Searching 21-cm Absorption Systems in Chinese Radio Telescopes

Hao-Ran Yu[1,2], Ue-Li Pen[2,3,4,5], Tong-Jie Zhang[6], Di Li[7,8] and Xuelei Chen[9]

[1] Kavli Institute for Astronomy & Astrophysics, Peking University, Beijing 100871, China;
[2] Canadian Institute for Theoretical Astrophysics, University of Toronto, Toronto, M5S 3H8, ON, Canada;
[3] Dunlap Institute for Astronomy and Astrophysics, University of Toronto, Toronto, M5S 3H4, ON, Canada;
[4] Canadian Institute for Advanced Research, Program in Cosmology and Gravitation;
[5] Perimeter Institute for Theoretical Physics, Waterloo, ON, N2L 2Y5, Canada;
[6] Department of Astronomy, Beijing Normal University, Beijing, 100875, China;
[7] National Astronomical Observatories, Chinese Academy of Sciences, Beijing, China;
[8] Key Laboratory of Radio Astronomy, Chinese Academy of Sciences, Beijing, China;
[9] Key Laboratory for Computational Astrophysics, National Astronomical Observatories, Chinese Academy of Sciences, Beijing, 100012, China.

Abstract Neutral hydrogen clouds are known to exist in the Universe, however their spatial distributions and physical properties are poorly understood. Such missing information can be studied by the Chinese new generation radio telescopes by a blind searching of 21-cm absorption systems. We forecast the abilities of surveys of 21-cm absorption systems by two representative radio telescopes in China – Five-hundred-meter Aperture Spherical radio Telescope (FAST) and Tianlai. The result shows that, in a few of years term, these telescopes with either high sensitivity (FAST) or wide field of view (Tianlai) can discover orders of magnitudes more 21-cm absorption systems, than the cumulative discoveries in the past 50 years.

Key words:

1 INTRODUCTION

Neutral hydrogen (H I) clouds are known to exist in the Universe, however only few of them are discovered in the past half a century, and we poorly understand their spatial distribution and physical properties (Wolfe et al. 2005). In damped Lyman-α absorption (DLA) systems, the radio spectrum is also substantially absorbed by the H I hyperfine structure, whose rest frame wavelength is approximately 21 cm ($\sim$1420 MHz in frequency). These systems are defined to have at least 2×10^{20} cm^{-2} H I column density, thus being able to house cold 21-cm absorbing gas in the cold neutral medium (CNM).

The 21-cm absorption systems are important in the study of the distribution, location, temperature and structure of neutral gas, and the evolution of neutral gas systems and galaxies over cosmic time scale. Due to the narrow intrinsic line width, the 21-cm absorption systems are proposed to be used to directly measure the cosmic acceleration (Darling 2012; Yu et al. 2014), via the Sandage-Loeb (SL) effect (Sandage 1962; Loeb 1998). The uncertainties are from the poorly understood neutral hydrogen clouds. Path finder surveys, taking less than a year, are needed to improve our understandings of spatial distribution and physical properties of neutral hydrogen clouds. This can be done by the Chinese new generation radio telescopes – Five-hundred-meter Aperture Spherical radio Telescope (FAST) (Li & Pan 2016) and Tianlai (Chen 2012). In the current and near future, these are the two symbolic modern radio telescopes in China. The single-dish FAST, like Arecibo[1], uses its gigantic single dish to achieve ultimate sensitivity, whereas Tianlai, designed like CHIME[2], has ultra wide field of view per day, by using its cylindrical reflectors and arrays of receivers to scan the northern hemisphere of the sky as the Earth turns.

According to their different design and observing strategies, we forecast their abilities of blind searching of 21-cm absorption systems. In section 2 we show the sensitivity estimation and all the aspects needed to be taken into account, and according to the configurations of FAST and Tianlai, we show their forecast in section 3 and section 4 respectively. Conclusions are made in section 5.

2 SENSITIVITY

NRAO VLA Sky Survey (NVSS)[3].

Recent studies show that the number density of absorbers to be $\mathrm{d}N/\mathrm{d}z \sim 0.45$ (Wolfe et al. 2005; Zwaan et al. 2007).

Recent discoveries of 21-cm absorption systems have about 20% fractional depth (Allison et al. 2015; Zwaan et al. 2015).

3 FAST ESTIMATION

Parameters:

Result: 90 per month.

4 TIANLAI ESTIMATION

Parameters:

Result: 80 per year.

5 CONCLUSION

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