Dwarf Galaxies in the Local Universe
The Local Luminosity and H I Mass Function *

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Abstract

We present the optical luminosity function and the HI mass function of the Local Volume (i.e. all galaxies within 10 Mpc) using the data base which was presented in our poster paper (Huchtmeier et al., this conference). We have twice as many galaxies as in the KKT sample but the integrated luminosity is up only 19% and the H I mass by 25% for the Local Volume.

The great increase in numbers of known galaxies in the last twenty years from 179 galaxies with corrected radial velocities $V_{\rm LG} \leq 500$ km s^{-1} with respect to the Local Group centroid in 1979 Kraan-Korteweg & Tammann (1979, KKT) to the present value of 385 galaxies within 10 Mpc is mainly due to searches for small low surface brightness (LSB) galaxies on the Second Palomar Observatory Sky Survey (POSS-II) (e.g. Binggeli et al. 1990, Schombert et al. 1992, Impey et al. 1996, Karachentseva et al. 1998, 1999, 2000, Karachentsev et al. 2000, 2001) and H I line surveys of the Milky Way (Henning et al. 1998), as well as a 'blind' H I survey of the southern sky with the Parkes radio telescope (the H I-Parkes Sky Survey = HIPASS, Kilborn et al. 1999, Banks et al. 1999).

The Karachentsev catalogs contain about 600 galaxies with angular diameters a $\geq 0.5'$ and blue magnitudes brighter than 19. Most of these galaxies have been searched for H I using the 100-m radio telescope at Effelsberg, the Nançay radio telescope, the compact array of the Australia telescope (ATCA) (Huchtmeier et al. 1997, 2000; Karachentsev et al. 2001), and the HIPASS data cube. About 60 galaxies from the Karachentsev catalogs are located within 10 Mpc and are added to the local sample of galaxies. Individual distances are available for about two thirds of these galaxies, the distances of one third of the galaxies have been derived from radial velocities assuming a Hubble contant of 75 km s^{-1} Mpc^{-1}.

The increase in number (e.g. Fig. 3) by a factor of two is mostly due to many dwarf galaxies especially in the absolute magnitude range -15 to -9, see Fig. 1 where we present the integrated luminosity of galaxies per magnitude intervall for the KKT sample and our present sample. This increase in numbers corresponds to an increase in integrated luminosity by 19% (to a total of 7.4 10^{11} L$_\odot$ and an increase of 25% for the integrated H I (to a total of 1.9 10^{11} M$_\odot$) in the Local Volume (LV) which yields a nominal value of $M_{\rm HI}/L_B = 0.26$ (0.21 for the KKT sample) for the relative H I content of the Local Volume.

By definition the LV (radius of 10 Mpc) is a volume-limited sample. Even within this nearby sample we are magnitude limited due to sensitivity problems for the faintest objects as can be seen from Fig. 2 where we plot the number of galaxies per apparent blue magnitude intervall. There

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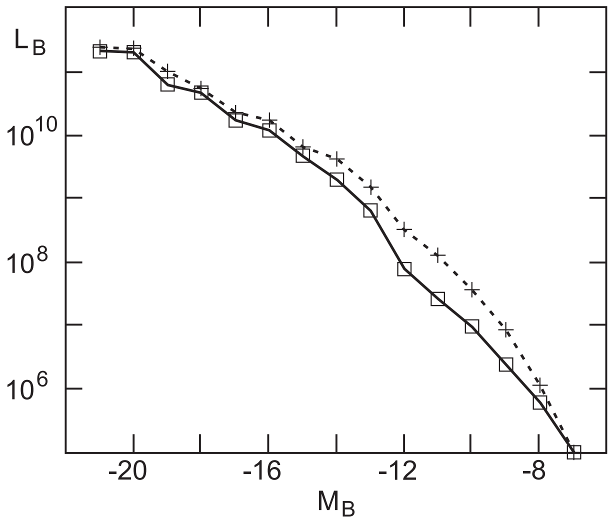

Figure 1: The integrated blue luminosity of galaxies is plotted per magnitude intervall for the KKT sample (open squares) and for our present sample (crosses).

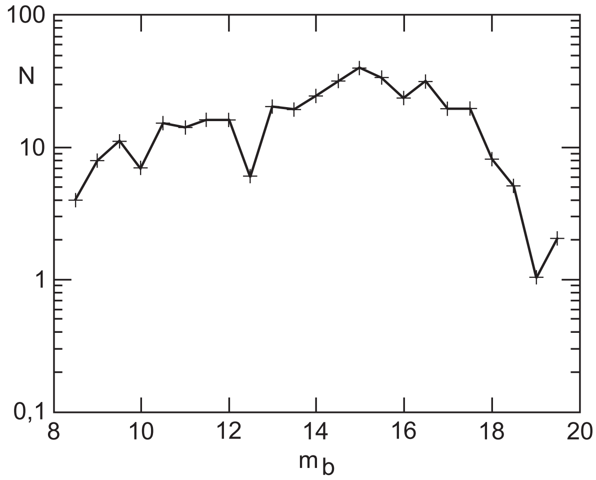

Figure 2: Numbers of galaxies are plotted per apparent blue magnitude intervall for our present sample.

is a steady rise in numbers until about 16 mag beyond which we observe a sudden decrease in galaxy numbers which is a sign of incompleteness. On the other hand a plot of galaxy numbers per apparent magnitude should show a turnover at a faint magnitude because there is a magnitude limit for galaxies (the absolute magnitude of the faintest galaxy in our sample is -7).

In order to estimate the degree of incompleteness we assume the Local Group to be complete and the shape of the luminosity function of the Local Group to be representative for the Local Volume. We are aware that both assumptions are not completely valid. There are differences in the populations of nearby groups. Most probably we are missing even galaxies in the Local Group (e.g. the extinction in the zone of avoidance which covers nearly 25% of the sky) and of course for more distant parts of the Local Volume due to reduced sensitivity and the dust in the Milky Way. To improve statistics we took the average of three nearby groups, the Local Group, the Maffei group, and the M81 group (Fig. 3), only the faint end (fainter than $M_B = -11$) is defined by the Local Group alone. Comparing this 'averaged' local luminosity function with that of the whole sample (Fig. 3) we see a similar shape of the LF for both curves for the bright galaxies ($M_B \leq -14$). Assuming the shape of the LF of the Local Volume to be the same as for the nearby groups we derive the 'corrected' LF (open squares). This 'corrected LF corresponds to a total number of 660 galaxies in the Local Volume; which would mean that we are about 60% complete.

For the luminosity function of the LV we assumed to be complete for galaxies brighter than $M_B = -14$. Galaxy counts for fainter objects correspond to smaller volumes, galaxies fainter than $M_B = -11$ refer to the Local Group only. The luminosity function of the Local Volume (open symbols in Fig. 4) is compared with the LF of the ESO slice project galaxy redshift survey (Zucca et al. 1997) which contains over 3300 galaxies. The Zucca et al. LF (filled circles) is a deep sample in a limited region of the sky and is given in numbers per 0.4 mag interval, our curve is given in number of galaxies per magnitude interval. Among other topics they discuss density fluctuations of a factor 2 to 3 in both directions, the local universe being underdense by a factor of 0.28 compared with the average given in this figure. So in the end our results are similar for the galaxy density. The shape of both curves is quite similar, rising toward the faint end.

The increase of known galaxies of the Local Volume by a factor of two in numbers corresponds

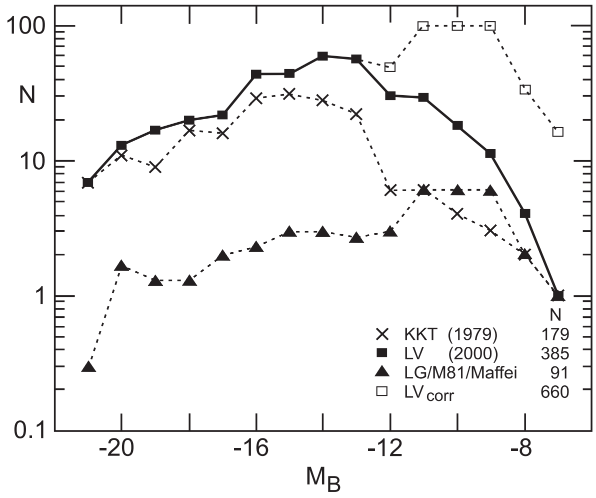

Figure 3: Galaxy numbers per absolute magnitude intervall for the whole sample (filled square), the KKT sample (crosses), and the nearby groups sample (filled triangles). The 'corrected' LV sample (open squares) suggests how the complete sample might look.

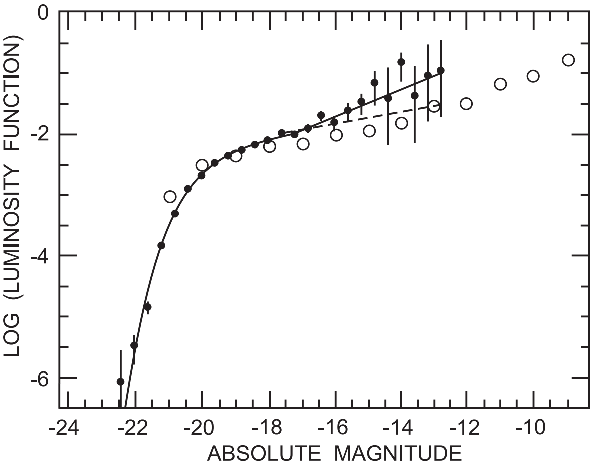

Figure 4: The luminosity function of the Local Volume (open symbols) is compared with the LF of the ESO Slice Project galaxy redshift survey (Zucca et al. 1997). The Zucca et al. LF (filled circles) is given in numbers per 0.4 mag interval, our data are in number of galaxies per magnitude interval.

to an increase of 25% in mass of neutral atomic hydrogen for this sample. This is due to a large number of small galaxies as can be seen in Fig. 1.

In Fig. 5 we show the H I mass function, i.e. the number of galaxies per H I mass intervall, for the Local Volume (274 galaxies with H I data) compared with a number of different studies using different samples. Except the Briggs & Rao sample, the Henning sample, and the Kilborn sample (HIPASS) all other comparison samples are based on the Arecibo strip survey which contains a total of 66 galaxies. We assume a sensitivity for our sample of 10^6 $M_\odot$ in H I for a distance of 3 Mpc and a sensitivity of 10^7 $M_\odot$ in H I for a distance of 10 Mpc in H I. Following Henning (2000) we assume to be complete for galaxies with H I masses greater than 10^8 $M_\odot$ in H I. The H I densities for smaller H I masses are derived from smaller volumes following the quoted sensitivities. Our resulting H I mass function is essentially similar in shape to the other samples and corresponds to similar H I densities. The histogram in Fig. 5 demonstrates on how many galaxies per H I mass intervall our investigation is based compared to the Arecibe strip survey sample (broken line). Our present curve extends to smaller H I masses than other studies. Most comparison samples in Fig. 5 are the result of 'blind' surveys, whereas our sample essentially is a pointed H I survey for optically selected galaxies. However, nearly all H I features detected in 'blind' surveys have been correlated with optical galaxies (Henning 2000). Again, the zone of avoidance is our main concern as a faint extragalactic H I signal is completely confused by the strong local H I emission. This is the case for part of the Local Group, the Sculptor group, the Maffei group, the M81 group, and the NGC 6946 group. Consequently our galaxy numbers in Fig. 5 are rather lower limits especially for the faint end of the H I mass distribution. The full line fitted to the Arecibo strip data in Fig. 5 is a Schechter function with α=1.2. Even the α=1.7 slope seems to be compatible with our data in the range 5 x 10^6 to 10^8 $M_\odot$ of H I. Such a steep slope would mean equal masses for different H I mass bins and hence an important contribution to the total mass of the sample from those tiny galaxies due to their large numbers. Obviously this discussion is not yet finished.

The space density of H I mass contained in objects of different masses is given in Fig. 6. Again, our data extend to galaxies nearly two orders of magnitude lower in H I mass than the Arecibo strip

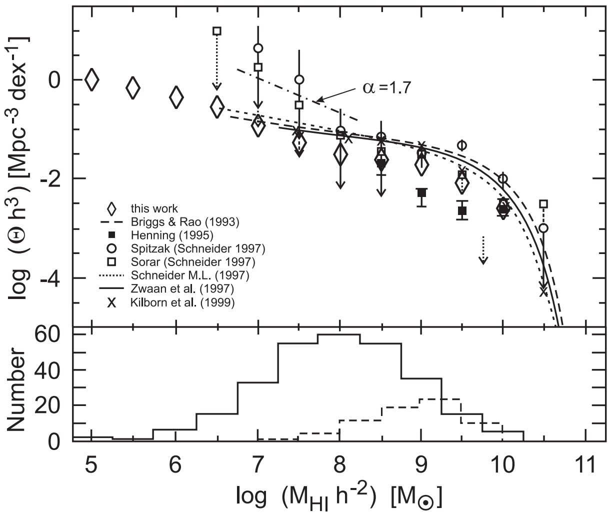

Figure 5: The H I mass function, i.e. the number of galaxies per H I mass intervall, is given for different samples. The lines are Schechter functions fitted to the Arecibo strip survey.
The histogram gives the number of galaxies per H I mass intervall for the Arecibo strip sample (broken line) and the present sample (full line).

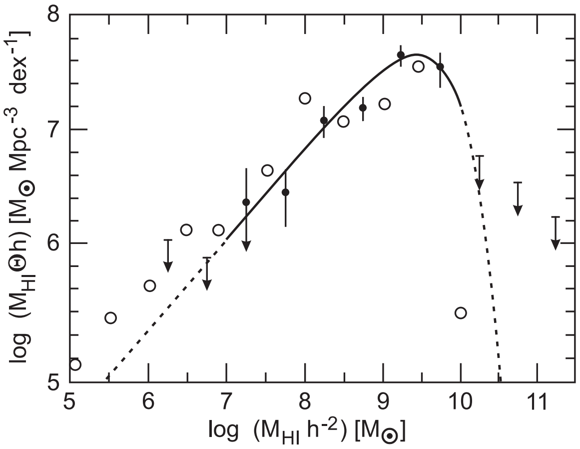

Figure 6: Space density of H I mass contained in objects of different masses per decade. The full line shows the converted analytical H I mass function plotted in Fig.5 for the Arecibo strip survey.

sample. With the curve fitted to the Arecibo data there is relatively good agreement between our data. However, our sample contains less bright galaxies but many more faint galaxies compared to the Arecibo sample. Do these samples contain different galaxy populations or do we have to change H_0 in order to adjust the data of both samples? Most of the H I in the Local Volume is contributed by galaxies in the H I mass range 10^8 to 5 x 10^9 $M_\odot$.

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