

## Preferred Alignment of Spatial Orientation of SDSS DR16 Galaxy Using U-band Data in the Redshift Range 0.21–0.24<sup>1</sup>

Janak Ratna Malla, Walter Saurer & Binil Aryal

### Abstract

This study investigates the spatial orientation of spin vectors of 915 galaxies selected from the Sloan Digital Sky Survey (SDSS) Data Release 16 (DR16), within the redshift range  $0.21 \leq z \leq 0.24$ . These galaxies were analyzed to examine the presence of any anisotropic patterns in their spin vector distributions, with a particular interest in the possible influence of the u-band magnitude. The inclination and position angles were computed using shape parameters ( $me1\_u$  and  $me2\_u$ ) to derive the three dimensional orientation of spin vectors. The spatial orientations were statistically tested using chi-square, auto correlation, and Fourier analysis methods, focusing on both the polar and azimuthal angle distributions. While the study aimed to explore the dependence of spin orientation on u-band magnitude, the analysis was conducted on the dataset due to scope limitations. None the less, the findings provide strong evidence for preferred spin vector alignment. These finding supports the pancake model of the galaxy evolution theory.

**Keywords:** SDSS, Anisotropy, U-band, Orientation, redshift

### Introduction

According to cosmological principle: on large scales, the Universe is both homogeneous and isotropic (Goncalves et al., 2018). As galaxies interact with surrounding matter and with each other, their spin directions can be influenced by tidal torques, mergers, in falls, and other dynamic processes. One of the most promising ways to test isotropy is by analyzing the orientation of galaxies, particularly the direction of their spin vectors. The spin vector of a galaxy represents the axis around which it rotates.

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If the Universe is truly isotropic, then we would expect these spin vectors to be randomly oriented across the sky. However, recent observational studies suggest that this may not always be the case. Investigating these orientations is not just about cataloging alignments; it's about unlocking the initial conditions of the Universe and testing the accuracy of our cosmological models. Several models have been proposed to explain how galaxies form and why their spin vectors might show preferred alignments. There are different models and theories proposed at different times by different scientists regarding the evolution of galaxies. The three most prominent theoretical frameworks are: Hierarchical clustering model (Peebles, 1969): since this process is driven by random mergers, it predicts a random orientation of galaxy spin vectors. Pancake model proposed by Zel'dovich (1970), this model takes a top-down approach. Galaxies may exhibit aligned spin vectors, typically oriented parallel to the plane. Primordial Vorticity Model proposed by Gamow (1952), angular momentum vector of galaxies are oriented perpendicular to the cluster plane. Modern surveys like the Sloan Digital Sky Survey (SDSS) have revolutionized our ability to study galaxies on a large scale (York, D.G. et al. 2000). With millions of galaxy observations, including both imaging and spectroscopy, SDSS provides a treasure trove of data for examining galaxy orientations. Studies using this data (Aryal et al. 2005) have shown that spiral galaxies in clusters and Superclusters tend to exhibit non-random spin vector orientations, whereas galaxies in isolated environments ("field galaxies") show a more random distribution. Further evidence suggests that galaxies near filaments or sheet-like structures of the cosmic web tend to align their spins either parallel or perpendicular to those structures, depending on their mass, morphology, and local environment.

By focusing on this specific redshift slice ( $0.21 \leq z \leq 0.24$ ) with a complete sample, this study will contribute to a more thorough understanding of galaxy formation processes and the influence of large-scale structures on spin vector orientation. Poudel et al. 2015 split 3271u-band selected galaxies (SDSS DR7,  $z < 0.11$ ) into bright and faint halves; the brighter subset shows a  $\sim 3\sigma$  alignment signal, interpreted as deeper potential wells resisting re-orientation. Yadav et al. 2015 confirmed the trend in the r-band. Moving to intermediate redshift, Malla et al. 2019 examined 1198 galaxies in the Supercluster S[195+027+0022] ( $0.07 < z < 0.09$ ) and found global randomness. Thus, examining spin vector orientations not only refines our models of galaxy evolution but also sheds light on the large-scale organization of matter in the universe.

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## Data compilation

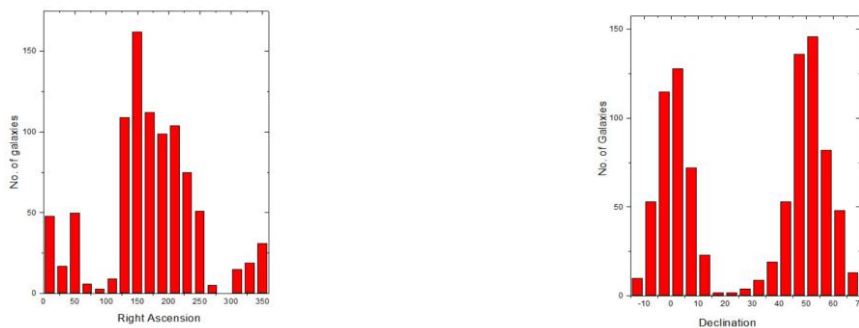
In this paper, the spatial orientation of galaxy spins vectors using data from the Sloan Digital Sky Survey (SDSS) (York et al.2000), with particular attention to galaxies in the redshift range  $0.21 \leq z \leq 0.24$ . In order to get the data from SDSS DR16, we have used the proper SQL Search syntax is shown in Appendix A. An initial query of the SDSS DR16 database returned 3000 objects. After removing the objects quasars, stars, and other non-galactic contaminants, and after discarding entries with incomplete or corrupted parameters, a refined sample of 915 galaxies was retained for the final analysis is shown in Appendix B.

## Histograms distribution

Figure1 shows the redshift of 915 galaxies in the 3D plane and contour map, respectively. Both visualizations are anchored to the same three observables: right ascension, declination, and spectroscopic redshift. Both figures showcase some galaxies merged at a lower redshift. We can see that a fair number of galaxies are merged in the region of right ascension between  $125^\circ$  to  $225^\circ$  and declination angle between  $-5^\circ$  to  $5^\circ$ .

### Figure1

*Distributions of Right Ascension and Declination SDSS DR16 Galaxies.*



### Figure2

*Distributions of Inclination angle and Polar angles SDSS DR16 Galaxies.*



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## Methods

Using the observed axial ratio  $q = b/a$ , the inclination angle  $i$  of each galaxy was calculated the Holmberg (1946) equation:

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

Where  $b/a$  is the intrinsic axial ratio for spiral galaxies.  $q^* = 0.2$ , treats each disk as an oblate spheroid is the intrinsic flatness of the galaxy and yields the tilt of the galaxy as plane with respect to the line of sight.

Once the inclination angle  $i$  is known, the two-dimensional observables must be converted into three-dimensional spin vectors. Adopted the Flin and Godlowski (1986) transformation, the polar and azimuthal angles of the spin vector in equatorial coordinates are:

$$\sin\theta = -\cos i \sin\alpha \pm \sin i \sin p \cos\delta \quad (2)$$

$$\sin\phi = (\cos\theta)^{-1}[-\cos i \cos\delta \sin\alpha + \sin i (\mp \sin p \sin\delta \sin\alpha \mp \cos p \cos\alpha)] \quad (3)$$

Here,  $\alpha$  is the right ascension angle,  $\delta$  is the declination angle,  $i$  is the inclination angle, and  $p$  is the position angle.

### Statistical test

The investigations on alignments of the galaxies are made by applying statistical tests of the polar angle ( $\theta$ ) and the azimuthal angle ( $\phi$ ) distribution resulting from the Godlowski transformation. The computer programs used in these statistical computations are MICROSOFT OFFICE EXCEL 2007, ORIGIN5.0 and MATLAB 7.0. In this work, we used;

#### *Chi-Square ( $\chi^2$ ) test*

One important set of statistical tests allows us to test for deviation of observed frequencies from expected frequencies. It tests whether a sample of data came from a population with a specific distribution or not. This test testing the null hypothesis, which states that there is no significant difference between the expected ( $N_{ei}$ ) and observed ( $N_{oi}$ ) results. The test can be applied to discrete distributions and used to binned data. However, the value of chi-square test statistic is dependent on how the data is binned. For computation of chi-square test, the data are divided into 'n' bins. It is expressed by;

$$\chi^2_v = \frac{\chi^2}{v} \quad (4)$$

$$\chi^2 = \sum \frac{(N_{oi} - N_{ei})^2}{N_{ei}} \tag{5}$$

**Auto-correlation test**

Different fields of study define autocorrelation differently, not all of these definitions are equivalent. In some fields, the term is used interchangeably with auto covariance. It is a mathematical tool for finding repeating patterns, such as the presence of a periodic signal which has been buried under noise, or identifying the missing fundamental frequency in a signal implied by its harmonic frequencies. In statistics, the auto- correlation of a random process describes the correlation between values of the process at different points as a function of time. In our case, it takes to account the correlation between the numbers of galaxies in adjoining angular bins. The correlation function is,

$$C = \sum_1^n \frac{(N_k - N_{0k})(N_{k+1} - N_{0k+1})}{(N_{0k}N_{0k+1})^{1/2}} \tag{6}$$

With the standard deviation

$$\sigma(C) = \sqrt{n} \tag{7}$$

In an isotropic distribution any correlation vanishes, so we expect to have  $C \rightarrow 0$ .

**Fourier test**

If the deviations from isotropy is only slowly varying with angles (here  $\theta$  and  $\phi$ ) the Fourier test can be applied. The Fourier series is the method of expanding a function by expressing it as an infinite series of periodic functions (sine and cosine). Let  $N$ ,  $N_k$ ,  $N_o$ , and  $N_{ok}$  denote the total number of solutions for galaxies in the sample, the number of solutions in the  $k^{th}$  bin, the mean number of solutions per bin and the expected number of solutions in the  $k^{th}$  bin, respectively.

Then the Fourier series is given by (taking first order Fourier mode),

$$\Delta_{11} = \frac{\sum_1^n (N_k - N_{0k}) \cos 2\theta_k}{\sum_1^n (N_{0k} \cos^2 2\theta_k)} \tag{8}$$

$$P(> \Delta_1) = \exp(-\frac{n}{4} N_o \Delta_1^2) \tag{9}$$

With standard deviation,

$$\sigma(\Delta_1) = \left(\frac{2}{nN_o}\right)^{1/2} \tag{10}$$

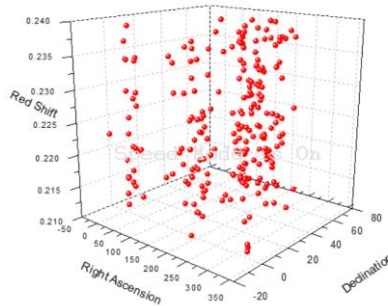
The Fourier coefficient  $\Delta_{11}$  gives the direction of departure from isotropy.

### Results and Discussion

The database used in this work consists galaxies located within the survey regions of SDSS DR16 those have redshift in the range 0.21 to 0.24. All sky distribution of 915 galaxies in the Supercluster SDSS DR16 is shown in figure 3.

#### Figure 3

*3D map of the 915 SDSS galaxies with their right ascension and declination within the redshift range 0.21 to 0.24*



#### Figure 4

*Radial velocity Contour map of the distribution of 915 SDSS DR16 galaxies in the sky*

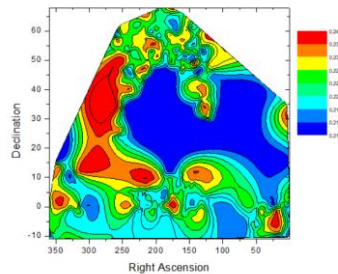


Figure 4 shows galaxies are shifted away. Here, seen that red color galaxies are more radial velocities than other colors in the Supercluster.

Using four statistical tests, for anisotropy, chi-square probability  $P(>\chi^2) < 0.050$ , auto correlation coefficient  $(C/C(\sigma)) > 1.0$ , first order Fourier coefficient  $(\Delta_{11}/\sigma(\Delta_{11})) > 1.5$  and Fourier probability  $P(>\Delta_1) < 0.150$  respectively. These tests are used by many authors in galaxy orientation studies, as follows: (Godlowski, 1993), (Godlowski, 1994), (Aryal & Saurer, 2004). We also study the 'humps' and 'dips' in the polar and azimuthal

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angle distributions. The binning effect and the local anisotropic effect will be discussed on the basis of these humps and dips.

**Table 1**

*Table showing the Statistics of the polar ( $\theta$ ) and azimuthal ( $\phi$ ) angle distributions of galaxies in the Supercluster SDSS DR 16*

| Statistics                        | Polar angle( $\theta$ ) | Azimuthal angle ( $\phi$ ) |
|-----------------------------------|-------------------------|----------------------------|
| $P(>\chi^2)$                      | $3.14 \times 10^{-57}$  | 0.378                      |
| $C/C(\sigma)$                     | 63.200                  | 1.560                      |
| $\Delta_{11}/\sigma(\Delta_{11})$ | 16.630                  | 3.120                      |
| $P(>\Delta_1)$                    | 0.000                   | 0.000                      |

To determine whether the observed distributions of galaxy spin vectors significantly diverged from what would be expected in a random (isotropic) or preferred to the equatorial coordinate, three independent statistical tests were employed: ( $P(>\chi^2)$ ), ( $C/C(\sigma)$ ), ( $\Delta_{11}/\sigma(\Delta_{11})$ ), and ( $P(>\Delta_1)$ ).

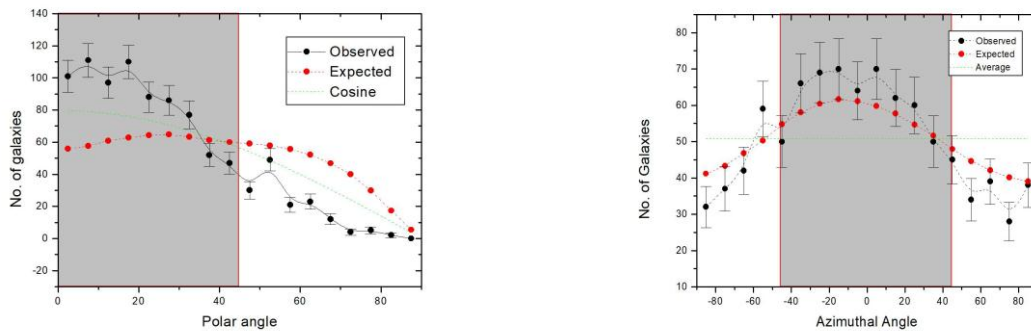
The polar distribution is strongly non-uniform ( $(P(>\chi^2) = 3.14 \times 10^{-57})$ ), rejecting isotropy at extremely high confidence. The azimuthal distribution yields ( $(P(>\chi^2) = 0.378$  ( $3.07 \times 10^{-3}$ )), indicating only marginal deviation. Polar angles exhibit strong clustering ( $C/C(\sigma) = 63.20$ ), whereas azimuthal angles show near-random correlations ( $C/C(\sigma) = 1.56$ ). The First order Fourier coefficient for  $\theta$  is 16.630 and  $\phi$  is 3.120 shows the anisotropic. The first order Fourier probability ( $P(>\Delta_1)$ ) for  $\theta$  and  $\phi$  also present anisotropic. All the statistics predicts strong anisotropy (Parallel) in the nature result Pancake model (Doroshkevich and Shandarin, 1978) (W. Godlowski, 2012).

**Figure 5**

*The polar ( $\theta$ ) and the azimuthal angle ( $\phi$ ) distribution of total samples*

The solid circle with a line symbolizes the expected distributions. The dashed lines symbolize the cosine distributions in polar angle ( $\theta$ ) and average in azimuthal angle ( $\phi$ ). The solid circles with  $\pm 1\sigma$  error bars represent the observed distribution.

In figure 5, the shaded region ( $\theta < 45^\circ$ ), multiple humps are observed around  $\theta \approx 10^\circ$  and  $25^\circ$ , where the observed galaxy counts exceed the expected counts. This suggests a preference for spin vector orientations tend to point radially towards the center of the equatorial coordinate system. In the region ( $\theta > 45^\circ$ ), dips are noted particularly in the  $\theta \approx 48^\circ$  and  $58^\circ$ . Similarly, Figure 5 shows the  $\phi$ -distribution, at an angles  $-45^\circ, -35^\circ, -30^\circ, -20^\circ, +5^\circ$ , and  $+18^\circ$  humps are seen.



Dips are seen at angles  $-85^\circ$  and  $-75^\circ$  with  $\sim 1\sigma$  error limit. Two more significant dips are seen at angles  $56^\circ$  and  $76^\circ$ . A hump in the middle (central eight bins) of the histogram suggests that the spin vector projections of galaxies tend to point towards the center of the chosen co-ordinate system. Similarly, a hump at first four and last four bins indicates that the spin vector projections of galaxies tend to be oriented tangentially with respect to the chosen reference co-ordinate system. In both the polar and azimuthal angle distribution, preferred alignment can be concluded. This indicates that the spin vectors of galaxies tend to lie within galactic coordinate system. Thus spin vector orientation of galaxies supports pancake model.

### Conclusion

In this research, investigated the spatial orientation of spin vectors of SDSS DR16 galaxies within the redshift range  $0.21 \leq z \leq 0.24$  using u-band data. A total of 915 galaxies were analyzed to understand their angular momentum alignment by applying the method proposed by Flin & Godlowski, which enables the transformation of two-dimensional to three-dimensional spin vector orientation of galaxies.

To establish the expected isotropic behavior, we performed a Monte Carlo simulation of  $10^7$  virtual galaxies following the approach outlined by Aryal & Saurer (2004). Then employed three statistical tests: chi-square, auto-correlation, and Fourier analysis, to compare the observed and expected distributions. The results of the statistical tests for the polar angle and azimuthal angle distributions show anisotropic suggest pancake model (Doroshkevich & Shandarin, 1978).

The spatial orientation of spin vectors of galaxies in the total sample is found to be oriented parallel with respect to equatorial coordinate system. It should be noticed strong anisotropy, support pancake model (Doroshkevich & Shandarin, 1978).

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### References

- Aryal, B., & Saurer, W. (2004). Spin vector orientations of galaxies in eight abell clusters of bm type i. *Astronomy & Astrophysics*, 425(3), 871–879.
- Doroshkevich, A.G., & Shandarin, S.F. (1978). Spatial structure of protoclusters and the formation of Galaxies. *Monthly Notices Royal Astron. Soc.*, 184, 643 – 660.
- Flin, P., & Godlowski, W. (1986). The Orientation of Galaxy Groups and formation of the local Supercluster. *Monthly Notices Royal Astron. Soc.*, 222, 525.
- Gamow, G. (1952). Role of Turbulence in Evolution of the Universe. *Phys. Rev.*, 86, 251.
- Godlowski, W. (1993). Galactic orientation within the local Supercluster. *Monthly Notices Royal Astron. Soc.*, 265, 874 - 880.
- Godlowski, W. (1994). Some aspects of the galactic orientation within the local Supercluster. *Monthly Notices Royal Astron. Soc.*, 271, 19-30.
- Godłowski, W. (2012). Remarks on the Methods of Investigations of Alignment of Galaxies. *Astrophys. J.*, 747 7. DOI:[10.1088/0004-637X/747/1/7](https://doi.org/10.1088/0004-637X/747/1/7)
- Goncalves, R.S., et al. (2018). Cosmic homogeneity: a spectroscopic and model-independent measurement, *MNRASL*, 475, L20-L24. Doi: [10.1093/mnrasl/slx202](https://doi.org/10.1093/mnrasl/slx202)
- Holmberg, E. (1946). On the apparent diameters and the orientation in space of extragalactic Nebulae. *Medd. Lund. Astron. Obs.*, 117, 3-82.
- Malla, J., Aryal, B., & Saurer, W. (2019). No preferred alignments of angular momentum vectors of galaxies in the sdss supercluster s [202-001+ 0084]. *International Astronomical Union*, 14(S353), 259–261.
- Peebles, P. J. E. (1969). Origin of the angular momentum of Galaxies. *The Astrophysical Journal*, 155, 393.
- Poudel, A., and Aryal, B. (2015). A study of u-magnitude dependence in the spatial orientation of spin vectors of SDSS galaxies having redshift  $0.10 < z < 0.11$ . *APS April Meeting Abstracts*, L1.006.
- Yadav S.N., & Aryal, B. (2015). A study of r- and u-magnitude dependence in the spatial orientation of spin vectors of SDSS galaxies having redshift  $0.10 < z < 0.11$ . *Himalayan Physics*, 5, 1-11.

York, D.G., *et al.* (2000). The Sloan Digital Sky Survey: Technical Summary. *The Astronomical journal*, 120, 1579-1587.

Zel'Dovich, Y. B. (1970). Gravitational instability: An approximate theory for large density perturbations. *Astronomy and astrophysics*, 5, 84-89.

#### Appendix A

SELECT TOP 3000

p.objid,p.ra,p.dec,p.u,p.g,p.r,p.i,p.z,  
p.run, p.rerun, p.camcol, p.field, s.specobjid, s.class, s.z as redshift,  
s.plate, s.mjd, s.fiberid,me1\_u, me2\_u

FROM PhotoObj AS p

JOIN SpecObj AS s ON s.bestobjid = p.objid

WHERE

p.i BETWEEN 0 AND 30.0

AND s.z BETWEEN 0.21 AND 0.24

#### Appendix B

915 SDSS DR16 Galaxies Data

| objid     | ra        | dec        | u        | specobjid | class  | redshift  | me1_u      | me2_u      |
|-----------|-----------|------------|----------|-----------|--------|-----------|------------|------------|
| 1.238E+18 | 178.54381 | -0.5601042 | 21.15798 | 4.326E+18 | GALAXY | 0.2394382 | 0.3125895  | 0.0822265  |
| 1.238E+18 | 187.9986  | -0.589152  | 22.56591 | 4.333E+18 | GALAXY | 0.2191517 | -1.194258  | 0.870854   |
| 1.238E+18 | 218.59817 | -0.6167996 | 20.3671  | 3.457E+17 | GALAXY | 0.2219461 | -0.6264151 | 0.2007457  |
| 1.238E+18 | 218.62855 | -0.5714676 | 20.6467  | 3.446E+17 | GALAXY | 0.2209859 | 0.1110619  | -0.205876  |
| 1.238E+18 | 224.47147 | -0.6213698 | 20.98733 | 3.479E+17 | GALAXY | 0.2169825 | -0.8750898 | 0.157632   |
| 1.238E+18 | 228.22403 | -0.4603959 | 20.97362 | 3.502E+17 | GALAXY | 0.213161  | 0.0908541  | 0.2489778  |
| 1.238E+18 | 229.17488 | -0.552915  | 22.79161 | 4.519E+18 | GALAXY | 0.2305454 | 0.4791709  | 1.951335   |
| 1.238E+18 | 229.22449 | -0.5363222 | 24.56416 | 4.519E+18 | GALAXY | 0.2340701 | 0.1288676  | -0.9916618 |
| 1.238E+18 | 138.12953 | 59.518101  | 22.08245 | 6.431E+18 | GALAXY | 0.228611  | 0.2229809  | -0.9475752 |
| 1.238E+18 | 141.23992 | 60.85231   | 21.11242 | 5.462E+17 | GALAXY | 0.2147706 | 0.1367455  | 0.0551785  |
| 1.238E+18 | 141.49331 | 60.913829  | 20.74027 | 5.462E+17 | GALAXY | 0.2148233 | 0.4290974  | 0.0847454  |
| 1.238E+18 | 142.05098 | 61.225924  | 22.3662  | 8.384E+18 | GALAXY | 0.2192747 | -0.6832687 | -0.5290036 |
| 1.238E+18 | 144.80171 | 62.136085  | 20.9528  | 5.473E+17 | GALAXY | 0.2296928 | -0.0885947 | 0.4845583  |
| 1.238E+18 | 144.90998 | 62.112541  | 20.53265 | 5.473E+17 | GALAXY | 0.2284737 | -0.2004038 | 0.2143221  |
| 1.238E+18 | 151.08937 | 64.198159  | 20.09689 | 5.495E+17 | GALAXY | 0.2329583 | 0.1087636  | -0.0713221 |
| 1.238E+18 | 160.24603 | 66.108319  | 20.36172 | 5.507E+17 | GALAXY | 0.2225038 | 0.6751837  | -0.2412167 |
| 1.238E+18 | 173.25723 | 67.609442  | 21.7267  | 5.53E+17  | GALAXY | 0.2102713 | -0.3543101 | -0.8942568 |
| 1.238E+18 | 174.59928 | 67.69545   | 20.71702 | 8.011E+18 | GALAXY | 0.2360048 | 0.4378023  | 0.0232552  |
| 1.238E+18 | 177.45213 | 67.855598  | 21.3189  | 8.011E+18 | GALAXY | 0.2255841 | -0.1663314 | 0.7994513  |
| 1.238E+18 | 179.63219 | 67.951071  | 23.38932 | 8.011E+18 | GALAXY | 0.2352033 | 0.6348123  | 0.246641   |

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|           |           |           |          |           |        |           |            |            |
|-----------|-----------|-----------|----------|-----------|--------|-----------|------------|------------|
| 1.238E+18 | 200.73193 | 67.185388 | 20.95196 | 5.586E+17 | GALAXY | 0.2273425 | 0.1786602  | -0.7053134 |
| 1.238E+18 | 207.30175 | 66.439677 | 21.27459 | 5.597E+17 | GALAXY | 0.2318584 | 0.7346674  | 0.5602052  |
| 1.238E+18 | 207.30069 | 66.435774 | 21.48709 | 7.685E+18 | GALAXY | 0.2319185 | -0.3293383 | -0.2033607 |
| 1.238E+18 | 207.64501 | 66.434116 | 21.12989 | 5.597E+17 | GALAXY | 0.2207032 | 0.6579124  | 0.7220348  |
| 1.238E+18 | 113.02955 | 38.653038 | 19.75143 | 1.951E+18 | GALAXY | 0.219731  | -0.1117017 | 0.0885783  |
| 1.238E+18 | 113.25204 | 38.936666 | 20.39796 | 1.952E+18 | GALAXY | 0.2197473 | 0.3005854  | -0.4754871 |
| 1.238E+18 | 113.13538 | 38.979585 | 20.67624 | 1.952E+18 | GALAXY | 0.2221559 | -0.1748173 | 0.1130781  |
| 1.238E+18 | 113.28542 | 39.046754 | 20.22891 | 1.952E+18 | GALAXY | 0.217406  | 0.2410936  | -0.1974512 |
| 1.238E+18 | 113.59198 | 39.466367 | 21.20427 | 4.118E+18 | GALAXY | 0.2218291 | 2.572488   | 1.231855   |
| 1.238E+18 | 113.66457 | 39.446537 | 21.24275 | 1.952E+18 | GALAXY | 0.2190313 | -0.8124716 | 0.1866269  |
| 1.238E+18 | 113.62618 | 39.529864 | 21.22661 | 4.125E+18 | GALAXY | 0.2236835 | -0.3027708 | -0.2679408 |
| 1.238E+18 | 113.71127 | 39.526906 | 21.2922  | 1.952E+18 | GALAXY | 0.2202361 | -0.0736767 | 1.159334   |
| 1.238E+18 | 113.71335 | 39.550611 | 23.18026 | 1.055E+19 | GALAXY | 0.225549  | -0.1980012 | -1.087697  |
| 1.238E+18 | 113.69745 | 39.537162 | 22.94504 | 1.055E+19 | GALAXY | 0.2205902 | 0.6593619  | 0.0967268  |
| 1.238E+18 | 113.6692  | 39.553981 | 24.63235 | 1.055E+19 | GALAXY | 0.2235944 | -9999      | -9999      |
| 1.238E+18 | 118.59655 | 45.754645 | 19.81007 | 7.192E+18 | GALAXY | 0.2107773 | -0.2048026 | -0.0284242 |
| 1.238E+18 | 118.98904 | 46.192104 | 22.42722 | 4.91E+17  | GALAXY | 0.2327942 | -0.8010941 | -0.4441673 |
| 1.238E+18 | 124.44566 | 51.601054 | 21.33103 | 4.977E+17 | GALAXY | 0.2309185 | 0.3578909  | -0.8344728 |
| 1.238E+18 | 137.74437 | 0.8152907 | 21.0497  | 5.303E+17 | GALAXY | 0.2264491 | 0.3096925  | -0.4536165 |
| 1.238E+18 | 143.69736 | 0.7491501 | 21.37365 | 4.307E+18 | GALAXY | 0.2307156 | 0.3320967  | -0.6098437 |
| 1.238E+18 | 144.64124 | 0.6285274 | 20.20961 | 5.361E+17 | GALAXY | 0.2343175 | 0.0858029  | -0.2584386 |
| 1.238E+18 | 146.51005 | 0.8134072 | 21.56078 | 4.309E+18 | GALAXY | 0.2202991 | 0.0792594  | 0.0517999  |
| 1.238E+18 | 146.51127 | 0.8132697 | 23.28675 | 2.996E+17 | GALAXY | 0.2202564 | -0.9943901 | 1.664073   |
| 1.238E+18 | 146.68491 | 0.6784755 | 21.36485 | 2.996E+17 | GALAXY | 0.2109386 | 0.0501057  | -0.1658238 |
| 1.238E+18 | 146.8517  | 0.7878707 | 21.78601 | 4.309E+18 | GALAXY | 0.2102371 | -1.218008  | 0.5872178  |
| 1.238E+18 | 147.08047 | 0.7880276 | 20.74845 | 2.997E+17 | GALAXY | 0.2109481 | -0.5355202 | 0.114625   |
| 1.238E+18 | 147.31838 | 0.8216486 | 21.47723 | 3.007E+17 | GALAXY | 0.2251949 | 0.4609091  | 0.6156244  |
| 1.238E+18 | 147.56858 | 0.7060887 | 19.83328 | 3.007E+17 | GALAXY | 0.2205509 | -0.1013345 | -0.0436928 |
| 1.238E+18 | 149.9468  | 0.8235284 | 23.79609 | 5.641E+17 | GALAXY | 0.2236696 | -1.243312  | -11.90661  |
| 1.238E+18 | 149.94873 | 0.8188125 | 20.85163 | 3.019E+17 | GALAXY | 0.2193648 | 0.068119   | -0.6001676 |
| 1.238E+18 | 152.08655 | 0.8036106 | 21.04264 | 3.041E+17 | GALAXY | 0.2179554 | 0.4373522  | 0.164173   |
| 1.238E+18 | 152.81605 | 0.747585  | 21.46642 | 3.041E+17 | GALAXY | 0.2209484 | 0.0265689  | 0.463671   |
| 1.238E+18 | 158.29338 | 0.6323649 | 21.65854 | 4.315E+18 | GALAXY | 0.2193782 | -0.4510032 | 0.6002547  |

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