

Surveying the Zone of Avoidance with the Arecibo L-Band Feed Array

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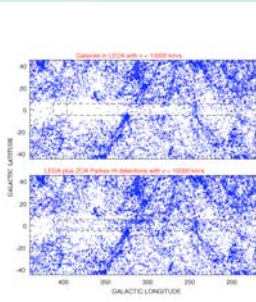
Why Survey the Zone of Avoidance?

The obscuration due to dust and the high stellar density in our Galaxy blocks our optical view of the extragalactic Universe over ~20% of the sky, somewhat less in the infrared, the "Zone of Avoidance" (ZOA). Accurate knowledge of the mass distribution within the local Universe is essential if we are to understand the dynamical evolution of the Local Group from kinematic studies (e.g. Peebles et al. 2001). In addition the discovery of previously unknown galaxies would further efforts to understand the dipole in the CMB, caused by the net gravitational acceleration of the Local Group due to the inhomogeneous mass distribution in the surrounding 4π steradians of the sky, and other velocity flow fields which require all-sky mapping of mass inhomogeneities to understand. Mapping hidden galaxies over a range of redshifts also allows the connectivity in three dimensions of large-scale structures across the Galactic plane to be explored. Many of the known nearby large-scale structures, eg. the Pisces-Perseus supercluster and the Great Attractor, are partially hidden by the Milky Way, and have not yet been satisfactorily mapped. Are there other dynamically important structures which remain hidden?

Why Survey the ZOA at 21-cm?

The ZOA has been successfully narrowed by deep searches in the optical and IR, but both fail in regions of high extinction and stellar confusion. Galaxies which contain HI can be found in regions of thickest obscuration and worst IR confusion. The HI Parkes Zone of Avoidance Survey (HIZOA) surveyed the southern ZOA to 6 mJy/beam, and the Dwingeloo northern ZOA survey to a shallow 40 mJy/beam.

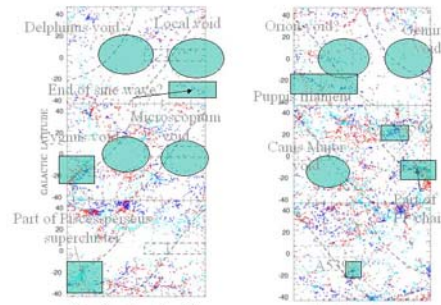
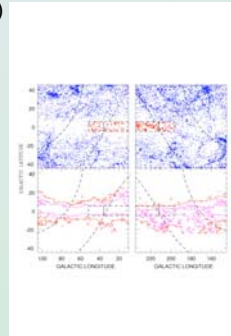
How a 21-cm survey fills in the ZOA: Top panel shows galaxies from the LEDA database with velocities measured within 10,000 km/s. Dashed lines show the borders of the Parkes ZOA search area in the southern hemisphere, and extension to the north, to Dec +20°. The lower panel adds the galaxies uncovered by the HI Parkes ZOA Survey (Henning et al. in prep.). The HI-detected objects fill in the optical ZOA remarkably well. The Great Attractor region is seen as an overdensity at $l \sim 300^\circ \rightarrow 340^\circ$, the Hydra-Antlia filament at $l \sim 280^\circ$ and the Puppis filament crosses the Galactic plane at $l \sim 240^\circ$. The Local and Sagittarius voids are visible as an underdensity at $l \sim 350^\circ \rightarrow 52^\circ$.



ZOA in the Arecibo Sky

Our Plan: Map the ZOA accessible to Arecibo, using the Arecibo L-Band Feed Array (ALFA)

Top panel shows LEDA galaxies within 12,000 km/s in and near the two ZOA regions accessible to Arecibo, the inner (left) and outer Galaxy (right). Dashed curves show the regions of sky Arecibo can see. The rectangles containing the Galactic equator show the overlap with the HI Parkes ZOA survey, with galaxies detected by Parkes plotted with heavy dots. The bottom panels indicate the Galactic extinction from the $100\mu\text{m}$ DIRBE experiment (Schlegel et al. 1998) with contours at $A_b = 1$ mag (outer) and 3 mag (inner).



Redshift slices of known galaxies in and near the inner and outer Galaxy regions accessible to Arecibo. Top panels show galaxies with $v_{\text{hel}} < 3500$ km/s, middle panels with $3500 < v_{\text{hel}} < 6500$ km/s, and bottom panels with $6500 < v_{\text{hel}} < 9500$ km/s. Known and suspected large-scale structures are labeled (Fairall 1998).

The ALFA ZOA Survey will:

- Define the edges of the Gemini, Canis Major, Microscopium, and Cygnus voids; probe contents of Delphinus void
- Determine the reality of the Orion void
- Map end of the "sine wave" feature, indicated by southern surveys (Kraan-Korteweg et al. 1999)
- Map the newly-discovered nearby Monoceros filament (Henning et al. 2005, Kraan-Korteweg et al. 2005)
- Almost certainly uncover new large-scale structures

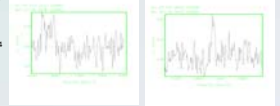
Results from Precursor Observations

- We have mapped and reduced a 38 square degree field, using a meridian-nodding "basketweave" mode, near Galactic longitude 40° , achieving 4 sec per Nyquist pixel, ~6 mJy/beam rms noise. Observations were conducted in "commensal" mode with a Galactic HI survey (GALFA).
- Data reduced using software originally developed for the Parkes Multibeam surveys (*LiveData*, *Gridzilla*), adapted for Arecibo. Data are gridded using a median filter, taking advantage of the re-observations of sky pointings afforded by the basketweave technique. Cubes are searched by eye, parameters fit in *miriad*.
- 9 Galaxies were uncovered in this precursor region, 6 previously known from HIZOA, and 3 new HI detections.
- For ALFA detections of HIZOA sources, all measured positions and heliocentric velocities are within beam size, and velocity resolution for HIZOA. No systematic difference for fluxes.

RA (J2000)	Dec	l	b	Flux Int.	v_{hel}	W_{50}	Ident?
				Jy km/s	km/s	km/s	
18h 44m 38.4s	5° 54' 18"	37.42°	-4.20°	1.15	8656	63	None
18 55 13.3	7 37 06	40.15	-2.83	5.39	8156	284	HIZOA J1905+07
19 01 34.6	6 51 44	40.19	-0.88	11.36	2950	81	HIZOA J1901+06
19 06 33.8	7 35 03	41.40	0.11	6.26	3081	196	HIZOA J1906+07
19 08 28.9	5 59 29	40.29	-1.03	3.48	4664	178	HIZOA J1908+05
19 17 23.7	7 50 21	42.87	-2.17	6.18	3029	217	HIZOA J1917+07
19 20 03.3	6 11 10	41.71	-3.50	1.14	6215	109	None
19 20 43.2	6 11 42	41.80	-3.64	6.72	6341	425	IRAS 19182+0604
19 22 02.2	8 19 21	43.82	-2.94	6.10	3094	137	HIZOA J1921+08

Profile of an ALFA ZOA detected galaxy, also known from the Parkes HIZOA survey

A newly-discovered galaxy from ALFA ZOA precursor observations.



A 100 square degree field near $l=190^\circ$ has been observed, reductions are ongoing.

Conclusion

The ALFA ZOA team intends to map the full ZOA in the Arecibo sky, starting with the inner Galaxy, $l = 30^\circ - 75^\circ$, to $b = \pm 10^\circ$ commensally with GALFA. Extrapolating from the detection rate of the $l \sim 40^\circ$ region and the HIZOA, this should yield ~500 galaxies in the inner Galaxy region alone. We also plan to map the outer Galaxy $l = 170^\circ - 215^\circ$ area as well.

When new spectrometer development allows, we will also map the ZOA over all longitudes within $\pm 5^\circ$ of the plane commensally with a deep PALFA pulsar project, with effective integration time ~30 times longer per pointing.

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