Anisotropy in the Angular Momentum Vector of Galaxies in the SDSSCGB 73384

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Abstract

This work studied the angular momentum vectors of 1,017 galaxies in the SDSS CGB73384 Supercluster. This paper finds the preferred alignments of spin vectors of galaxies in the SDSS CGB73384 Supercluster. Using three statistical tests: Chi-square, Auto-correlation and the Fourier test for whether angular momentum vector of galaxies isotropy or anisotropy. To check our results to the different galaxy evolution models namely Hierarchy, Primordial vorticity and Pancake model. Finally, we observed that the spin vector orientations of galaxies are parallel with respect to the equatorial co-ordinate system in the SDSS CGB73384 Supercluster, supporting Pancake model.

Keywords: Galaxies, Supercluser, spin vector, SDSS, anisotropy

Introduction

Superclusters are the most extensive density enhancements in the universe of common origin. Observations of Superclusters tell us something about the initial condition of the universe when these Superclusters were created. The directions of the rotational axes of galaxies within Superclusters may also give us insight into the formation process of galaxies early in the history of the universe. The ratio of the dark matter density to the stellar density is approximately constant on Supercluster scale and observational counterpart for the total density is the luminosity density. Galaxy Superclusters have complex inner structures that can be quantified with morphological descriptors as Minkowski functional. Einasto et al. (2007,2011) found in the wide morphological variety of Superclusters two main types of Superclusters: spiders and filaments. By systematically and sensitively observing a large fraction of the sky, the Sloan Digital Sky Survey (SDSS) will have a significant impact on astronomical studies as diverse as the large-scale structure of the universe.

This work studied one of the largest structures of the Universe, called, Supercluster. Our intension is to identify spin vector orientation of galaxies within the Supercluster and study their preferred alignments.

Data Compilation

The database used in this work was provided from Sloan Digital Sky Survey (SDSS DR7) which has redshift in the range 0.08 to o.09.In this range 1033 galaxies were included. Among them, 16 galaxies were excluded due to b/a≤0.2. Now we have 1017 galaxies in our sample of which the right ascension (α), declination (δ), position angle (P) and inclination angle (i) are found.

Figure1

The distributions of α, δ, I and P of the galaxies in the Supercluster SDSSCGB73384.

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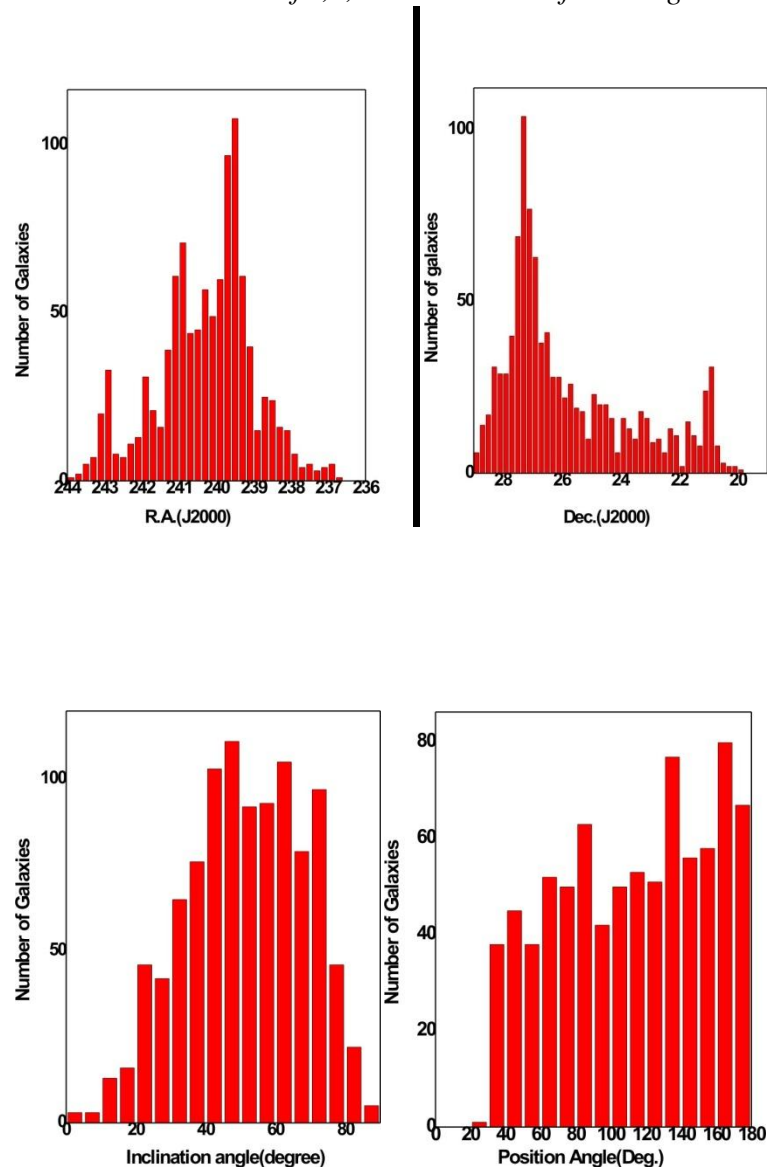
Methods

We are using Flin and Godlowski (1986) method to calculate spin vector orientation of galaxies. The equations in terms of α, δ, i, p.

$$\sin\theta = -\cos i \sin\alpha \pm \sin i \sin p \cos\delta \tag{1}$$

$$\sin\varphi = (\cos\theta)^{-1}[-\cos i \cos\delta \sin\alpha + \sin i(\mp\sin p \sin\delta \sin\alpha \mp \cos p \cos\alpha)] \tag{2}$$

Here, α, δ, i, and p represent the right ascension, declination, inclination angle, and position angles respectively.
By using Holmberg's formula (1946) inclination angle (i) is calculated.

$$\cos^2 i = \frac{\left(\frac{b}{a}\right)^2 - q^{*2}}{1 - q^{*2}} \tag{3}$$

Where, b/a is the axial ratio and q* is the intrinsic flatness of the galaxy.

Results and Discussion

Supercluster is connected by a small filament. In spider there are many galaxy chains between high density cores in the Supercluster. Sky distribution of the 1,017 galaxies in the Supercluster SDSSCGB73384 is shown in figure 2.

Figure 2:
Sky distribution of galaxies in the Supercluster SDSSCGB73384.

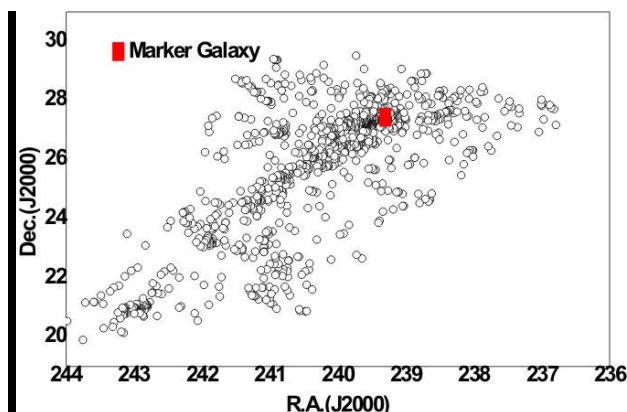..

Figure 3:

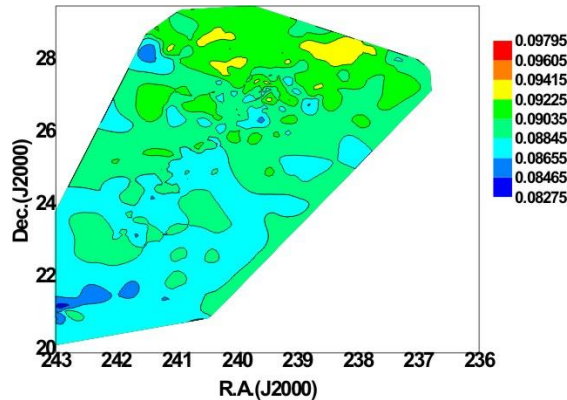*Radial velocity contour map of galaxies in the Supercluster SDSSCGB73384.*

Figure 3 shows galaxies are shifted away. We see that yellow color galaxies are more radial velocities than other below colors in the Supercluster SDSSCGB73384.

We use four statistical tests like chi-square probability $(P > \chi^2)$, auto correlation coefficient $(C/C(\sigma))$, first order Fourier coefficient $(\Delta_{11}/\sigma(\Delta_{11}))$ and first order Fourier probability $(P > \Delta_1)$ to test any deviation from expected isotropic distribution. For anisotropy, the limit of chi-square probability $P(>\chi^2)$ is <0.050, auto correlation coefficient $(C/C(\sigma))$ is >1.0, first order Fourier coefficient $(\Delta_{11}/\sigma(\Delta_{11}))$ is >1.5 and Fourier probability $P(>\Delta_1)$ is <0.150 respectively. These statistical limits were proposed by Godlowski [1993, 1994]. Selection effects may cause "humps' and 'dips'.

Table 1

Table showing the Statistics of the polar (Θ) and azimuthal (ɸ) angle distributions of galaxies in the Supercluster SDSSCGB73384.

| Statistics	Polar angle(θ)	Azimuthal angle (ɸ)
$P(>\chi^2)$	0.00	0.00
$C/C(\sigma)$	60.00	77.13
$\Delta_{11}/\sigma(\Delta_{11})$	5.70	2.05
$P(>\Delta_1)$	0.00	0.00

Table 1 shows, polar angle (Θ) distribution, that chi-square probability $(P(>\chi^2)$ to be 0.00 (less than the significant level 0.050), the auto-correlation coefficient $(C/C(\sigma))$ is found to be 60.00 (more than the 1σ limit), the first order Fourier coefficient $(\Delta_{11}/\sigma(\Delta_{11}))$ is found to be 5.70 (Greater than the limit 1.5σ) and The first order Fourier probability $(P>(\Delta_1))$ is 0.00 i.e. (smaller than the 0.15 limit). These test shows strong anisotropic distribution. Hence, our result gives preferential orientation of angular momentum vectors of galaxies in the Supercluster SDSSCGS73384.

For the azimuthal angle (ϕ) distribution, Table 1 shows that the value of chi-square probability ($P (>\chi^2)$) to be 0.00 (very less than 0.050), the value of auto-correlation coefficient ($C/C (\sigma)$) is found to be 77.13 (Greater than 1σ limit), the first order Fourier coefficient ($\Delta_{11}/\sigma (\Delta_{11})$) is 2.05 (more than the significant level than 1.5σ) and the first order Fourier probability ($P> (\Delta_1)$) is 0.00 (very smaller than 0.15). These statistical tests suggest anisotropy.

In Fig 4, in the Θ- histogram and ϕ-histogram no significant 'humps' and 'dips' are seen.

Figure 4

Polar and azimuthal angle distribution of galaxies in the Supercluster SDSSCGB73384.
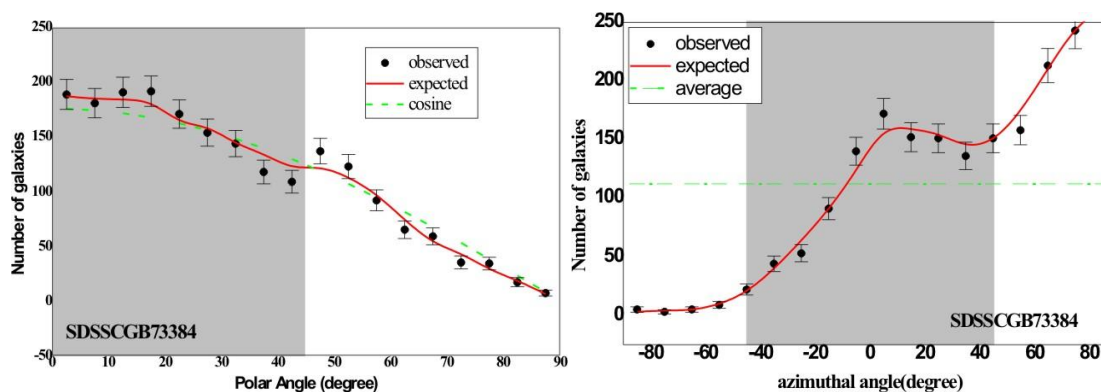
Conclusion

The spatial orientation of angular momentum vectors of galaxies in the Supercluster SDSSCGB73384 is found to be oriented parallel with respect to the equatorial coordinate system. A preferred alignment suggesting "Pancake model" [1973,1978] is a noticeable result.

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