JOURNAL OF THE KOREAN ASTRONOMICAL SOCIETY
29: S55 ~ S56, 1996

SPATIAL DISTRIBUTION OF THE SPIN VECTORS OF THE DISK GALAXIES IN THE VIRGO CLUSTER

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ABSTRACT

In order to investigate the spatial orientation of the spin vectors of galaxies in the Virgo cluster, we carried out a detailed identification of all the certain and possible member disk galaxies with four UK Schmidt Telescope (UKST) IIIa-j direct plates digitized by the Automated Plate Measuring System (APM). As a result, a relatively large and complete database with no selection effect of the member galaxies has been established. We provide the APM measured values of the position angle (P.A.) and diameters at the isophotal level of 24.5 m_j/arcsec^2. Based on this newly generated database, an initial study on the spatial orientation of the spin vectors of galaxies in the Virgo cluster is shown.

Key Words : identification, spin vectors of galaxies, the Virgo cluster

I. INTRODUCTION

The spatial distribution of the spin vectors (hereafter SVs) of galaxies in a cluster is generally regarded as " the dynamical fossil " which allows us to investigate the epoch of origin and formation of galaxies and clusters. Indeed, several representative theories pertaining to the origin and formation processes of galaxies and clusters have been well established . Different theories provide different predictions on the spatial orientation of the SVs of the cluster member galaxies. (see e.g. Ozernoy 1978; Doroshkevich and Shandarin, 1978; Ostriker & Cowie, 1981; Peebles 1969)

Some investigators have carried out the studies on the distribution of the SVs of galaxies in this cluster (see e.g., Hu et al., 1995, hereafter HWSL, and the references therein). However, the results of the various studies are significantly different. The values of the position angle (P.A.) and axial ratio (b/a) on which most previous studies were based are predominantly taken from the Uppsala General Catalog of Galaxies (Nilson, 1973, hereafter UGC). However, these UGC values were measured by eyes, and the position angles for many face-on galaxies were not given.

To provide the relatively large, homogeneous and accurate photometric database with no selection effect, we carried out a detailed identificaion of the certain or possible member disk galaxies in this cluster by using four UK Schmidt Telescope (UKST) direct plates which had been digitized by the Automated Plate Measuring Systems (APM) (Irwin et al., 1984). We derived the position angles and the diameters of the cluster member galaxies from the shape parameters of their counterparts given by the APM measurement. Then, following HWSL , we computed the spatial orientation of the SVs of these galaxies. This paper briefly reports the identification results and a preliminary analyses of the distribution of SVs of the disk galaxies in the Virgo cluster. The detailed investigation on the alignment effects of the morphologically various galaxies is to be given in separate paper.

II. THE NEW DATABASE

We identified the cluster member disk galaxies by using four overlapping UKST direct plates centered on the Virgo cluster region. The APM-scanned areas of these four plates cover a right ascension range from $12^h03^m30^s$ to $12^h44^m50^s$, and a declination range from 8°06'00" to 18°08'00" (for equinox 1950.0). The isophotal level of digitisation threshold for these 4 plates is $\sim 24.5\ m_j$/arcsec^2, where m_j is the magnitude at J band which is close to the conventional Johnson B magnitude: $m_j = B - (0.28 \pm 0.02) \times (B - V)$. The details of the plates can be found in Yuan et al.(1996a).

The member disk galaxies in our identification sample are mainly taken from the updated Catalogue of 2096 Galaxies in the Virgo Cluster Area (hereafter VCC) (Binggeli et al., 1985; 1993). The values of the P.A. and diameters for the selected galaxies can be derived from the second order moments produced by the APM scan.

As a result, we established a catalogue of 340 disk galaxies with APM measured values of the P.A. and diameter which will soon be published in Yuan et al. (1996b). It should be noted that there are more than one hundred irregulars listed only in our catalogue which significantly enlarges the sample size. This sample will surely facilitate the investigation of the orientation of morphologically various galaxies.

III. THE RESULTS

The method we used follows that applied by HWSL. Firstly, we calculated the SV of each galaxy with the given P.A. and axial ratio. In the supergalactic polar

Table 1. The chi-square test of θ, ϕ and area distribution

Samples	Size	θ (9 bins)		ϕ (18 bins)		Area (36 bins)	
		χ^2_ν	$P(>\chi^2_\nu)$	χ^2_ν	$P(>\chi^2_\nu)$	χ^2_ν	$P(>\chi^2_\nu)$
(1) SS'E	101	0.299	0.967	1.023	0.429	0.874	0.680
(2) VCC(6°)	321	1.027	0.412	2.599	0.0003[a]	1.525	0.024[a]
(3) VI	111	0.602	0.777	1.116	0.330	0.922	0.601

[a] $P(>\chi^2_\nu) < 0.05$ means anisotropic distribution

coordinate (L,B) system, where SGX and SGY axes are in the local supercluster (LSC) plane, and SGZ is in the direction of the supergalactic north pole, the Virgo cluster is near the SGX axis (L=0, B=0). To specify the orientation of SV of a galaxy, two quantities, θ and ϕ, are defined as the polar angle between the SV and the LSC plane, and the azimuthal angle between the SV projection on the LSC plane and the SGX axis, respectively. Then, we formed three sample sets: (i) the SS'E set, with member galaxies of S, S' and E clouds of the Virgo I cluter; (ii) the VCC(6°) set, including the VCC galaxies with R smaller than 6.5 or 6 degrees for spirals and irregulars, and lenticulars respectively; (iii) the VI set, including the members of Virgo I cluster inferred with the hierarchical algorithm by FGCP.

Finally, a χ^2 test is used to examine the θ, ϕ and area distribution of the SVs in each sample. For the χ^2 test, we have

$$\chi^2_\nu = \chi^2/\nu,\ \chi^2 = \sum_{i=1}^{n}((N_{oi} - N_{ei})^2/N_{ei}$$

where n is the number of bins, N_{oi} and N_{ei} are the observed and expected (isotropic) values in the ith bin respectively, and ν is the degree of the freedom. The statistics of the χ^2 test for θ, ϕ and area distribution of all sets are listed in Table 1. The bin size is 10 degree for both θ and ϕ distributions, and 30 × 30 square degree for area distribution of whole sky.

Three samples we used contain the lenticulars, spirals and irregulars. The ϕ and area distributions of the SVs for galaxies in sample VCC(6°) shows remarkable anisotropy with significant more than 2σ. However, the sample (1) and (3) are likely to be isotropic both in θ- and ϕ-distribution. Compared with HWSL, our samples are larger in size, and deeper in limiting magnitude. The threshold of isophotal level for galaxies in our samples is also different from that of the UGC. It should not be surprising that above result is not in agreement with HWSL.

ACKNOWLEDGEMENTS

We are grateful to Dr. Mike Irwin and Dr. Paul Hewett for their kindly providing the APM-scanned data of the UKST plates. Q.R. Yuan wants to thank Dr. Keith Tritton for his hospitality during the visit of Royal Greenwich Observatory. This project was partly supported by the National Natural Science Foundation of China.

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