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HI in Karachentsev Objects Properties of new nearby Dwarf Galaxies

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Abstract. This is a report on HI observations of newly discovered nearby dwarf galaxies, most of which of low surface brightness, from the first section of the Karachentsev catalog. Observations were performed using the 100-m radiotelescope at Effelsberg, the Nançay radiotelescope, and the compact array of the Australia Telescope. We observed 220 galaxies with a detection rate of about 60%. 35 of the observed galaxies are located within the Local Volume (i.e., within 10 Mpc). The smallest detected galaxies have diameters around 0.3 kpc and HI-masses of a few times 10^6 solar masses. We confirm a correlation between HI column density and surface brightness of gas-rich disk galaxies.

1. Introduction

The study of the faintest and smallest galaxies is limited to our local cosmic neighborhood, i.e., the Local Group. In order to get a reasonable sample of galaxies representing (nearly) all morphological types the volume searched needs to have a certain size. A value of the order of 10 Mpc has been choosen for catalogs of the Local Volume (Kraan-Korteweg and Tammann 1979 (KKT), Schmidt and Boller 1992, Karachentsev 1994).

As this sample covers the whole sky it will be incomplete by two reason, the Zone of Avoidance with its strong foreground extinction and by sensitivity. However, our knowledge of the Local Volume is increasing steadily from a membership of 179 objects in 1979 (KKT) to 303[1] in 1998 (Karachentsev 1998, priv. comm.). The latest improvement became possible with the availability of the Second Palomar Sky Survey (POSS-II) which is more sensitive compared to its predecessor. Karachentseva and Karachentsev started to search the POSS-II and the ESO/SERC films for weak galaxies to a limiting diameter of 0.5′ instead of 1′, as was used before for many galaxy catalogs based on the POSS-I. In a first step, Karachentseva and Karachentsev (1998) searched for candidates of nearby dwarf galaxies in the neighborhood (i.e., within 50 times the optical diameter D_{25}) of known galaxies and in known groups of galaxies within the Local Volume. This survey covers roughly 25% of the total sky. They found

[1]not counting the detection of two spheroidal companions of M31 reported in this conference; AndV (Armandroff) and Peg B (Karachentsev)

245 objects from which 139 were not cataloged so far. A great majority of the galaxies in the Karachentsev catalog is of low surface brightness.

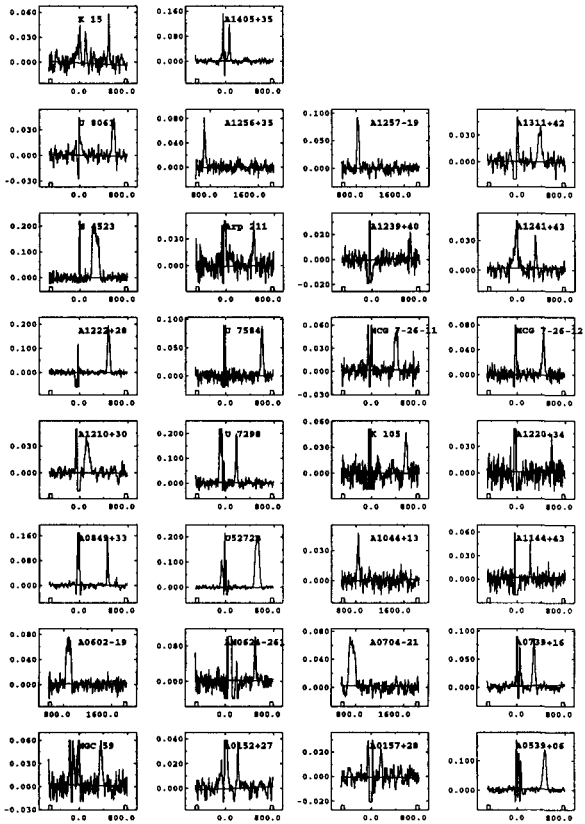

Figure 1. HI profiles of galaxies in the Local Volume as observed with the 100-m radio telescope at Effelsberg. The observed flux in Jansky [Jy] is plotted versus heliocentric radial velocity in [km s^{-1}].

In order to check the 'dwarf' nature of these objects we want to observe their radial velocities for a rough distance estimate. Gas rich dwarf galaxies seem to be relatively easy objects to detect in the 21-cm line of neutral hydrogen. Therefore we decided to search the list from Karachentseva and Karachentsev (1998) for HI emission. The result of this search is presented in this paper.

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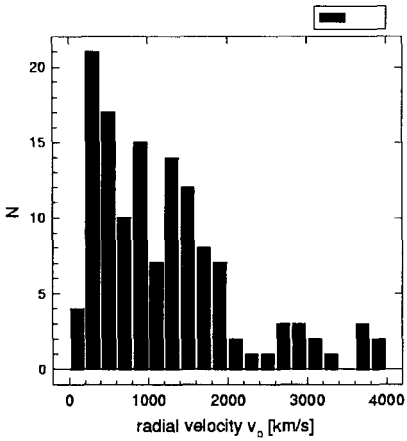

Figure 2. The distribution of corrected radial velocities (v_o) of our galaxy sample demonstrates that most galaxies are relatively nearby. This histogram shows the number of galaxies per velocity interval of 200 km s^{-1}.

2. Observations

HI observations have been performed for 220 galaxies using three different radio telescopes for three different declination ranges. 165 galaxies north of declination $-30°$ have been observed using the 100-m radio telescope at Effelsberg which has a half power beam width (HPBW) of 9.3'; 15 galaxies in the declination range between $-30°$ and $-38°$ have been observed with the Nançay radio telescope which has a HPBW of 3.6' x 22' (in R.A. and Dec., respectively). In both cases the velocity coverage was $\sim$ 4400 km s^{-1} with a channel separation of 5 km s^{-1}, i.e., a velocity resolution of 6 km s^{-1} (10 km s^{-1} after Hanning smoothing) using a 1024 channel autocorrelation receiver split into four banks of 256 channels each and a bandwidth of 6.25 MHz.

40 galaxies south of declination $-38°$ have been observed with the Compact Array of the Australia telescope (ATFN) in Culgoora (NSW). For the 'snapshot' observations (in the 750A configuration) we spent a total of 5 to 6 times 10 min per galaxy. The resulting synthesized beam was of the order of 1'. The velocity coverage was of the order of 3000 km s^{-1} yielding a channel separation of 6.6 km s^{-1} amd a velocity resolution of 7.9 km s^{-1}. The overall detection rate was slightly above 60%. This is a good value in view of possible background objects which are not included within the bandwidths used in these observations. In addition we might have 'lost' galaxies in the velocity range of local neutral hydrogen in case of the single-dish observations.

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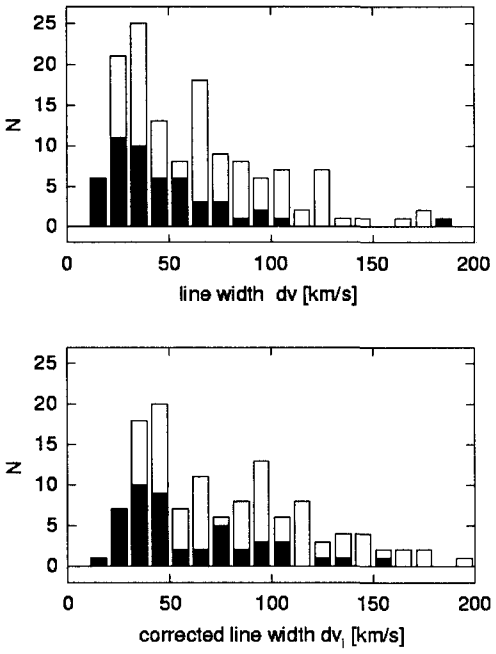

Figure 3. The distribution of line widths of our galaxies is given for the observed values (dv) in the upper panel and for the (for inclination) corrected values in the lower panel (dv_i). Galaxies within the Local Volume are shown by shaded areas.

In a number of cases HI features with negative radial velocities have been observed. All these features were found to be in regions where the Dwingeloo Galactic HI Survey (Hartman and Burton 1997) shows evidence for local HI emission in the corresponding velocity range. Therefore these features were considered to be high velocity clouds and not emission from the searched galaxies.

As an example for the HI profiles observed we selected for Fig. 1 the HI profiles (100-m telescope) of the galaxies within the Local Volume (i.e., within a distance of 10 Mpc). The single-dish observations were performed in the total power mode combining the ON-source observation with a reference field earlier in R.A. by 5 min. Hence, for the local HI emission only a residual from the ON - OFF procedure is left around a velocity of $0\,\mathrm{km\,s^{-1}}$. There have been only few cases of confusion as the galaxies in this sample tend to be isolated.

Most of the HI profiles are narrow (small rotational velocities). The ATNF observations show HI emission centered on the optical positions and an extent of the HI distributions of two to three times the optical diameter of the galaxies.

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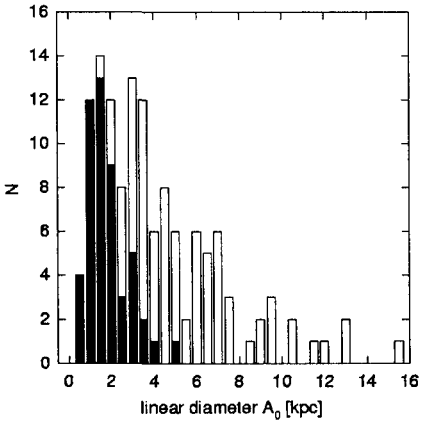

Figure 4. The distribution of the linear diameters of the whole sample is given in this figure. Galaxies within the distance limit of the Local Volume (i.e., within 10 Mpc) are shown by the shaded areas.

3. Discussion

For the discussion we will also include recent observations of nearby dwarf galaxies like the pilot observations for this project (Huchtmeier et al. 1997) and observations of new nearby galaxies (Kraan-Korteweg et al. 1994, Huchtmeier et al. 1995, Burton et al. 1996, Huchtmeier and van Driel 1997).

In Fig. 2 we show the radial velocity (v_o, corrected for the rotation of our galaxy) distribution of our galaxy sample; approximately 25 % are located within the Local Volume and most of the galaxies are within the Local Supercluster. Apart from a few large background galaxies (mostly LSB objects) most of the galaxies are rather small as can be seen from their small line widths (i.e., small rotational velocities) (Fig. 3) and their small linear dimensions (Fig. 4).

Two more global parameters are shown in Fig. 6. Here we show the range The line width distribution in Fig. 3 shows the observed line widths in the upper panel whereas the (for inclination) corrected line widths are given in the lower panel. The optical axial ratio has been used as a measure for the inclination. Galaxies within the Local Volume are indicated by shaded areas.

The distribution of the linear diameters (Fig. 4) of our galaxy sample extends from 0.2 kpc to 26 kpc, the galaxies within the limits of the Local Volume (closer than 10 Mpc) are given as shaded areas. It is evident that all new nearby galaxies are relatively small with 1 to 2 kpc on the average for the optical diameter (D_{25}).

How do the galaxies of our present sample compare to the galaxies of the Local Volume known before? In Fig. 5 we compare global parameters of these two samples. The total mass of neutral hydrogen (M_{HI}) is plotted versus the

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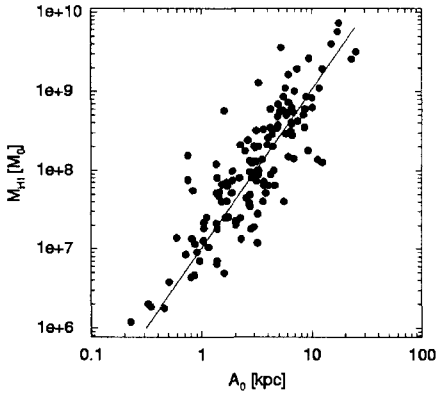

Figure 5. The total mass of neutral hydrogen of the galaxies in our present sample is plotted versus the linear extent (in kpc). The full line represents the regression line for the KKT sample (Huchtmeier and Richter 1988).

linear extent (A_0) for the present sample of galaxies. The full line represents the regression line for the galaxies of the Kraan-Korteweg-Tammann sample (Huchtmeier and Richter 1988). This regression line seems to be an excellent fit for the present sample, too.

Two more global parameters are shown in Fig. 6. Here we show the range of the pseudo HI surface density Σ_{HI} which is obtained by dividing the total HI mass (M_{HI}) by the disk area of the galaxy as defined by its optical diameter (D_{25}). This quantity is given in units of solar mass per square parsec and in the usual HI column density (N_{HI}) in $atoms\,cm^{-2}$ (on the right hand side of the figure).

This quantity is plotted versus the relative HI content in mass (M_{HI}/M_T). This diagram demonstrates that this sample fills the usual range of the defined quantities as observed for normal galaxies. To summarize this plot we can say that the present sample of galaxies is relatively rich in HI on average. Some of the scatter in this diagram is due to uncertainties in the observed quantities, especially the inclination which is used to correct the line width. This widths enters the total mass calculation by the square. The optical diameters get uncertain for galaxies at low galactic latitudes due to the high extinction, e.g., Cas 2, ESO 137-G27, BK 12, ESO 558-11.

Last but not least I show the correlation between HI surface density and optical surface brightness. The Karachentsev catalog contains a surface brightness (SB) class in four steps from high surface brightness to low, very low, and extremely low SB which are coded here in this sequence from 4 to 1 in steps of 1. The different values of the errors of the mean of each class depends essentially on the different population size of each SB class. There are relatively few objects

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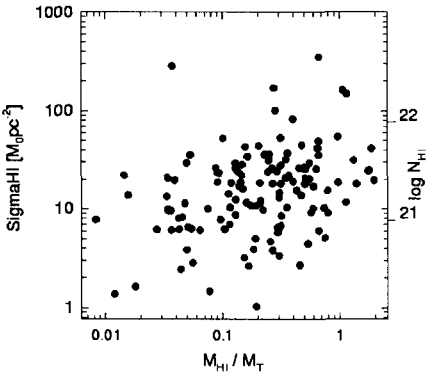

Figure 6. The pseudo column density of neutral hydrogen (Σ_{HI} in $M_\odot\, pc^{-2}$) of our present sample is plotted versus the relative HI content (M_{HI}/M_T).

in classes 1 and 4. However, the difference in HI column density over the range in SB is a factor of 2 to 3. This value has been quoted in this conference before (e.g. de Blok 1998).

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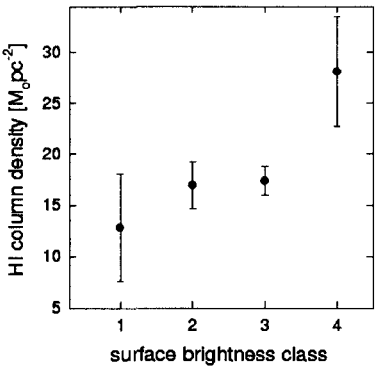

Figure 7. In this figure we show a correlataion between the pseudo HI column density with the optical surface brightness of the galaxies of our actual sample. The surface brightness class is taken from the Karachentsev catalog; 1 = extremely low SB, 2 = very low SB, 3 = low SB, 4 = high SB. The error bars correspond to twice the rms error of the mean of each SB class.

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