NIBLES – an HI census of local SDSS galaxies

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PRA2009, Groningen, 02/06/09
Nançay Interstellar Baryons Legacy Extragalactic Survey

30+ NIBLErS:

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Present at PRA 2009:

Erwin de Blok, Sarah Blyth, Antoine Bouchard, Renée Kraan-Korteweg, Kurt van der Heyden: University of Cape Town
Laurent Chemin: Paris Observatory
Tom Oosterloo: ASTRON
Benjamin Winkel: Argelander Institute

Open collaboration!
Single-dish HI survey in the pre-SKA Precursors Era?

Strategic questions for the 100m-class Nançay Radio Telescope

In 2007:
Don’t we already have enough published HI data?
Why to observe galaxies in HI with a 100m-class telescope,
while a 300m telescope (Arecibo) is doing blind HI galaxy surveys?

In 2009:
Continue HI observations once the SKA Precursors are unleashed in 2013?
Blind and pointed HI surveys – complementarity

**Blind: complete survey of a limited space volume**
Short integration per source, need high sensitivity/large field-of-view
Universe is basically empty → detections only few % of the time,
• Important for checking if classes of galaxies are missed in optical surveys,
  e.g., gas-rich low surface brightness (LSB) galaxies,
  but time-inefficient (few % on-source)

**Pointed: survey of pre-selected objects**
Longer integrations, can use a 100m-class telescope (NRT) to be competitive,
but need to know positions and redshifts of galaxies
• An optical *blind* survey changes the game: Sloan Digital Sky Survey (SDSS)
  → time-efficient (50% on-source) for galaxy properties studies
Sloan Digital Sky Survey (SDSS) – present state

7000 square degrees; 200 million objects; 800,000 spectra (stars to quasars)

Imaging → 5-band photometry
Spectroscopy → redshifts, gas metallicities

40,000 SDSS galaxies
with V<12,000 km/s
**Towards a robust HI census of local galaxies**

**Goal**: determine the HI (and CO) properties of local galaxies over the full width of their absolute magnitude distribution (12 mag):
stellar mass-based selection: z-band absolute magnitude

Can’t we do this with the thousands of galaxies already detected in HI?

- 40,000 SDSS galaxies with V<12,000 km/s;
- 18,000 also have NIR:

  - only 8% detected in HI …
  - 50% of which are gas-rich spirals at $M_z$ –20.5 to –23.5
**Scientific justification - 1**

- Star formation is the most fundamental driver of the properties of the ensemble of galaxies in the local Universe.
- The distribution of HI and H₂ gas over galaxy type and mass tells us how efficient the star-formation has been.
- Star formation yields: compare galactic gas fractions and metallicity, to determine the effective yields of the largest sample of galaxies available

- Compared to the stellar mass content, the HI + H₂ gas adds a further 20%, but there is an uncertainty of at least a 40% in the global HI + H₂ budget

- Complete and robust analysis of the baryon density in the local Universe, determine the phase in which these baryons reside; Co-moving space density of HI, H₂, stellar, and dynamical mass

- Determine the HI and CO Mass Functions, their joint probability distribution, correlations with other galaxy characteristics, e.g., total stellar mass, dynamical mass, infrared luminosity, morphological type, stellar age, average stellar density
NIBLES observation strategy

Goal: 3000 galaxies, finish (well) before end of ALFALFA (late 2009)
Standard at NRT: 1 hour/galaxy, gives 2 mJy rms

1. Start with 30/40 minutes per galaxy: rms 2.6 mJy
   - rms comparable to ALFALFA; but can cover δ -39° to +70°

2. Continue with longer (60 min) observations of non-detections in 2009
   - significantly better sensitivity than ALFALFA (1.6 mJy)
   - 50% of short non-detections now detected

→ expected overall detection rate of 75-80%
NIBLES: meet the galaxies

colour SDSS images of 250 galaxies, sorted per absolute magnitude
NIBLES: SDSS sources that are part of larger galaxies

Their real luminosities are higher – and can be re-measured
Misunderestimated SDSS Petrosian magnitudes

Improbably high $M_{\text{HI}}/L$ ratios found for lowest luminosity, tiny sources
Due to underestimated SDSS Petrosian magnitudes
- Started re-measuring with SourceExtractor, gives correct $M_{\text{HI}}/L$ ratios
NIBLES: detection statistics

135 objects observed per 0.5 mag wide bin
Detection percentage rather constant: average 60%
NIBLES: detections as function of magnitude

$M_z -21.75$, $-19.25$: early-types not detected

$M_z -21.75$

Detections

Non-dets

$M_z -19.25$

Detections

Non-dets

$M_z -21.75$, $-19.25$: early-types not detected
NIBLES: detections as function of magnitude -2

$M_z -16.75$: early-types not detected; $M_z -14.25$: ?
NIBLES: detectability

Results of short observations only
Reliability limit of blind HI surveys: S/N=6.5
NIBLES: distances

Started observing the most nearby objects
Detections and non-detections have similar velocity distributions
NIBLES: gas masses and gas content

More luminous objects have higher $M_{HI}$ but lower $M_{HI}/L_z$ ratio
- confusion cases have not yet all been eliminated
NIBLES: detectability and colour
NIBLES: work in progress

Hope to finish Nançay HI observations this year

Obtaining 5 times deeper Arecibo spectra

Stacking analysis of non-detections: CRUMBS (Sarah Blyth’s talk)

Complementary CO observations (TICLES survey @ IRAM)

→ Insight in HI and related properties across absolute magnitude range
Towards the SKA:
increasing the evolution rate in radio astronomy

Observatoire de Paris, France
24 to 28 August 2009
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MCCT SKADS
Training School
Paris, August

MeqTrees Workshop
Nançay, September