HI SURVEY OF DENIS/LEDA SPIRAL GALAXIES

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Abstract

DENIS is the first survey made directly from CCD photometry and provides us with I, J, K band photometry for the whole southern sky. A programme of semi-automatic galaxy recognition has been started at the Observatoire de Lyon using I-band strips. Images are regularly analyzed and galaxies are cross-identified with the help of the LEDA extragalactic database. The result is a set of I-band parameters for each DENIS galaxy (I, logD, logR, ...). However, spectroscopic measurements are an essential complement to these photometric data. We proposed an HI follow-up of DENIS as a key project for the Nançay radiotelescope, whose next renovation will largely increase its sensitivity (FORT project). We would like to report preliminary results obtained during the test phase of the project.

1 Introduction

The DENIS catalogue has clearly numerous advantages for a Tully-Fisher analysis, especially in the zone of avoidance. Its homogeneity, its large sky coverage, the simultaneous good three bands photometry in I, J and K, and the good resolution (1 arcsec per pixel), allow both morphological decription and a study of matter distribution up to z=0.06. Fig. 1 shows the distribution of apparent I magnitude; the completeness in I-band reaches 14.5 mag. The study of the distance scale and peculiar motions still requires complementary spectroscopic data. We are presently performing a preliminary limited HI observational programme ($\simeq$80 hours) with the Nançay Radiotelescope, to decide for an optimal follow up of newly discovered DENIS spiral galaxies. We will report here on these preliminary attemps.

We recall that DENIS I-images consist of a series of strips divided into 12'x12' fields (768x768 CCD-pixels) on which stars and galaxies have to be recognized and reliably separated. Objects are detected automatically above the constant sky background on the basis of shape recognition

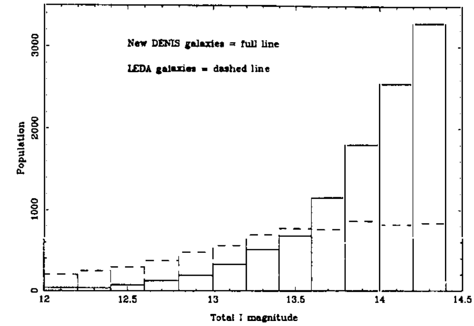

Figure 1: I-band completeness of DENIS galaxies. Comparison with present LEDA deepness

programs and stored in matrixes. The selection criteria are the following: diffraction cross in stellar objects, multiple objects (two non-connex maxima), ellongated objects (generally galaxies), objects cut up by the edge of the field, ratio of maximal intensity and the surface of the object on the sky (there is typically a factor 1000 between stars and galaxies), brightness gradient from the boundary to the center of the object. The selection is particularly robust, because applied after a 2σ threshold of the analyzed images. Each extracted matrix which has been recognized as a galaxy is then checked by eye.

Each field is cross-identified with the Guide Star Catalogue to improve the astrometry and adjust at best the positions. Objects recognized as galaxies are then cross-identified with galaxies catalogued in LEDA extragalactic database (see Vauglin et al. 1997).

The field displayed in Fig.2 contains 4 galaxies, 3 being already known in LEDA, 1 being a new galaxy. Their corresponding matrix-images are presented in Fig. 3; the images being rebined for reason of file compression, each point is the average intensity over 4 pixels (2x2).

2 Extraction of astrophysical parameters:

For each galaxy, the following parameters are extracted: center, barycenter, maximum intensity, major and minor axis, position angle, magnitude. This is done for three different isophotes corresponding to three intensity levels 65, 130, and 260 ADU on the CCD plate. The first level represent the boundary of the object on the sky: for a threshold at 2σ, it corresponds to a surface brightness of 23.2 mag $(\text{arsec})^{-2}$; the DENIS detection level at 1σ is equal to 23.58 mag $(\text{arsec})^{-2}$. The two other isophotes are used to characterize the light profile and to define an equivalent of the morphological type. An example is given in Fig.4 for one of the above objects.

The magnitude within each isophote (i=1, 2, 4) is defined as follows:

$$I(i) = -2.5log\Sigma_{pixel}(intensity) + 24. + Corr. \tag{1}$$

where the correction term ($\simeq$0.32) is used to adjust the magnitudes to the Mathewson system. An atmospheric correction 0.045 is applied so that $I_{corr.} = I - 0.045 (\cos z)^{-1}$.

The total magnitude It, extrapolated and integrated on the total brightness profile, and the parameter atype connected with the morphological type are calculated as follows:

$$It = 2(I(1) - I(2)) \tag{2}$$

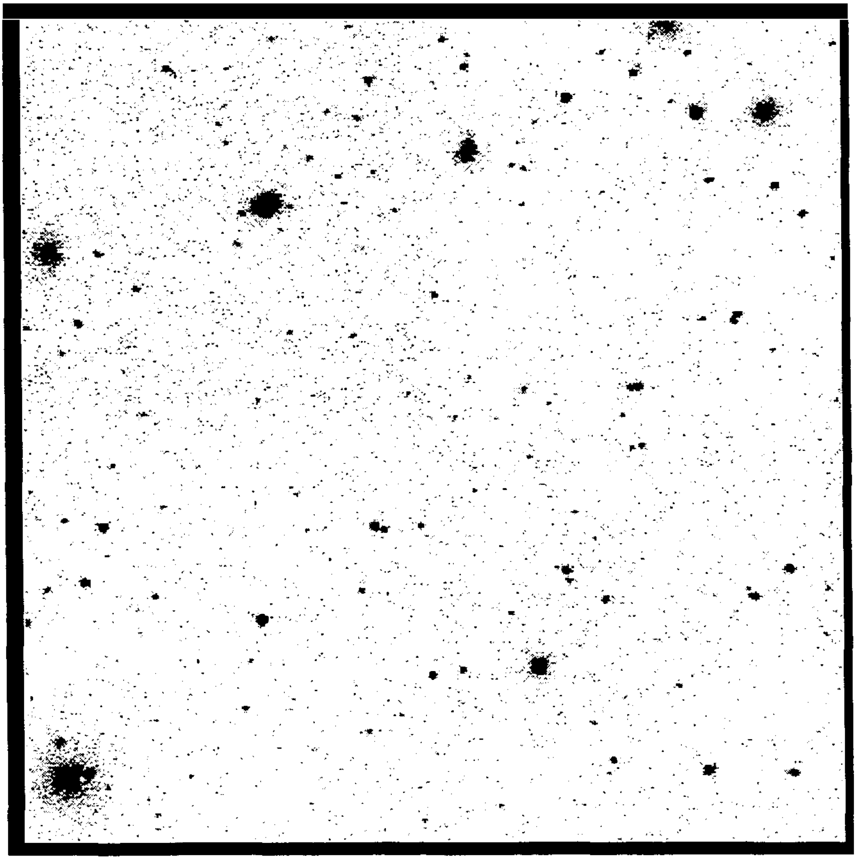

Figure 2: a DENIS 12'x12' field in I-band

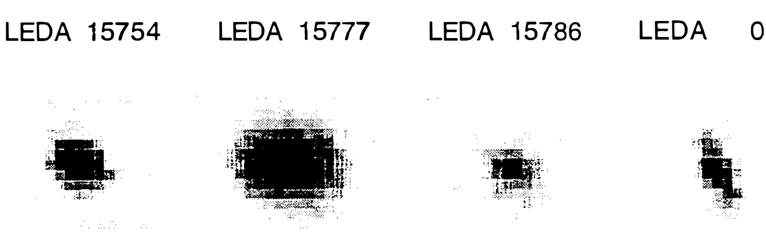

Figure 3: Matrixes of DENIS objects. The last one, LEDA0 is a newly discovered galaxy

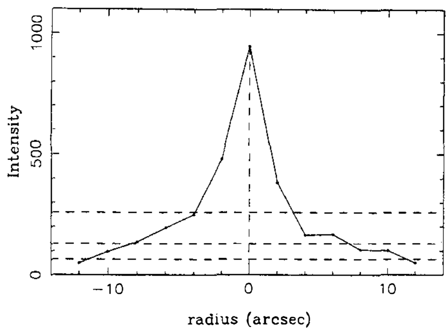

Figure 4: photometric profile of LEDA0

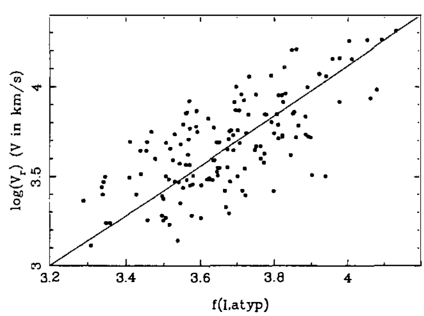

Figure 5: correlation between logarithm of radial velocity logV and f(It , log(atype))

$$atype = I(4) - I(1) \tag{3}$$

3 Preparation of an HI follow up:

To be efficient, the HI-detection of a galaxy mainly requires two informations: 1) its radial velocity with a reasonable uncertainty, given the available radiotelescope bandwidth. 2) its morphological type, to select exclusively spiral galaxies.

The radial velocity range is estimated using the correlation between morphological type and intrinsic luminosity (on the basis of the subsample common to DENIS and LEDA). From It magnitudes and atype parameter we defined the following velocity indicator:

$$logVest = f(It, log(atype)) = aIt + blog(atype) + c \tag{4}$$

the corresponding correlation is displayed in Fig. 5. The correlation coefficient is $r = 0.69$ and the dispersion $\sigma = 0.186$. A bandwidth of 25 MHz, typically the frequency band covered with the Nançay radiotelescope (present state) in velocity search mode at λ=21 cm, is enough to cover the corresponding velocity range up to $V_{est} = 6000$ km s^{-1}.

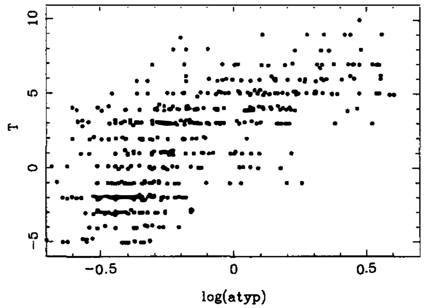

Figure 6: correlation between morphological type T and log(atype)

The selection in morphological type is done using the atype parameter defined above: its correlation with the classical morphological type is seen in Fig.6. For $log(atype) \geq 0.2$ we are confident to select exclusively a type greater than 2 (i.e. Sab and later). However, the probability of selecting a dwarf (Irregular galaxy) is not negligible With a less conservative cut-off at $log(atype) = 0.2$, we may keep some lenticular, while the large majority of selected objects will be classical spirals.

With a maximum of four hours of integration time per galaxy, we obtained about 25% of success with the most conservative selection, and almost 100% for $0 \leq log(atype) \geq 0.2$. We recall some of the results in terms of detection rate obtained by Theureau et al. (1997) with the same instrument, on the basis of a sample of 2700 galaxies: (1) the detection rate depends on type (15% better for Sm than for Sa spirals). (2) for velocities less than 10 000 km s^{-1}, it is close to 90% in normal mode, and close to 60% in velocity search mode. (3) it doesn't depend on distance (4) it doesn't depend on inclination (inclined objects have a large HI profile with a low signal to noise ratio). Note that newly discovered DENIS galaxy are generally faint and small, except in the zone of avoidance where the probability to discover a large object is higher. Fig. 7 shows examples of successful HI detections.

However, this run was done in looking toward the future: the renovated Radiotelescope. it will be available at the end of the year 1998 through the FORT project), which will significantly increase the sensitivity of the receiver and improve widely the detection. The system temperature will decrease from $\simeq$45 K to $\simeq$23 K, leading to an improvement of a factor 5.8 (at 21 cm) in terms of integration time. The possibility of observing simultaneously in horizontal and vertical polarizations on a very large frequency band will double this factor in velocity search mode: what was detected in 4 hours will be observed in 20 minutes!. The new autocorrelator will have more than 8000 chanels (1024 today), divided in 8 independent banks (4 today), each covering up to 100 MHz (instead of 6.4 MHz): it will be possible to cover a range of 32,000 km s^{-1} in one observation instead of only 4,800 km s^{-1}. This makes the future Nançay radiotelescope an ideal instrument for the DENIS HI follow up in the Northern hemisphere (d$\geq$ -38°).

4 Conclusions

- the complementary use of J and K bands should improve the type determination and then reduce the expected velocity range. These bands are a very good tool for the study of the

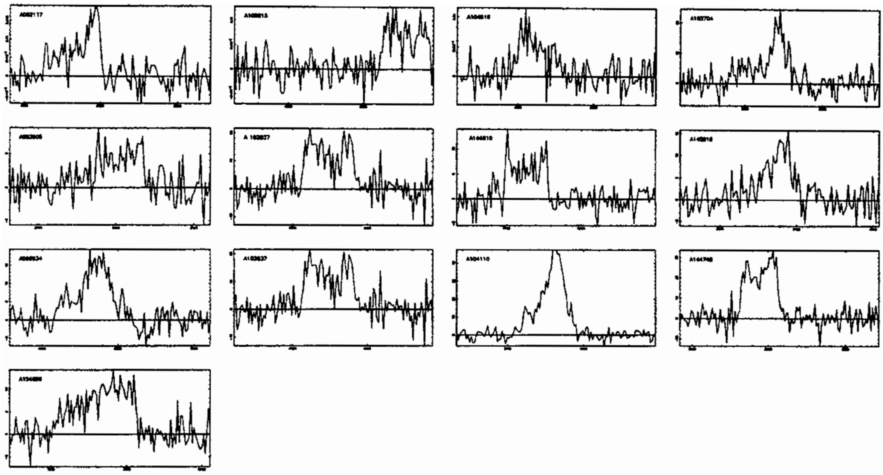

Figure 7: examples of HI detection

ZOA, where the probability of detecting a new object at relatively small radial velocity is considerably high.

- The new Nançay radiotelescope will be an efficient instrument for this kind of survey for d$\geq$ -38°. For d$\leq$ -38°, to complete the coverage of DENIS, a complementary programme with the Parkes radiotelescope should be the optimal choice.
- Before the first lights of the FORT project, the priority should be given to objects with known optical velocity. A complementary spectroscopic survey (FLAIR) can be an important preliminary step.
- From the end of 1998, the detection rate will be equivalent in normal and velocity search mode. As an example, one year of dedicated telescope time should provide us with HI measurements for more than 10,000 new objects.

References

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