DETERMINATION OF INTRINSIC SHAPE OF ELLIPTICAL GALAXY: NGC 2768 USING MODIFIED PRIOR

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ABSTRACT

Using the triaxial model, the intrinsic shapes of elliptical galaxies can be determined by combining the profiles of photometeric data. These data has been taken from the literature. We have developed methodology by making a modification in the methodology described in Statler (1994). The intrinsic shape of elliptical galaxies are reported by Chakraborty et al (2008) and Singh (2011), Singh & Chakraborty (2009) and Singh (2015), Singh (2019), Singh (2019), Singh (2020) and Singh (2021) using flat as well as modified prior. We find that short to long axial ratios at very small radii and at very large radii, and the absolute value of the triaxiality difference are the best constrained shape parameters.

The result obtained by the determination of modified prior are compared with the previous results which are determined by using flat prior. We apply this methodology to a galaxy NGC 2768. The intrinsic shapes of the NGC 2768 are shown in the figures as a function of (q_0, q_∞) summed over (T_0, T_∞) for two dimensional shape and $(q_0, q_\infty, |T_d|)$ for three dimensional shapes, where the values of T_d are constant in each section and $|T_d|$ is the absolute values of the triaxiality difference, defined as $|T_d| = |T_\infty - T_0|$. The probability of finding the shape as shown in the dark gray region: darker is the region higher is the probability. We find that the galaxy NGC 2768 are flatter inside and flatter outside.

Keywords: Intrinsic Shapes, Triaxial Models, Photometry, Distribution and Elliptical Galaxies.

INTRODUCTION

Intrinsic shapes of the individual elliptical galaxies have been investigated by Binney (1985), Tenjes et al (1993), Statler (1994a, b), Bak and Statler (2000) and Statler et al (2001). These authors have used both the kinematical data as well as the photometric data. They have used the triaxial models with the density distribution $\rho = \rho(M^2)$, where $M^2 = x^2 + y^2/p^2 + z^2/q^2$ with constant axial ratios p and q. It was shown analytically that the projected density of such density distribution is stratified on similar and coaligned ellipses (Stark 1977, Binney 1985). Statler (1994a, b) uses (apart from the kinematical data) a constant value of ellipticity, which is an average over a suitably chosen range of the radial distance for the shape determination.

We determine the distribution of the intrinsic shapes of the light distribution of elliptical galaxy NGC 2768 by combining the profiles of photometric data from the literature. We have used the triaxial models. The intrinsic shape of elliptical galaxies are reported by Chakraborty et al (2008) and Singh (2011), Singh & Chakraborty (2009) and Singh (2015), Singh (2019), Singh (2019), Singh (2020) and Singh (2021) using flat as well as modified prior. We find that short to long axial ratios at very small radii and at very large radii, and the absolute value of the triaxiality difference are the best constrained shape parameters.

METHODOLOGY

The likelihood of obtaining the observed data from the model 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 the normalization factor, and σ_j is the error in σ^job. The probability (posterior density) of obtaining the data is the product of the likelihood and the parent distribution (prior density) .

It is necessary that the likelihood be a sharply peaked function, so that the probability is relatively insensitive to the parent distribution. This is called a `likelihood-dominated' posterior density. Integrating the posterior density over the `uninteresting' parameters (θ', Φ') one obtains the marginal posterior density P.

The photometeric data of these galaxies are obtained from Peletier et al(1990), Franx et al(1989) and Mollenhoff and Bender(1989). Intrinsic shapes of these galaxies are presented and discussed in Chakraborty et al (2008) and Singh & Chakraborty (2009) using flat prior. Using modified prior we re-determine the shape estimate of NGC 2768.

OBSERVATIONS AND RESULTS

Observational data's are shown in table 1. The plot shows the intrinsic shapes of the NGC 2768 as a function of (q_0,q_∞) for two dimensional shapes in figure 1 & 2 and $P(q_0,q_\infty,T_d)$ for three dimensional shapes in figure 3 & 4. Results calculated by using modified prior is shown in the Table 2 and 3 respectively. The table 2 and 3 represents the results obtained using flat prior and is used to compare the results obtained by using modified prior. We have recalculated the shape by using modified prior up-to two iteration. This results calculated by using modified prior gives better agreement with the previous results calculated by using flat prior. We find the galaxy NGC 2768 is flatter inside and flatter outside by using flat prior and modified prior.

Table-1: Observational data used in models:

Galaxy	R_e	R_{in}	R_{out}	ε_{in}	ε_{out}	Θ_d
NGC 2768	76''.5	7''.9	144''.2	0.302	0.601	$-4^o.2$

SHAPE OF NGC 2768

The photometric data source of this galaxy is Peletier et al (1990). The effective radius is 76".5. The ellipticity ε in inner side is 0.302 at R_{in} = 7".9 and in outer side is 0.601 at R_{out} = 144".2. The position angle decreases by -4^o.2. The expected values of the shape are $<q_0> = 0.55$, $<q> = 0.45$, $<|Td|> = 0.59$, while the most probable values are $q_{0P} = 0.43$, $q_P = 0.43$, $|T_{dP}| = 0.78$. We find that NGC 2768 is flatter inside and flatter outside. The expected values of the shapes and the most probable values by using modified prior are shown in Table 2 and Table 3. We find that NGC 2768 is flatter inside and flatter outside.

DISCUSSION

We have presented the shapes of the galaxy for two dimensional and for three dimensional in figure1 and figure 3 by using flat prior. The shapes of the galaxy for two dimensional and for three dimensional in figure 2 and figure 4 by using modified prior. The plot shows the two dimensional shapes estimates and the three dimensional shapes. The changes in shapes recalculated by using modified prior, 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.

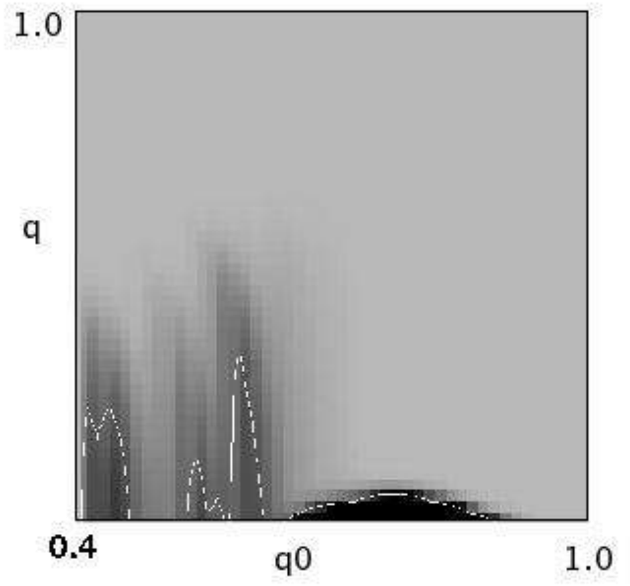

Figure: 1: Plot of MPD as a function of (q_0,q_∞=q), summed over various values of (T_0,T_∞) for NGC 2768, using flat prior.

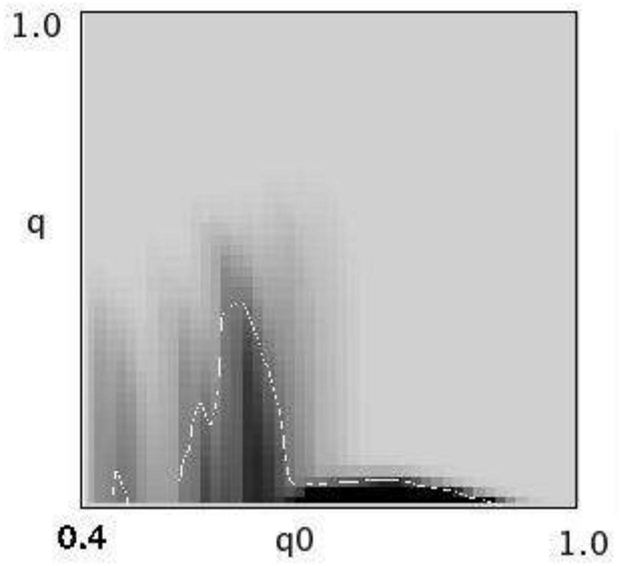

FIGURE 2: Plot of the distribution as a function of (q_0,q_∞), summed over various values of (T_0,T_∞) for NGC 2768 using modified prior.

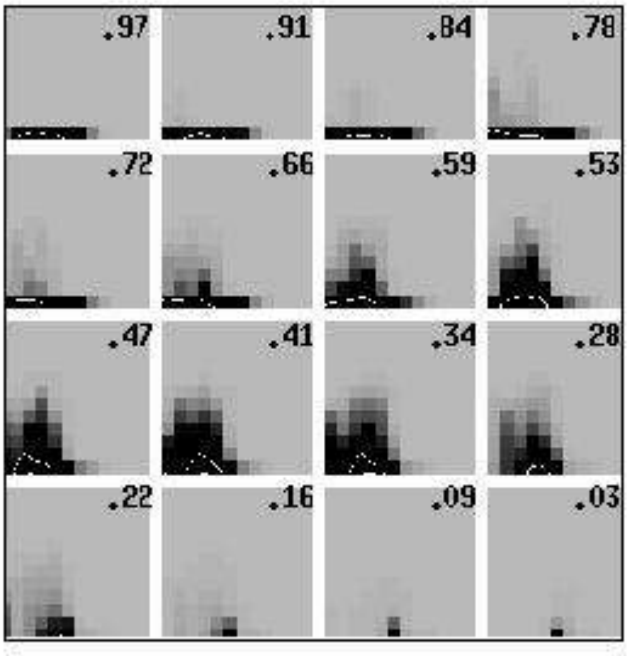

FIGURE 3: 3-dimensional plot of the unweighted sum of the distribution as a function of (q_0,q_∞,T_d) for NGC 2768 using flat prior. Values of T_d are constant in each section. q_0 goes from left to right, while q_∞ runs from bottom to top, each between 0.4 to 1.0, in each section.

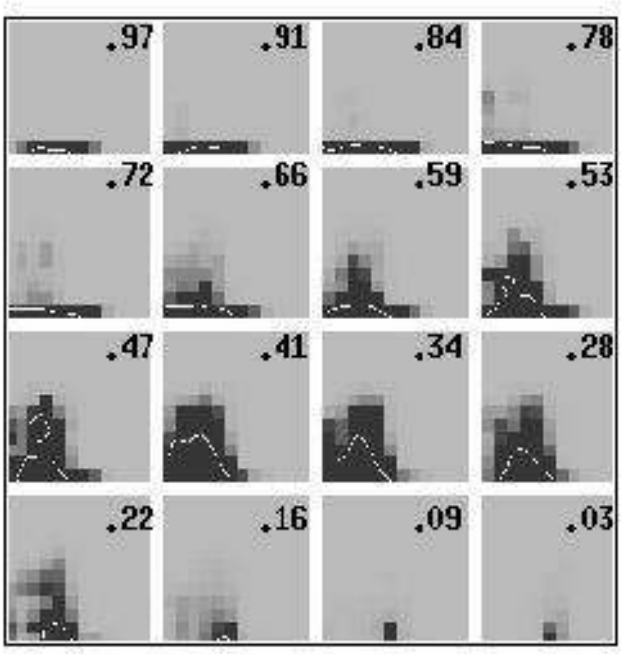

FIGURE 4: 3-dimensional plot of the unweighted sum of the distribution as a function of (q_0,q_∞,T_d) for NGC 2768 using modified prior. Values of T_d are constant in each section. q_0 goes from left to right, while q_∞ runs from bottom to top, each between 0.4 to 1.0, in each section.

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 2768	0.64	0.77	0.72	0.77	FF	Flat
NGC 2768	0.66	0.47	0.78	0.41	FF	First Iteration
NGC 2768	0.72	0.44	0.78	0.41	FF	Second Iteration

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 2768	0.55	0.45	0.59	0.43	0.43	0.78	FF	Flat
NGC 2768	0.57	0.46	0.51	0.63	0.43	0.41	FF	First Iteration
NGC 2768	0.56	0.56	0.50	0.43	0.43	0.78	FF	Second Iteration

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