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APPROCHER LES DEUX INFINIS PAR LES ONDES ELECTROMAGNETIQUES

Les grandes structures et les grands radiotélescopes
Large Structures and large radio telescopes

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large structures ; dark matter ; SKA

Résumé/Abstract

De par des relevés faites en raie HI à 21 cm la radioastronomie joue un rôle important dans la mise en relation de nos connaissances de l'Univers à ses plus grandes et plus petites échelles. Ces relevés montrent la présence de matière noire, dont la nature précise reste inconnue. Des nouveaux grands relevés vont être mise en route avec une nouvelle génération de radiotélescopes, les "Pathfinders" vers le Square Kilometre Array. L'un des objectifs de ces relevés est la détection d'hydrogène neutre dans es structures de la "toile cosmique".

Through surveys made in the 21cm HI line, radio astronomy plays an important role in connecting our knowledge of the Universe on its largest and smallest scales. These surveys have shown the presence of Dark Matter, whose precise nature remains unknown. New large surveys are about to start with a new generation of radio telescopes, the so-called Pathfinders towards the Square Kilometre Array. One of the goals is the detection of neutral hydrogen inside "cosmic web" structures.

1 Proposition de communications

La radioastronomie joue un rôle important dans la mise en relation des études de l'Univers à ses plus grandes et plus petites échelles - des nombreuses études faites en raie HI à 21cm de galaxies et d'amas de galaxies ont montré la présence à toutes échelles de matière noire, dont la nature précise reste inconnue, et qui domine la masse dans l'Univers.

La communauté mondiale en radioastronomie s'emploie à construire un instrument géant: le Square Kilometre Array, SKA. Sur le chemin menant au SKA, des instruments appelés "Pathfinders" sont en train d'être mis en service, tels que ASKAP en Australie et MeerKAT en Afrique du Sud. Bien qu'ils aient la même sensibilité que les instruments existants, ils ont un champ de vue (beaucoup) plus large, et la décision stratégique a été prise de réaliser principalement un nombre limité de relevés de très grande taille avec ces instruments.

Certaines de ces grands relevés visent à cartographier des structures en HI à des très basses densités de colonne dans des amas de galaxies et autour des galaxies proches. L'un des objectifs est la détection de l'hydrogène neutre dans les structures de la toile cosmique, qui, selon les modèles, devrait être omniprésentes dans l'univers.

Un revu sera présenté des études antérieures des grandes structures dans l'Univers en raie HI à 21cm ainsi que des nouveaux relevés avec les instruments Pathfinder de SKA, en préparation de SKA Phase 1.

large structures and large radio telescopes

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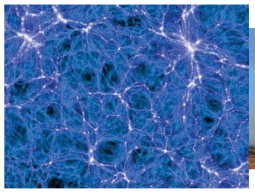
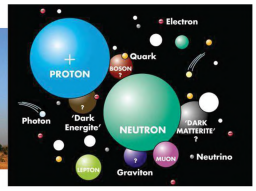
Linking infinitely large and small structures

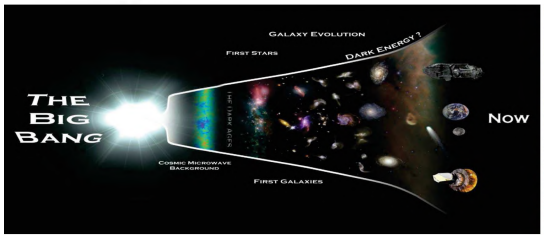
The theme of this meeting - in which astronomy plays a key role

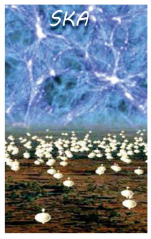




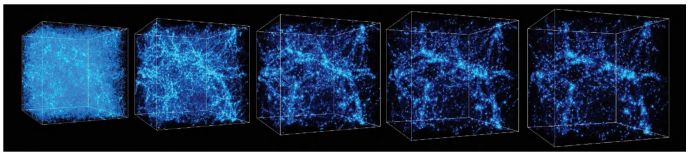
I will focus on the role of radio astronomy, in particular the impact of the Square Kilometre Array (SKA) and its Precursor instruments

The big picture: from Big Bang to big bucks

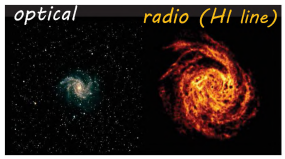


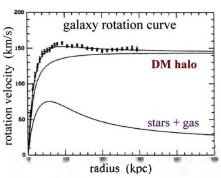


Precision cosmology: lots of basic parameters known
ΛCDM model with cold dark matter - need observations to improve it

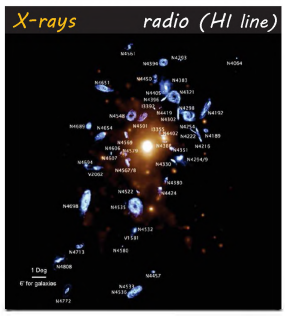


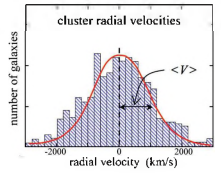
Galaxies and clusters - stars, gas and Dark Matter





Galaxies: dark matter dominates their mass



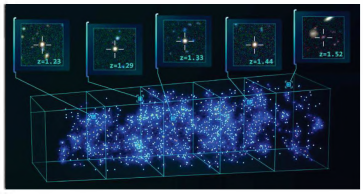


Clusters: dark matter dominates even more

Ubiquitous and still mysterious Dark Matter: relatively more at larger scales - new elementary particle?

Large Scale Structures - in the optical

Largest identified local supercluster: Laniakea (immense horizon)
100 000 galaxies out to z~0·04 - gravitationally bound?



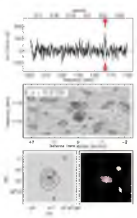
Sloane Digital Sky Survey
2·5m optical telescopes

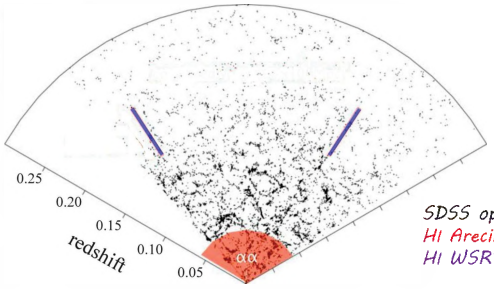
Structures at z=1·2-1·5
(8 billion years ago)

Large Scale Structures - at radio wavelengths

Hydrogen is a ubiquitous element, has been around since the beginning, fuel source for star formation, component of Large Scale Structures

Spectral line of cold neutral hydrogen gas at 21 cm
"blind" surveys of space volumes - full sampling



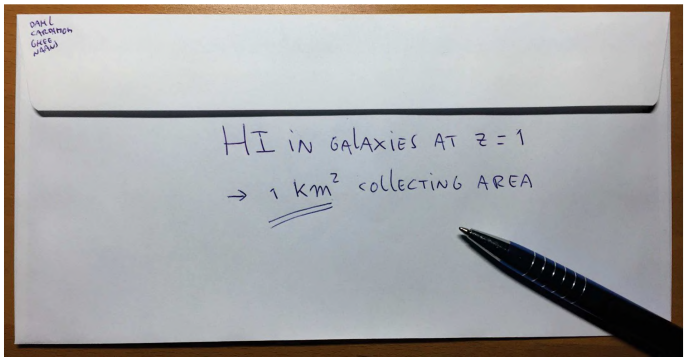


Limited by sensitivity:
1000 hour integration with Westerbork 14x25m interferometer at z~0·2

SDSS optical
HI Arecibo 305m
HI WSRT 14x25m

What next? - on the backs of envelopes

For a paradigm shift: measure HI in galaxies when the Universe was really different - at z~1 (~8 billion years ago)



[1990]

Square Kilometre Array: basic parameters

Huge collecting area (= sensitivity) + very large field(s)-of-view

1 billion galaxies in HI line, out to z~2
10 billion radio continuum sources

- ***collecting area: one square kilometre*** *(equiv. 5500 15m dishes)*

- *radio line observations:* *100 x more sensitive*
- *frequency range:* *0.1 - 10 GHz* *(λ 1 cm - 1 m)*
- *field of view:* *50 (degrees)²* *@ λ 21 cm*
- *multiple fields of view*
- *angular resolution:* *0.01 arcsec* *@ λ 21 cm*

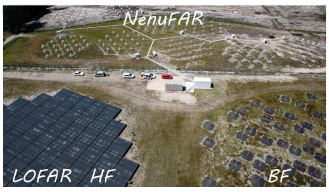
interferometer, baselines up to ~3000 km

Versatile instrument - for discovering unknown unknowns

[2005]

Towards the SKA

Pathfinders - *operational; e.g.:*



LOFAR: international telescope, station at Nançay Radio Facility
NenuFAR: at Nançay Radio Facility
Phased arrays, at 10-240 MHz

Precursors - *completed*
Size of existing radio telescopes, large field-of-view, 1-10 GHz
Australia, South Africa (+ Netherlands)

SKA1 - *construction will start in a few years*
10% of SKA2 ; budget-limited (650 MEUR construction costs)

SKA2 - *full monty square kilometre size radio telescope*
science-limited ; > 2030?

SKA Precursors: HI surveys - complementarity

Large Programmes, for first 5 years of operations

ASKAP

36 x 12 m parabolas, 0.6-14 GHz, FoV 30 deg², resolution 30"

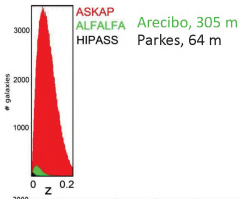
WALLABY 21cm HI line survey of 75% of entire sky
mJy rms, 500 000 galaxies, mean z~0.05

MeerKAT

64 x 13 m parabolas, 0.6-14 GHz, FoV 1 deg², resolution 8"

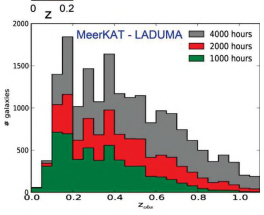
MHONGOOSE *deep HI, selected nearby galaxies*
Fornax cluster *deeper HI in nearby cluster - cosmic web*
LADUMA *ultra-deep HI field*

SKA Precursors: HI surveys II.



ASKAP + APERTIF: all-sky, shallowish

detection of a million galaxies
imaging of thousands of galaxies:
HI distributions and velocity fields
mean redshift ~0.05



MeerKAT: targeted, deeper

LADUMA: 1 deg² field, ultra-deep
detection of 20,000 galaxies
mean redshift ~0.3

Fornax cluster: detection of cosmic web

SKA1

SKA1-mid
200 15 m dishes
(0.03 km²)
freq. 0.35-14 GHz
1 deg² FoV
baselines 150 km

SKA1-low
130 000 phased array antennas
(0.4 km²)
freq. 0.05-0.35 GHz
30 deg² FoV
baselines 65 km

Da capo: the radio astronomy HI revolution

The SKA is designed for gigantic surveys

Example: extragalactic HI surveys

2019: 40,000 detections, out to z~0·05
2028: 1,000,000 detections, out to z~0·5
2038: 1,000,000,000 detections, out to z~2

Telescope time to be shared with other key projects

↔

quietly, or we will all be sent to our rooms...