations are almost same. The small difference appears in the observation table shows th effect of using the models. The triaxiality is defined as $|T_d|$ is the absolute values of the triaxiality difference, defined as $|T_d| = |T_\infty - T_0|$. The probability is shown in dark grey region which 68% of the total area enclosed within the contour; which is also called as one sigma error bar. The enclosed region is shown by darker region. Darker is the region higher is the probability.

Table 1 represents the observational data for galaxy NGC 315

Galaxy	R_e	R_{in}	R_{out}	ϵ_{in}	ϵ_{out}	θ_d	Source
NGC 315	6''.0	15''.0	69''.0	0.284	0.226	1°.3	Peletier et al 1990

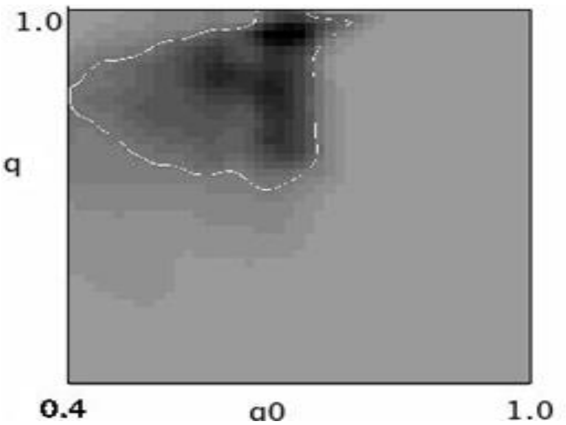

Figure 1: Plot of the distribution as a function of (q0,q∞), summed over various values of (T0,T∞) for NGC 315 using flat prior

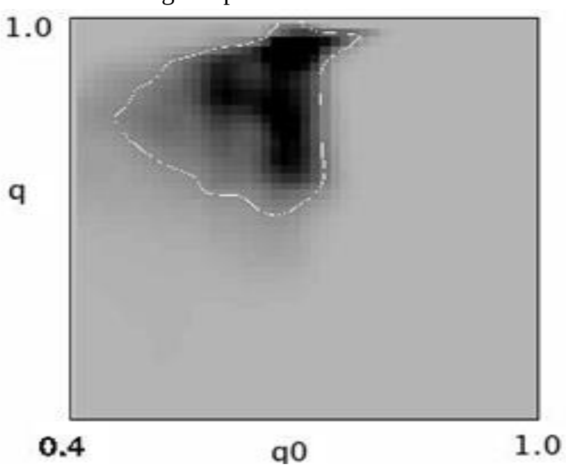

Figure 2: Plot of the distribution as a function of (q0,q∞), summed over various values of (T0,T∞) for NGC 315 using modified prior

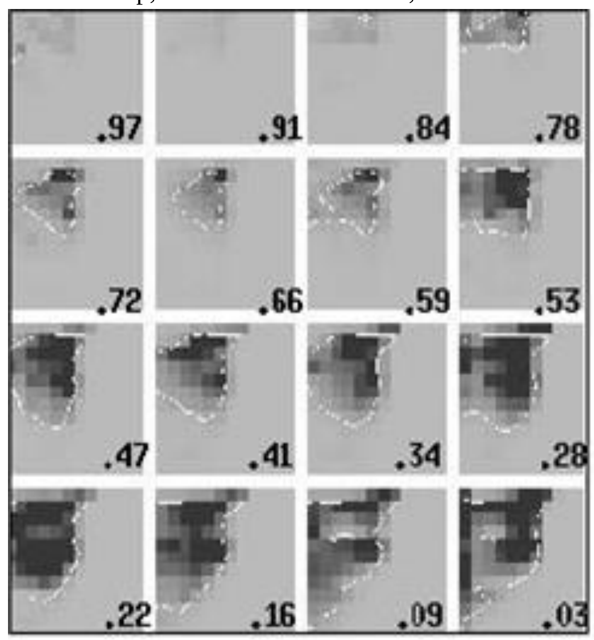

Figure 3: 3-dimensional plot of the unweighted sum of the distribution as a function of (q0,q∞,Td) for NGC 315 using flat prior. Values of Td are constant in each section. q0 goes from left to right, while q∞ runs from bottom to top, each between 0.4 to 1.0, in each section.

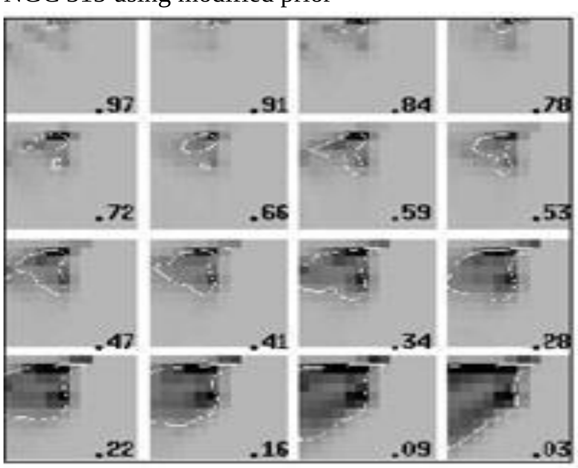

Figure 4: 3-dimensional plot of the unweighted sum of the distribution as a function of (q0,q∞,Td) for NGC 315 using modified prior. Values of Td are constant in each section.

Table 2. Summary of the 2-dimensional shape estimates by using flat and modified prior.

Galaxy	$<q_0>$	$<q_\infty>$	q_{0p}	$q_{\infty p}$	Type	Prior
NGC 315	0.59	0.83	0.66	0.94	FR	Flat
NGC 315(1st Iteration)	0.62	0.84	0.67	0.94	FR	Modified
NGC 315(2nd Iteration)	0.62	0.86	0.67	0.94	FR	Modified

Table 3. Summary of the 3-dimensional shape estimates by using flat and modified prior.

Galaxy	$<q_0>$	$<q_\infty>$	$<T_d>$	q_{0p}	$q_{\infty p}$	T_{dp}	Type	Prior
NGC 315	0.58	0.82	0.32	0.48	0.93	0.03	FR	Flat
NGC 315(1st Iteration)	0.58	0.83	0.28	0.43	0.93	0.03	FR	Modified
NGC 315(2nd Iteration)	0.59	0.84	0.26	0.63	0.93	0.28	FR	Modified

VII. CONCLUSION

In this paper the two and the three dimensional shape distribution of the elliptical galaxy NGC 315 is shown. From the observation table and figures it has been determined that the intrinsic shape of NGC 315 is flatter in the inner side of the galaxy and rounder at the outer side of the galaxy. The shapes of the galaxies NGC 315 in the plots shown in Figure 1 and Figure 2 for two dimensional are determined using the flat prior and modified prior. The shapes of the galaxies NGC 315 in the plots shown in Figure 3 and Figure 4 for three dimensional are determined using the flat prior and modified prior. The results of the galaxy is presented in Table 2 and Table 3. The changes in shapes, as compared to those calculated by using a flat prior are although small, but are significant, which illustrates the effect of the use of a prior which is not flat. The result obtained in table 2 and 3 is compared with the previous results was also well satisfactory and support the results which is observed for the two iteration.

ACKNOWLEDGMENT

I Arun Kumar Singh would like to express my sincere thanks to my supervisor (Prof. D. K. Chakraborty). I also like to thank Miss Lata Bharti, Government Higher secondary school gorkapar, Gunderdehi, District- Balod, India for her support.

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