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LARGE-SCALE STRUCTURE AT LOW GALACTIC LATITUDE

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ABSTRACT

We have extended the CfA Redshift Survey to low galactic latitudes to investigate the relation between the Great Wall in the North Galactic Cap and the Perseus-Pisces chain in the South Galactic Cap. We present redshifts for 2020 galaxies in the *Catalogue of Galaxies and of Clusters of Galaxies* (Zwicky *et al.* 1961–68, CGCG) in the following regions: $4^h \leqslant \alpha \leqslant 8^h$, $17^h \leqslant \alpha \leqslant 20^h$, $0° \leqslant \delta \leqslant 45°$. In these regions, the redshift catalogue includes 1664 galaxies with $B(0) \leqslant 15.5$ (of which 820 are newly measured) and is 97% complete. We also include redshifts for an additional 356 galaxies in these regions with $B(0) > 15.5$; of these, 148 were previously unmeasured. The CGCG samples the galaxy distribution down to $b_{\rm II} \simeq 10°$. In this paper, we discuss the acquisition and reduction of the spectra, and we examine the qualitative features of the redshift distribution. The Great Wall and the Perseus-Pisces chain are *not* simply connected across the Zone of Avoidance. These structures, which at first appear to be coherent on scales of $\sim 100h^{-1}$ Mpc or more, actually form the boundaries of neighboring voids of considerably smaller scale, approximately $50h^{-1}$ Mpc. The structures delineated by our optically-selected sample are qualitatively similar to those detected by the far-infrared-selected *IRAS* 1.2 Jansky Survey (Fisher *et al.* 1995). Although the *IRAS* survey probes more deeply into the Zone of Avoidance, our optically-selected survey provides better sampling of structures at $b_{\rm II} \geqslant 10°$. © *1996 American Astronomical Society.*

1. INTRODUCTION

At optical wavelengths, dust in our own Galactic plane significantly obscures nearly half the sky. Most optical redshift surveys are thus restricted to galactic latitudes $b_{\rm II} \geqslant 30°$, where the extinction in the blue is usually less than a few tenths of a magnitude. As luck would have it, many of interesting features of the galaxy distribution (e.g., the Great Attractor) lie at lower Galactic latitude.

In both Galactic caps, the CfA Redshift Survey reveals large, coherent structures which span the surveyed volume ($\sim 7 \times 10^5$ Mpc^3). The northern sample (CfA2N) includes the Great Wall, the southern sample (CfA2S) the Perseus-Pisces chain. The Second Southern Sky Redshift Survey (SSRS2, da Costa *et al.* 1994) reveals similar features.

Full-sky redshift surveys allow measurements of the gravitational acceleration acting upon our local volume (Hudson 1994a, 1994b); Hudson 1993; Strauss *et al.* 1992; Lynden-Bell *et al.* 1989). Recent analyses suggest that the source of our motion with respect to the microwave background extends beyond the nearest ~80 Mpc (Lauer & Postman 1994). The large swath cut out by the Zone of Avoidance (ZOA) complicates the interpretation of optical dipoles. Far-IR surveys probe more deeply into the ZOA, but they are sparse and are largely restricted to spiral galaxies, which may not fairly represent the distribution of mass (Strauss *et al.* 1992). In order to fully understand the sources of motion nearby, we require dense, uniform redshift surveys at low galactic latitude.

Several ongoing redshift surveys probe large-scale structure at very low Galactic latitude. Most of these are selected in the infrared and are therefore biased toward spiral galaxies (Fisher *et al.* 1995; Bottinelli *et al.* 1994; Hauschildt-Purves 1994; Lu & Freudling 1994; Saunders *et al.* 1994; Yamada 1994; Takata 1994). Other searches are based on blind surveys at H I (Henning 1994; Stewart 1994; Henning & Kerr 1989). These H I surveys provide a critical window through regions that are totally obscured in the optical, but they are currently confined to very low Galactic latitude ($|b_{\rm II}| \leqslant 5°$) or specific regions of high obscuration.

Kraan-Korteweg *et al.* (1989) demonstrate that optical searches can trace large-scale structure all the way down to the Galactic plane itself. Many of the ongoing optical surveys focus on quite low Galactic latitudes: $|b_{\rm II}| \leqslant 10°$ (Kraan-Korteweg *et al.* 1994; Kraan-Korteweg & Woudt 1994; Seeberger *et al.* 1994). Our aim is to complement both the very low-latitude surveys and the high-latitude surveys by covering the regions in between, roughly $10° \leqslant |b_{\rm II}| \leqslant 30°$. The large angular coverage and dense sampling of our survey provides a detailed-picture of large-scale structure over more than 4 steradians of the sky.

Figures 1 and 2 show full-circle slices of the CfA Redshift Survey in the declination ranges $0° \leqslant \delta \leqslant 20°$ and $20° \leqslant \delta \leqslant 45°$, respectively. The Galactic cap regions between

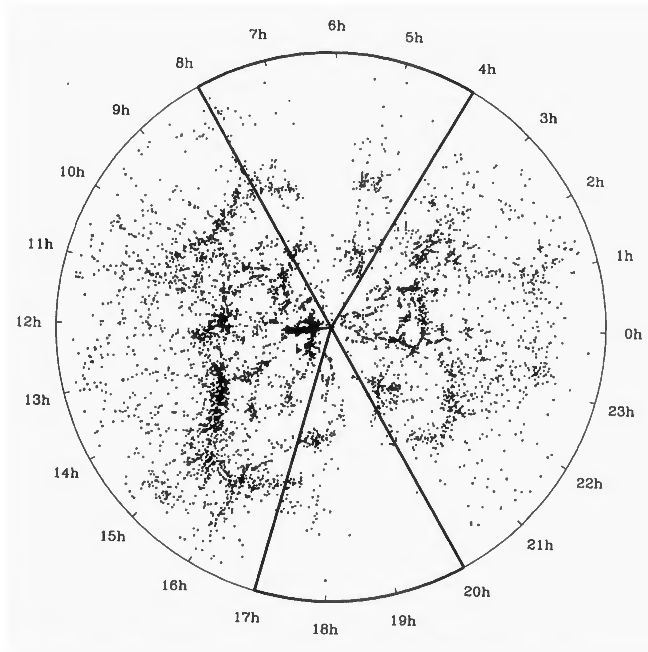

FIG. 1. Southern slice of CfA survey including GPS. The declination range is $0° \leq \delta \leq 20°$; the circle indicates $cz = 15\,000$ km s^{-1}.

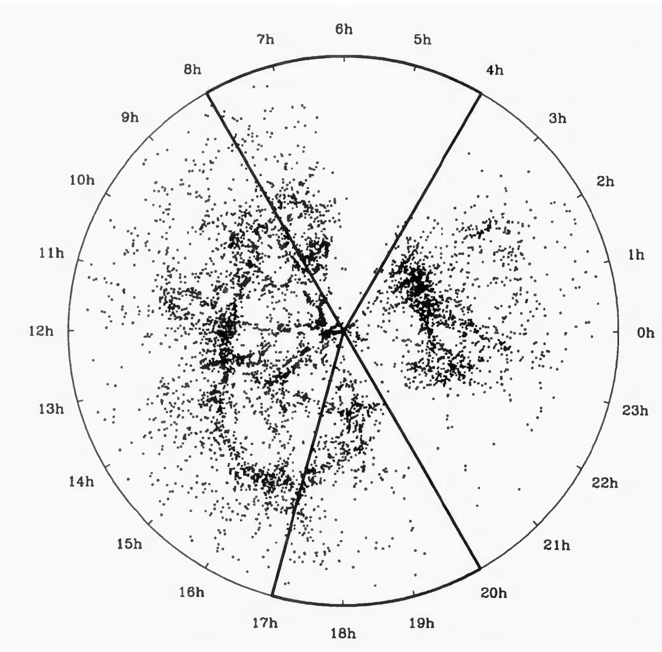

FIG. 2. Northern slice of CfA survey including GPS. The declination range is $20° \leq \delta \leq 45°$; the circle indicates $cz = 15\,000$ km s^{-1}.

8^h and 17^h and between 20^h and 4^h appeared earlier in Geller & Huchra (1989). These earlier surveys, which avoided regions of low galactic latitude, led many authors to speculate that the Great Wall and the Perseus-Pisces chain are simply connected across the ZOA (e.g., Giovanelli & Haynes 1982). In the spring of 1990, we began a redshift survey of the regions between the Galactic caps in order to explore the relation between these two vast structures.

In this paper, we discuss the first complete region of the Galactic Plane Survey (GPS), an extension of the CfA Redshift Survey. In Sec. 2, we discuss the observations and present the data. In Sec. 3, we discuss the qualitative features of the redshift distribution, and in Sec. 4 we compare our results with the *IRAS* 1.2 Jy survey (Fisher *et al.* 1995). We conclude in Sec. 5.

2. DATA

Galaxies in the GPS are drawn from the CGCG (Zwicky *et al.* 1961–68). Figure 3 shows the angular distribution of CGCG galaxies in equatorial coordinates. Solid lines outline complete subsamples of the CfA Redshift Survey including the GPS. The GPS includes the regions $4^h \leq \alpha \leq 8^h$, $0° \leq \delta \leq 45°$ and $17^h \leq \alpha \leq 20^h$, $0.° \leq \delta \leq 45°$. The survey is 97% complete. For display purposes, we divide the GPS into two slices: a northern slice between $\delta = 20°$ and $\delta = 45°$ and a southern slice between $\delta = 0°$ and $\delta = 20°$.

Dashed lines in Fig. 3 indicate contours of constant galactic latitude, $b_{\rm II} = \pm 10°$. This figure demonstrates the large number of galaxies catalogued by Zwicky at quite low Galactic latitudes. The catalogue contains a few galaxies at $|b_{\rm II}| \leq 10°$, but the sampling density increases rapidly at $|b_{\rm II}| > 10°$. At $|b_{\rm II}| = 10°$, the surface densities of galaxies in the CGCG and the *IRAS* 1.2 Jy survey are roughly equal.

We select candidates for the GPS based on the original Zwicky magnitude. Although better magnitudes exist for a small fraction of these galaxies, we use the original Zwicky photometry in order to assure uniform selection over the sky. We quote the apparent magnitude in the $B(0)$ system, which is indistinguishable from the Zwicky scale (Huchra 1976). The rms scatter in the Zwicky photometry is 0.35 magnitudes. We do not correct the magnitudes for extinction in the Galaxy or for internal extinction. A small fraction of the galaxies in our sample are multiple systems for which Zwicky *et al.* (1968) estimate only a combined magnitude. For most of these cases, we estimate the relative contributions of each component by eye. In a few cases, the multiple components have individual magnitudes listed in Kirshner *et al.* (1978;1983); for these cases, we use the Kirshner *et al.* magnitudes.

We obtained the vast majority of the GPS redshifts at the Tillinghast 1.5 m telescope on Mt. Hopkins. We collected the remaining redshifts from the literature. A few of the faintest galaxies required observations at the Multiple Mirror

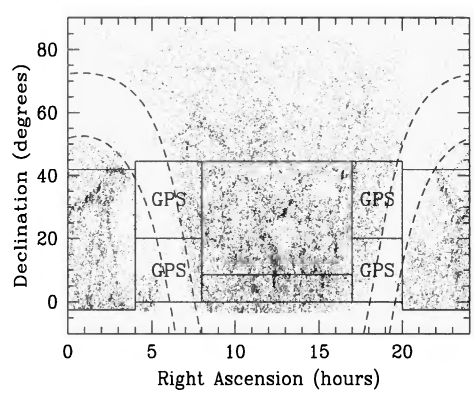

FIG. 3. Distribution of Zwicky galaxies in equatorial coordinates. Solid lines indicate the boundaries of the Galactic Plane Survey (labeled GPS) along with other complete subsamples of the CfA Redshift Survey. Dashed lines show contours of constant galactic latitude: $b_{\rm II} = \pm 10°$.

Telescope. We measure redshifts by cross-correlating galaxy spectra with stellar and galactic templates (Tonry & Davis 1979) or by fitting Gaussian profiles to emission lines. Averaged over the sample, the mean error in cz is approximately 35 km s^{-1}. We quote heliocentric redshifts.

Table 1[1] lists positions, magnitudes and redshifts for all galaxies with $B(0)\leq 15.5$ in the completed regions of the GPS. Fainter than $B(0)=15.5$, the sample is incomplete; these galaxies are listed in Table 2.[1] Column (1) is the IAU name of the galaxy. For brighter galaxies in the NGC or IC, we list the catalogue numbers instead of the IAU designation. Columns (2) and (3) give the Zwicky coordinates in right ascension and declination. Column (4) is the Zwicky-$B(0)$ magnitude. For the small number of magnitudes with sources other than the CGCG, we list a source code to the right of the magnitude in column (4). The source code "H" refers to magnitudes split by eye by JPH; "K" refers to magnitudes from Kirshner *et al.* (1978,1983). Column (5) lists the heliocentric radial velocity cz where z is the redshift and c is the speed of light. Column (6) notes the source of the redshift; these source codes are explained in Table 3. Column (7) gives the revised Hubble type, using the numerical system devised by deVaucouleurs *et al.* (1976) for the Second Reference Catalog. Only a small fraction of galaxies have measured types. Where available, we list the major and minor axis diameters in columns (8) and (9). Column (10) is the UGC number. Column (11) lists comments and references to other catalogues.

At low Galactic latitude, extinction in the B band is significant. Patchy obscuration leads to variations in the effective magnitude limit of several tenths of a magnitude over $\sim 5°$ scales. These small-scale variations are superimposed on the large-scale $csc\ b$ gradient. These variations in the effective magnitude limit complicate the interpretation of the redshift distribution from samples limited by observed magnitude. In this paper, we concentrate on the gross features of the distribution, which (as we show later) are unlikely to be affected by extinction. We will address the details of foreground extinction in a separate paper (Pantoja *et al.* 1996).

3. RESULTS

Figures 1 and 2 show full-circle slices of the sky at $0°\leq\delta\leq 20°$ and $20°\leq\delta\leq 45°$, respectively. The regions bounded by dark solid lines indicate the contributions of the GPS. The most striking feature of the GPS is the newly detected wall between 17^h and 19^h which encloses the largevoid in the eastern half of CfA2N. This "eastern wall" is clearly visible in both declination slices, but it is defined particularly well in the northern slice. It is clear from these figures that the Great Wall is not simply connected to the Perseus-Pisces wall. Both the Great Wall and the Perseus-Pisces wall form the boundaries of a network of voids with diameters $\sim 50h^{-1}$ Mpc (cf. Geller & Huchra 1989).

The GPS also reveals a number of small clusters. In the southern slice, concentrations are visible between 17^h and 19^h at $\sim$2500 and $\sim$7000 km s^{-1}. The other side of the southern slice reveals clusters between 4^h and 6^h at $\sim$4000 and $\sim$7500 km s^{-1}. In the northern slice, a concentration appears between 7^h and 8^h in the foreground of the Great Wall. The depth of this structure is consistent with the depth of the Perseus-Pisces cluster, suggesting that these structures might connect across the ZOA. The wealth of nearby structure at low galactic latitude emphasizes the importance of full-sky surveys in the determination of large-scale motions.

The effective depth of the survey decreases in regions with heavy extinction. In a magnitude-limited sample, the majority of galaxies lie near the peak of the distribution $\phi(r)V(r)$, where ϕ is the selection function and V is the volume of a shell at distance r. As extinction decreases the effective magnitude limit near the plane, this peak moves to smaller redshift. Thus the picture of large-scale structure in regions of heavy extinction may be distorted. In particular, peaks in ϕV may masquerade as walls in a magnitude-limited survey.

To demonstrate that the "eastern wall" in the northern slice is real, we plot the redshift distribution in the region $17^h\leq\alpha\leq 20^h, 20°\leq\delta\leq 45°$ along with the peak of ϕV in Fig. 4. Using the reddening maps of Burstein & Heiles (1982) and the standard ratio of total to selective absorption, $A_B=4.0\ \mathrm{E}(B-V)$, we compute the expected redshift distribution ϕV averaged over declination. The eastern wall lies well beyond the peak of the expected redshift distribution, and the shape of the wall does not follow the trend of ϕV with right ascension.

For comparison, Figs. 5 and 6 show the distribution of galaxies in the *IRAS* 1.2 Jy survey over the same regions displayed in Figs. 1 and 2. Two factors contribute to the superior definition of structure in the optical catalogue: first, the overall sampling density is higher in the optical survey. Second, the poor representation of elliptical galaxies in the *IRAS* catalogue decreases the contrast between high-density and low-density regions.

Figures 7 and 8 (Plates 68 and 69) superimpose galaxies from the *IRAS* 1.2 Jy survey and the CfA Survey. These catalogues overlap significantly; only 29% of the galaxies in the *IRAS* catalogue are not included in the CfA survey. In Figs. 7 and 8, we plot *IRAS* galaxies as red points only if they are not included in the CfA survey. Although the samples differ in detail, the large-scale distribution of *IRAS* galaxies not included in the CfA survey appears consistent with the structure delineated by the CfA survey. Although the *IRAS* survey probes more deeply into the plane, the density of optical galaxies is larger than the density of *IRAS* galaxies above $b_{\mathrm{II}}=10°$. In these regions, the optical data provide much better contrast between walls and voids, allowing a better deter-mination of the coherence of structure. Because of large and uncertain variations in the selection function of the GPS, we do not explore the differences between the *IRAS* and optical samples in detail. These comparisons are better made at high galactic latitude (Babul & Postman 1990; Strauss *et al.* 1992; Oliver *et al.* 1996).

[1]Tables 1 and 2 are presented in their complete form in the AAS CD-ROM Series, Vol. 7, 1996. The first pages of these tables are presented here for guidance regarding their form and content.

TABLE 1. The Galactic Plane Survey [$B(0)\leq 15.5$].*

Name	α (1950)	δ	m_{zw}	V_h	σ	Source	Type	D_1	D_2	UGC	Notes
04000+2120	04:00:00.0	21:20:00	15.5	5921	±35	T					
04005+2613	04:00:27.7	26:13:33	14.9	7102	±50	M					
I 357	04:00:47.1	22:01:27	14.3	6260	±20	0623	3B	1.3	1.0	02941	
04008+3042	04:00:48.0	30:42:00	15.1	5473	±37	T					
I 358	04:00:48.9	19:45:13	15.3	6734	±49	CfA	-2	1.0	0.4	02940	
04014+3340	04:01:26.8	33:40:20	15.2	5240	±20	0644	0	1.5	1.1	02945	IR
04020+2507	04:02:01.2	25:07:43	14.6	7203	±34	CfA	2B	1.2	0.6	02949	
04027+2521	04:02:42.0	25:21:00	15.3	6908	±20	CfA					
N1508	04:02:48.0	25:16:00	15.2	7160	±47	T					
04029+0417S	04:02:52.1	04:16:38	15.4	5345	±20	0623	5	1.0	0.4	02954	See Notes
04029+0417N	04:02:54.0	04:19:00	15.4	5214	±60	3700					KDG98A
04039+2244	04:03:54.7	22:43:47	15.0	6221	±20	0623	20	1.4	0.3	02958	
04042+0649	04:04:08.2	06:48:28	15.4	5827	±44	M					
04051+0351	04:05:01.1	03:50:13	15.3	5300	±25	0623	5A	2.3	0.8	02963	
04050+2310	04:05:04.5	23:09:40	14.9	6259	±33	T					IR
04059+2704	04:05:54.0	27:04:00	15.5	15797	±61	CfA	5A	1.3	1.2	02964	
N1517	04:06:29.0	08:31:01	14.3	3483	±10	0909	5	1.2	1.1	02970	
04083+2645	04:08:18.0	26:45:00	14.6	6345	±34	CfA	5A	1.8	0.7	02976	
I 359	04:09:24.0	27:35:00	15.4	4053	±47	CfA	-3	1.3	1.3	02980	
04097+0526	04:09:43.0	05:25:11	15.5	5322	±31	CfA	20	1.0	0.5	02982	
04102+0214	04:10:16.4	02:14:31	15.3	5001	±25	0619	3A	2.3	0.8	02983	
04105+2725	04:10:30.0	27:25:00	15.2	3912	±29	T					
04106+2521	04:10:36.0	25:21:00	15.5	3816	±5	0912	3A	3.0	1.0	02988	
04111+0138	04:11:07.2	01:39:06	15.4	5075	±38	M	D	1.5	0.5	02992	
04112+2432	04:11:13.6	24:32:06	15.5	6766	±76	M					
04130+0102	04:13:00.0	01:02:00	15.3	4987	±66	CfA	0	1.0	0.3	02996	
04133+0804	04:13:22.4	08:03:21	15.0	1585	±34	CfA		1.2	0.6	02997	IR23482
04135+0157	04:13:30.0	01:57:00	15.4	3576	±31	T					
04139+0237	04:13:58.0	02:38:00	14.9	3346	±20	0623	3B	1.6	1.5	02998	
N1541	04:14:24.0	00:42:00	14.9	5009	±28	CfA	0	1.3	0.6	03001	
N1542	04:14:37.1	04:39:38	15.1	3714	±20	0617	2A	1.4	0.6	03003	
04147+0217S	04:14:42.0	02:17:00	14.9	3572	±16	CfA	3A	1.5	1.0	03004	
04148+0214	04:14:48.0	02:14:00	15.0	3621	±66	CfA	-2	1.8	0.8	03006	
04148+0010	04:14:49.6	00:11:06	15.4	5272	±44	M					
04151+0125	04:15:06.0	01:25:00	14.9	4919	±36	T					IIZw7
04160+0225	04:16:00.0	02:25:00	14.8	3251	±28	CfA	0X	1.3	0.7	03008	
04163+0520	04:16:18.0	05:20:00	15.4	3870	±20	0617	5B	1.1	0.7	03010	
I 363	04:16:18.0	02:53:00	15.4	3509	±34	T					
I 364	04:16:30.0	03:03:00	15.2	3862	±39	T					
I 365	04:16:36.0	03:13:00	14.8	7372	±53	CfA					
04167+0228	04:16:42.0	02:29:00	15.5	4207	±35	CfA	20	1.1	0.6	03011	
N1550	04:17:02.0	02:17:25	14.0	3689	±34	CfA	-7	1.7	1.7	03012	
04173+0159	04:17:17.8	01:58:34	14.7	4213	±20	0623	20	1.4	0.8	03014	
04181+0212	04:18:06.0	02:12:00	15.0	3912	±29	T					
04183+0231	04:18:18.0	02:31:00	15.2	3973	±29	T					
I2057	04:19:18.0	03:56:00	15.2	7346	±33	2754					
04194+0143	04:19:22.1	01:43:20	14.9	13200	±	0504	-2B	1.4	1.0	03023	AK106
04197+0706	04:19:42.0	07:06:00	15.2	4972	±46	T					
04200+0306	04:20:00.0	03:06:00	15.4	3878	±50	1820					
04220+0706	04:22:00.0	07:06:00	14.8	4136	±33	CfA	-2B	1.7	1.1	03035	
04224+0704	04:22:20.4	07:03:34	15.5	8089	±	3800	3	1.3	0.3	03038	
04230+0712	04:23:00.0	07:12:00	15.5	8017	±23	T					
04243+0135	04:24:14.1	01:35:23	15.4	7581	±34	CfA	4A	1.1	0.5	03049	
04252+2133	04:25:12.6	21:32:45	14.9	2407	±15	0909	5	1.0	0.8	03053	
04262+0738	04:26:12.0	07:38:00	15.2	4301	±18	T					
04270+0005	04:27:00.0	00:05:00	15.0	3574	±26	T					
04271+0335	04:27:04.9	03:34:23	15.4	4810	±6	0639	8A	2.4	1.0	03059	
04275+0650	04:27:29.5	06:49:52	15.5	4359	±50	1802		2.2	2.0	03061	VV555
N1587	04:28:05.2	00:33:17	13.3	3667	±23	CfA	-5	1.8	1.7	03063	See Notes
N1588	04:28:09.5	00:33:30	14.1	3478	±30	2732		1.5	0.8	03064	See Notes

*Table 1 is presented in its complete form in the AAS CD-ROM Series, Vol. 7, 1996. Only the first page is printed here for form and content.

TABLE 2. The Galactic Plane Survey [$B(0)>15.5$].*

Name	α (1950)	δ	m_{zw}	V_h	σ	Source	Type	D_1	D_2	UGC	Notes
04002+0149	04:00:12.6	01:49:41	15.7	3823±	20	GH	5	2.6	0.9	02936	
04003+2652	04:00:18.0	26:52:00	15.7	14539±	21	CfA					
04004+0425	04:00:24.9	04:24:24	15.7	5512±	20	GH	2B	1.3	0.7	02938	
04009+2415	04:00:54.0	24:15:00	15.6	6005±	61	T					
04020+2041	04:01:59.5	20:41:40	15.7	5204±	20	GH	2	1.4	0.4	02948	
04118+0235	04:11:48.0	02:35:00	15.7	3318±		RC3	8A8	1.5	0.8	02994	PGC14718
N1539	04:16:00.0	26:43:00	15.7	5555±	50	T					
04287+0632	04:28:42.0	06:31:58	15.6	4435±	25	B	8	1.3	1.1	03074	
I 374	04:29:36.0	16:32:00	15.7	4110±	32	T					
04310+1648	04:31:00.0	16:48:00	15.6	4612±	31	CfA	4A	1.1	1.0	03089	
04331+0209	04:33:12.3	02:09:23	15.6	3580±	55		-2	1.2	0.6	03097	See Notes
04359+1844	04:35:59.7	18:44:22	15.7	3290±	34	SHD	-2	1.4	0.7	03115	
04371+0255	04:37:06.0	02:55:00	15.6	4517±	30	MH	20	1.4	0.4	03121	
04436+1823	04:43:35.7	18:22:18	15.7	4615±	25	B	20B	1.4	1.3	03157	(+CompS)
04458+0008	04:45:48.0	00:08:00	15.7	8533±	39	MH					
04470+0314	04:47:00.0	03:14:00	15.7	8383±	10	P	-2 P	1.1	0.9		KDG103A
04486+0217	04:48:36.0	02:17:00	15.7	8936±	57	MH					
04491+0645	04:49:03.7	06:46:27	15.7	4734±	25	B	5	1.5	0.9	03187	
04504+0543	04:50:24.0	05:43:00	15.7	12774±	43						
04505+0418	04:50:32.5	04:17:37	15.6	16335±	40		5A	1.5	1.0	03195	
04510+0222	04:51:00.0	02:22:00	15.7	8403±	39	MH					
04510+0225	04:51:00.0	02:25:00	15.7	3168±	35	MH					
04513+0136	04:51:18.0	01:36:00	15.7	9029±	36						
04521+0115	04:52:06.0	01:15:00	15.7	8665±	29	MH					
04522+0105	04:52:12.0	01:05:00	15.7	15828±	45	MH					
04537+0131	04:53:42.0	01:31:00	15.6	8681±	36	MH	5A	1.3	1.2	03208	
04541+0058	04:54:06.0	00:58:00	15.7	8310±	34	MH					
04553+0547	04:55:18.0	05:47:00	15.7	14686±	38						
04561+0654	04:56:06.0	06:54:00	15.7	8482±	25		5A	1.4	0.6	03219	
04561+0702	04:56:06.0	07:02:00	15.7	8529±	44		5	1.1	0.7	03220	
04562+1220	04:56:12.0	12:20:00	15.7	3431±	36	MH					
04583+0117	04:58:18.0	01:17:00	15.7	7155±	30	MH					
04588+0053	04:58:48.0	00:53:00	15.7	4010±	34	MH					
04596+0733	04:59:36.0	07:33:00	15.7	11318±	27		5A	1.3	1.3	03229	
05008+0635	05:00:51.8	06:35:23	15.6	8513±	20	GH	4A	1.1	0.4	03236	
05011+1057	05:01:06.0	10:57:00	15.6	5013±	38						
05017+0435	05:01:39.2	04:34:59	15.7	10903±	48		4A	1.1	0.4	03240	
0502+0415	05:02:00.0	04:15:00	15.7	6138±	40		3				
05022+0425	05:02:12.0	04:25:00	15.7	6088±	47		3A	1.4	0.3	03242	
05070+0629	05:07:00.0	06:29:00	15.7	11961±	29						
05072+0725	05:07:07.9	07:25:16	15.6	5670±	22		3X	1.3	0.3	03255	
05079+1625	05:07:52.0	16:26:16	15.7	5360±	23	CfA					AGN
05105+0055	05:10:30.0	00:55:00	15.7	13011±	40						
I 404	05:10:36.0	09:42:00	15.7	9067±	36						
05111+0154	05:11:06.0	01:54:00	15.7	8657±	32						
05114+0215	05:11:24.0	02:15:00	15.7	8307±	34						
05115+0228	05:11:30.0	02:28:00	15.6	8601±	35						
05133+0643	05:13:18.0	06:43:00	15.7	8304±	41		2				A539-D86
05134+0531	05:13:24.0	05:31:00	15.7	8384±	32						
05138+0620	05:13:47.9	06:20:52	15.6	7465±	29		-2				A539-D44
05139+0627	05:13:54.3	06:27:02	15.6	7114±	30		-4				A539-D63
05143+0630	05:14:13.7	06:29:56	15.6	9694±	24		-4				A539-D68
05146+0605	05:14:37.1	06:05:01	15.7	9672±	31		-2				A539-D16
05150+0645	05:14:55.9	06:44:50	15.7	8265±	25		5B	1.2	0.9	03282	A539-D85
05150+0305	05:15:00.0	03:05:00	15.7	8585±	31						E421-22
05166+0549	05:16:32.3	05:49:37	15.7	8797±	22		5				A539-D7
05166+0445	05:16:36.0	04:45:00	15.7	10893±	28						
05171+0340	05:17:06.0	03:40:00	15.6	8376±	31						
05174+0631	05:17:25.4	06:31:57	15.6	8851±	41		3B	1.1	0.3	03289	
05175+0547	05:17:30.0	05:47:00	15.7	8663±	38						

*Table 2 is presented in its complete form in the AAS CD-ROM Series, Vol. 7, 1996. Only the first page is printed here for form and content.

TABLE 3. Velocity Sources.

T	This paper (Tillinghast)
M	This paper (MMT)
CfA	Previously published CfA Redshift Survey
-800	Thorstensen, J. Wegner, G. & Boley, F. Dartmouth Century Survey Data, private communication.
0000	de Vaucouleurs, G., de Vaucouleurs, A. & Corwin, H. 1976, *The Second Reference Catalogue of Bright Galaxies*, University of Texas Press, Austin, Texas. (RC2)
0002	de Vaucouleurs, G., de Vaucouleurs, A., Corwin, H., Buta, R. J., Paturel, G. & Fouqué, P. 1991, *Third Reference Catalogue of Bright Galaxies*, Springer-Verlag, New York. (RC3)
0004	de Vaucouleurs, G., de Vaucouleurs, A., & Nieto, J. L. 1979, AJ 84, 1811.
0005	Kelton, P. 1980, AJ 85, 89.
0100	Sandage, A. & Tammann, G. 1981, *The Revised Shapley-Ames Catalog,* Carnegie Institution of Washington.
0200	Fisher, J.R. & Tully, R.B. 1981, ApJS 47, 139.
0400	Rubin, V., Ford, K., Thonnard, N., Roberts, M. & Graham, J. 1976, AJ 81, 687.
0402	Rubin, V., Thonnard, N., Ford, W. & Roberts, M. 1976, AJ 81, 719.
0501	Arakelyan, M., Dibai, E. & Esipov, V. 1975, Astrofizika 11, 15.
0502	Arakelyan, M., Dibai, E. & Esipov, V. 1975, Astrofizika 11, 377.
0503	Arakelyan, M., Dibai, E. & Esipov, V. 1976, Astrofizika 12, 195.
0504	Arakelyan, M., Dibai, E. & Esipov, V. 1976, Astrofizika 12, 685.
0505	Arkhipova, V. & Esipov, V. 1979, Soviet Astron. Lett. 5, 140.
0510	Dibai, E., Doroshenko, V. & Terebizh, V. 1976, Astrofizika 12, 689.
0511	Doroshenko, V. & Terebizh, V. 1975, Astrofizika 11, 631.
0513	Markaryan, B., Lipovetskii, V. & Stepanyan, J. 1980, Astrofizika 16, 5.
0514	Markaryan, B., Lipovetskii, V. & Stepanyan, J. 1980, Astrofizika 16, 609.
0527	Arakelyan, M., Dibai, E. & Esipov, V. 1972, Astrofizika 8, 329.
0600	Giovanelli, R. & Haynes, M. 1981, private communication.
0603	Biermann, P., Clarke, J. & Fricke, K. 1979, A&A 75, 19.
0613	Peterson, S. 1979, ApJS 40, 527.
0615	Schombert, J.M., Bothun, G.D., Schneider, S.S. & McGaugh, S.S. 1992, AJ 103, 1107.
0617	Haynes, M. & Giovanelli, R. 1984, AJ 89, 758.
0619	Bothun, G., Beers, T., Mould, J. & Huchra, J. 1985, AJ 90, 2487.
0623	Bicay, M. & Giovanelli, R. AJ 91, 705 & 732.
0627	Bicay, M. & Giovanelli, R. 1987, AJ 93, 1326.
0631	Haynes, M., Giovanelli, R., Starosta, B. & Magri, C. 1988, AJ 95, 607.
0633	Freudling, W., Haynes, M. & Giovanelli, R. 1988, AJ 96, 1791.
0636	Sulentic, J. & Arp. H. 1983, AJ 88, 489.
0639	Schneider, S., Thuan, T., Magri, C. & Wadiak, J. 1990, ApJS 72, 245.
0643	Lewis, B.M., Helou, G., & Salpeter, E.E. 1985, ApJS 59, 161.
0644	Lu, N.Y., Dow, M.W., Houck, J.R., Salpeter, E.E. & Lewis, B.M. 1990, ApJ 357, 388.
0647	Freudling, W., Haynes, M.P. & Giovanelli, R. 1992, ApJS 79, 157.
0650	Giovanelli, R. and Haynes, M.P. 1993, AJ 105, 1271
0806	Richter, O.-G. & Huchtmeier, W. 1987, preprint
0902	Giovanelli, R. & Haynes, M. 1982, AJ 87, 1355.
0909	Thonnard, N., Rubin, V., Ford, K. & Roberts, M. 1978, AJ 83, 1564.
0912	Tifft, W.G. & Cocke, W.J. 1988, ApJS 67, 1.
1115	Warner, P., Riley, J., Eales, S., Downes, A. & Baldwin, J.E. 1983, MNRAS 204, 1279.
1244	Moorwood, A., Veron-Cetty, M.-P. & Glass, I. 1987, A&A 184, 63.
1802	Afanasiev, V., Karachentsev, I., Arkhipova, V., Dostal, V. & Metlov, V. 1980, A&A 91, 302.
1804	Karachentsev, I. 1980, ApJS 44, 137.
1813	Karachentseva, V. & Karachentsev, I. 1981, Soviet Astron. Lett. 7, 108.
1819	Lipovetskii, V. A. & Stepanyan, J. A. 1986, *Communications of the Special Astrophysical Observatory, "First Byurakan Sky Survey."*
1820	Kostyuk, I. P. 1975, *Soobshch. Spets. Astrofiz. Obs. Akad. Nauk SSR* 13, 45.
1822	Karachentsev, I.D. 1983, Soviet Astron. Lett. 9, 36.
1824	Karachentsev, I.D. 1981, Soviet Astron. Lett. 7, 1.
1901	Ulrich, M.-H. 1975, A&A 40, 337.
2102	Faber, S. & Dressler, A. 1977, AJ 82, 187.
2200	Bottinelli, L., Gouguenheim, L. & Paturel, G. 1981, A&AS 44, 217.
2201	Balkowski, C., Chamaraux, P. & Weliachew, L. 1978, A&A 69, 263.
2407	Karachentsev, I., Sargent, W.L.W. & Zimmerman, B. 1979, Astrofizika 15, 25.
2608	van Driel, W., Davies, R. & Appleton, P. 1988, A&A 199, 41.
2722	Fabricant, D., Beers, T., Geller, M., Gorenstein, P. , Huchra, J. & Kurtz, M. 1986, ApJ 308, 530. (A754)

TABLE 3. (continued)

2732	Michel, A. & Huchra, J. 1988, PASP 100, 1423. (Winter Plane)
2733	Ostriker, E. C., Huchra, J. P., Geller, M. J., & Kurtz, M. J. 1988, AJ 96, 1775. (Abell 539)
2754	Strauss, M.A., Huchra, J.P., Davis, M., Yahil, A., Fisher, K. & Tonry, J. 1992, ApJS 83, 29. (1.936Jy IRAS) same as vsrc 4302
3300	Rood, H. 1981, private communication (Catalog of Galaxy Redshifts) - National Space Science Data Center.
3502	Merighi, R., Basso, L., Vigotti, M., Lahulla, J.F. & Lopez-Arroyo, M. 1991, A&AS 89, 225. (Zw/B3 radio galaxies)
3509	Focardi, P., Marano, B., & Vettolani, G. A&A 161, 217. (Lynx-Gemini Region)
3606	Davies, R., Burstein, D., Dressler, A., Faber, S., Lynden-Bell, D. Terlevich, R. & Wegner, G. 1987, ApJS 64, 581. (velocity dispersion listing)
3608	Augarde, R., Figon, P. Kunth, D. & Sevre, F. 1987, A&A 185, 4. (Case Blue Galaxies).
3700	Palumbo, G., Tanzella-Nitti, G. & Vettolani, G. 1983, *Catalogue of Radial Velocities of Galaxies*, (New York:Gordon & Breach).
3800	Huchtmeier, W.K. & Richter, O.-G. 1989, *A General Catalog of HI Observations of Galaxies* (Berlin: Springer-Verlag).
3905	da Costa, L.N., Pellegrini, P.S., Sargent, W.L.W., Tonry, J., Davis, M., Meiksin, A., & Latham, D.W. 1988 ApJ 327, 544. (Southern Sky Redshift Survey)
4000	Kriss, G. A., & Canizares, C. R. 1982, ApJ, 261, 51.
4105	Hill, G., Heasley, J., Becklin, E. & Wynn-Williams, C. 1988, AJ 95, 1031. (IRAS redshifts)
4300	Davis, M. & Strauss, priv. comm.
4302	Strauss, M.A., Huchra, J.P., Davis, M., Yahil, A., Fisher, K. & Tonry, J. 1992, ApJS 83, 29. (1.936Jy IRAS) same as vsrc 2754

4. DISCUSSION

The projection of the galaxy distribution onto the plane of the sky shows rich, filamentary structure (e.g., Shane & Wirtanen 1967; Zwicky *et al.* 1961–68). The past three decades have seen much speculation on the origin and evolution of this distribution. The filamentary appearance of the Perseus-Pisces chain is particularly intriguing (Giovanelli & Haynes 1982). Because the Lynx and Ursa Major clusters lie at similar depth to Perseus-Pisces but on the other side of the plane, Giovanelli & Haynes (1982) speculated that the two are connected across the ZOA. This led to further speculation that the universe contains vast, primarily one-dimensional features snaking over $100h^{-1}$ Mpc scales.

Although the power spectrum of galaxy density fluctuations confirms that galaxies are significantly correlated on large scales (Baugh & Efstathiou 1994; Park *et al.* 1994; Fisher *et al.* 1993; Vogeley *et al.* 1992), the geometry of the structure inferred from the CfA survey yields a different picture from the one proposed by Giovanelli & Haynes (1982). The combination of the CfA Redshift Survey and the GPS suggests that large-scale structure is inherently two-dimensional rather than filamentary. Furthermore, structures which appear coherent on scales of ~100 Mpc or more are

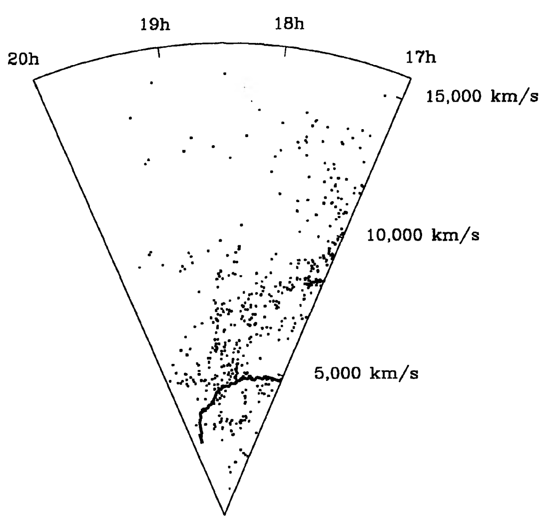

FIG. 4. The "eastern wall" in the northeastern slice of the GPS. The declination range shown here is $20°\leq\delta\leq45°$. The solid line shows the peak of ϕV; the eastern wall lies well beyond this peak.

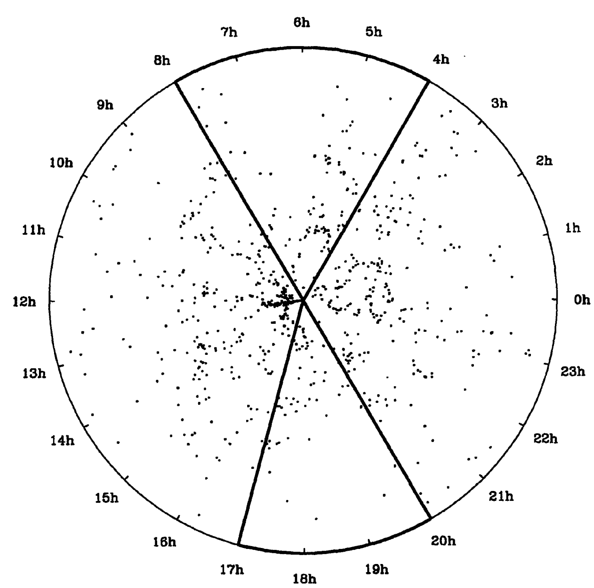

FIG. 5. Galaxies from the *IRAS* 1.2 Jy survey in the same region as the southern slice of the CfA+GPS surveys.

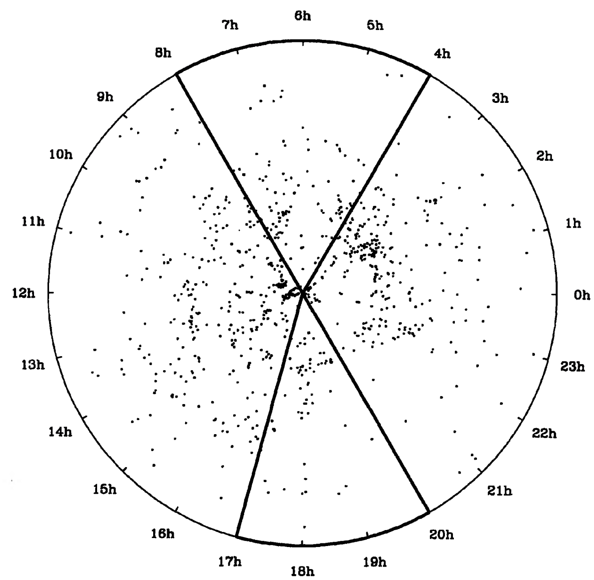

FIG. 6. Galaxies from the *IRAS* 1.2 Jy survey in the same region as the northern slice of the CFA+GPS surveys.

likely to be chance alignments of smaller structures. Figures 7 and 8 give the impression that the dominant structures nearby are $\sim 30-50h^{-1}$ Mpc voids; these are perhaps the more important physical scales for understanding the origin of structure in the universe.

This conclusion is consistent with statistical measures of large-scale structure in the CfA survey and is also consistent with deeper surveys of the Galactic caps. Vogeley *et al.* (1992) discuss a feature in the power spectrum which indicates enhanced power on the scale of $\sim 50h^{-1}$ Mpc. This feature may point out a preferred scale in the galaxy distribution, or it may be an artifact caused by the dependence of clustering on absolute luminosity (Park *et al.* 1994). In a much deeper survey of the Galactic caps, Landy *et al.* (1996) find no voids much larger than the ones in Figs. 3–8. This result is consistent with our claim that the large-scale structure is dominated by voids with characteristics scale $\sim 50h^{-1}$ Mpc. However, Landy *et al.* (1996) also find evidence for a feature in the two-dimensional power spectrum at the scale of $\sim 100h^{-1}$ Mpc, similar to the $128h^{-1}$ Mpc feature identified by Broadhurst *et al.* (1990) in a very deep pencil-beam survey. These scales are not well sampled in the CfA survey, and therefore we cannot compare directly with these results. However, it does seem surprising given the visual appearance of Figs. 5 and 6 that the LCRS does not show an additional feature at $\sim 50h^{-1}$ Mpc, roughly half the scale of the bump reported by Landy *et al.* (1996). Large, local, and densely sampled redshift surveys will shed new light on these smaller-scale features in the power spectrum (Geller *et al.* 1996; Gunn 1995).

5. CONCLUSION

We find that the Great Wall and the Perseus-Pisces chain are not simply connected across the zone of avoidance. Instead, these walls are formed by the boundaries of neighboring voids. The scale of these voids is $\sim 50h^{-1}$ Mpc, smaller than the scale of the walls themselves.

The large-scale structure delineated by galaxies from the *IRAS* 1.2 Jy sample appears consistent with our more densely sampled optical survey. The GPS regions contain many clusters, which are not well sampled by the *IRAS* catalogue. Thus if mass clusters with the galaxies, optical surveys of galaxies at low galactic latitude are critical for determining the source of the Local Group's motion with respect to the microwave background.

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FIG. 7. Comparison between the southern slice of the CfA+GPS surveys and the *IRAS* 1.2 Jy sample in the same region. Black dots are CfA galaxies, red dots are *IRAS* galaxies not included in the CfA Survey.

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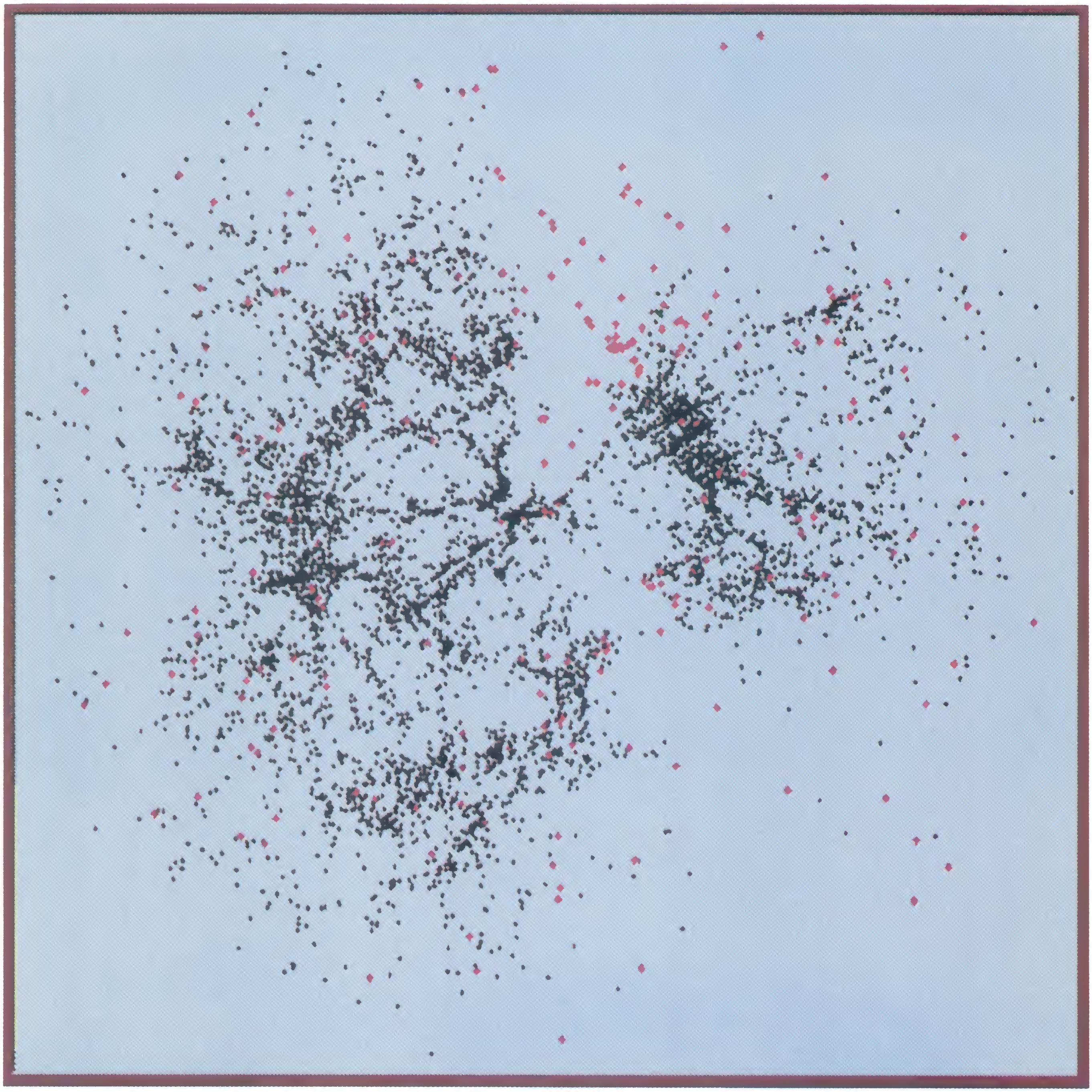

FIG. 8. Comparison between the northern slice of the CfA+GPS surveys and the *IRAS* 1.2 Jy sample in the same region. Black dots are CfA galaxies, red dots are *IRAS* galaxies not included in the CfA Survey.

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