THE 2MASS REDSHIFT SURVEY

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I. Introduction

With the current convergence of determinations of the Hubble Constant to a value of around 65 km/s/Mpc and an uncertainty near 10% and the clear possibility of determining the geometry of the Universe using supernovae (e.g., Garnavich et al. 1998, astro-ph/9806396; Perlmutter et al. 1998, astro-ph/9812473), the major remaining problem in observational cosmology is the accurate determination of Ω_M — what is the dark matter, how much is there, and how is it distributed?

The most direct approach to the last two parts of the question has been to study galaxy dynamics, first through the motions of galaxies in binaries, groups and clusters, and, in the last decade and a half, driven by the observation of our motion w.r.t. the Cosmic Microwave Background (CMB) and the notion that DM must be clumped on larger scales than galaxies, through the study of large scale galaxy flows.

The ratio of the mass density to the closure mass density, Ω, is now thought by almost everyone to be $\sim$0.2–0.3, primarily based on the results of dynamical measurements of galaxy clusters and, more recently, gravitational lensing studies of clusters (c.f. Bahcall et al. 1999, Science 284, 1481). However this last result is still controversial — matching the velocity field to the density field derived from IRAS (60μ) selected galaxy samples yields high $\beta = \Omega^{0.6}/b$ values (e.g. Dekel et al.. 1993, ApJ 412, 1; Schmoldt et al. 1999, astro-ph/9906035) but matching to optically selected samples yields low values (Santiago et al. 1995, ApJ 446, 457). At some level, part of the problem can be attributed to different biasing factors for IRAS and optically selected galaxies (Baker et al. 1998, ApJ 508, 6), however a jaundiced examination of the galaxy samples available for density field studies indicates that considerable improvement is needed. IRAS samples, even the PSCz, provide poor sampling on scales of less than 1000 km/s and are biased against dense regions. Optically selected samples have severe problems in regions of high galactic extinction, and, to date have been generally based on relatively poor and probably non-uniform photographic magnitudes.

II. 2MASS

To address the problem of an improved galaxy density field, as well as problems in galactic structure, the low-mass end of the stellar mass function, and star formation, a Two Micron All Sky Survey (2MASS) was proposed in the early 1990's The survey goal for galaxies was to produce a complete and reliable galaxy catalog to $K_s = 13.5$ at galactic latitiudes above about 10°. Surveying in the near-IR with modern detectors not only provides samples with significantly improved photometry over photographic surveys, but also minimizes the effects of galactic extinction.

2MASS is now in full production, utilizing two matched telescopes with 3 channel cameras operating at the J, H and K_s bands. Well over half the sky has been scanned, since the start of operations in 1997, more than half of that data has been photometrically processed and more than 1,400,000 galaxies are in the database. Current assesment of the extended source photometry shows that we are acheiving a mean photometric accuracy of ≤ 0.1 magnitude at K_s=13.8. We expect, when the survey is completed in late 2000, to have a catalog of over 3 million galaxies. The primary subset sample to $K_s = 13.5$ will have approximately 1 million galaxies, and will represent an improvement of a factor of almost 100 over the next largest extant all-sky survey, the PSCz.

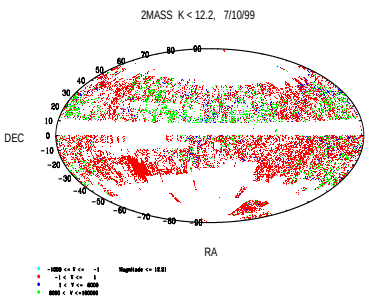

Figure 1. All sky plot of the distribution of 2MASS extended sources/galaxies brighter than $K_s = 12.2$. Objects w/o redshifts are shown in red. There are 76,016 objects in this plot, 14,668 with redshifts.

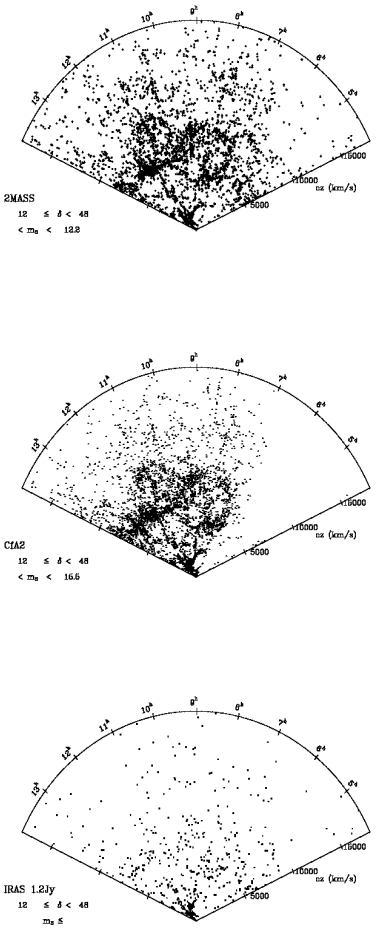

Figure 2. Wedge diagrams for three the same volume of space as covered by three surveys. Top: Current 2mass sample, only partially complete. Middle: CfA2 survey, complete to a blue magnitude of $\sim$ 15.5. Bottom: IRAS 1.2Jy survey.

III. The 2MASS Redshift Survey

To measure the density field we have also begun to measure redshifts for a bright subsample of 2MASS. The first stage of the 2MASS Redshift Survey (2MRS) is measurement of redshifts for the galaxies in the extended source catalog brighter than $K_s = 12.2$. On completion of the photometric survey, this catalog should contain approximately 150,000 galaxies. This substantial increase in numbers both improves the depth of the sample, providing both reasonable sampling to z=0.05 and also increasing the "resolution" of the density field as compared to the IRAS surveys and even the ORS. Redshifts for 2MASS galaxies are being obtained at Mt. Hopkins, at Arecibo and continually collected from the literature. When the 6DF survey gets underway in Australia, 2MASS will be the major source of accurate magnitudes and positions.

The current status of the catalog and redshift survey can be seen in the accompanying plots. Extended sources are identified in the survey using algorithms developed by T. Jarrett and T. Chester (see the 2MASS IPAC homepage http://www.ipac.caltech.edu/2mass) The current 12.2 magnitude catalog contains some 76,000 sources and is shown in Figure 1. Note that we have not yet examined in detail all of the southern sources so there are likley to be a large number of non-galaxies in the highly confused galactic center region.

Figure 2 is the comparison of a preliminary redshift wedge diagram for the region $4^h < \alpha < 14^h$, $12° < \delta < 48°$ and $v < 18{,}000$ km/s from 2MASS with the CfA2 survey (m_{Zw} <15.5) and the IRAS 1.2-Jy survey, both of which are complete, in the same volume. Even the first stage of the 2MRS, K=12.2, represents significant improvements in sampling in general and especially at low galactic latitude. The 2MASS survey, which is only about half complete, has $\sim$8200 galaxies in the plotted volume as compared to $\sim$5000 in CfA2 and only 787 in the 1.2Jy sample. 2MRS should be a little under twice as deep as CfA and will cover the *whole sky*.

IV. Summary

2MRS is well underway. We have already found a significant number of new galaxies in obscured regions (e.g. Jarrett et al. 1999, Nature, submitted) and easily extending the existing, large area galaxy samples. And, in addition to providing the best map of the local density field ever, we are also extracting other interesting results on galaxy properties. An example is Figure 3, which shows the blue to IR color as a function of absolute K magnitude measured for those galaxies in our sample with both redshifts and Zwicky magnitudes. When better optical photometry becomes available from surveys like SDSS, the 2MRS will also be a goldmine of information on stellar populations in galaxies.

Phases 2 and 3 of 2MRS will include measurement of independent distances to a large sample of edge on spirals in 2MASS via IRTF to study the galaxy flow field, and measurment of redshifts, hopefully with multifiber systems on larger telescopes, for the 1,000,000 galaxy, K=13.5 sample.

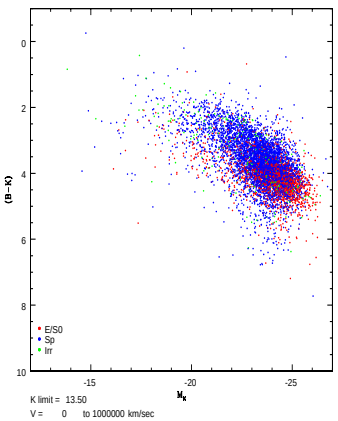

Figure 3. Color (B-K) versus Absolute Magnitude for those galaxies in our sample with both redshifts and estimated blue magnitudes from the Zwicky catalog. The B-K color is a hybrid, since m_{Zw} represents an 'isophotal' blue magnitude measured at an optical isophote of about B = 24 mag/sq-arsec and our K is measured in an elliptical isophote at 20.0 mag/sq-arsec. Since the average B-K of galaxies is about 4, though, the B-K color here is very close to isophotal.

For more information:

IPAC — http://www.ipac.caltech.edu/2mass/
UMass — http://pegasus.phast.umass.edu/
CfA — http://cfa-www.harvard.edu/~huchra/2mass