MNRAS 000, 1–7 (2021) Preprint 28 February 2022 Compiled using MNRAS LATEX style file v3.0

Detecting faint HI clumps with Tianlai as a proof for Intensity Mapping.

A. Hamie,

28 February 2022

ABSTRACT

Context. Intensity Mapping (IM) as a category of 21 cm cosmology uses radio interferometry to constraint Dark Energy (DE) via Baryon Acoustic Oscillations (BAO) analysis. IM is under development, five pathfinder interferometers are built to study its viability and resolve technical challenges. These pathfinders will determine the shape of future IM dedicated interferometers.
Aims. This work aims to prove the required sensitivity to detect faint and close HI clumps with the pathfinder Tianlai. These clumps have mK amplitudes and their detection represents a proof of concept for BAO's detection with future IM large interferometers.
Methods. We simulated the operation of Tianlai around the North Celestial Pole (NCP) region. The work consists of developing a pipeline that involves a sources detection stage, then post-processing that characterizes a large sample of simulated observation strategies sky maps. Thus, the required sensitivity is proved by detections statistics.
Results. Using simulations of operations of the central seven-dish of Tianlai with 1 mK of instruments noise. We detected with an efficiency of 70 % clumps having an S/N=1.5 and with a negligible false detection rate.
Conclusion. Detecting nearby faint HI clumps with an amplitude in the order of mK requires a total exposure time of six months.

Key words: Intensity Mapping, Point sources detection, Tianlai, 21cm cosmology, map-making artifacts.

CONTENTS

1 INTRODUCTION

Recently, the universe's expansion has shifted from power law to an exponential function of cosmic time. While Dark Energy (DE) represents the ΛCDM interpretation of this acceleration, alternative theories use modifications of General Relativity. An observational cosmology method for constraining the universe's expansion history consists of tracing Baryon Acoustic Oscillations (BAO) in the matter density field. So, what is BAO?

Most of the CMB anisotropies represent Dark Matter (DM) structures resulting from the early universe quantum fluctuations blown by inflation. In contrast, BAO are those anisotropies having an angular size equal to the sound horizon ($\theta = 0.7$). They correspond to frozen oscillating overdensities in the baryons-photons fluid at the time of the last scattering. The baryonic remnants of these structures expand along with the universe's history. Their physical sizes depend on redshifts, angular distances, and the instantaneous expansion rate of the universe. Thus, knowing the present size of BAO, one can constrain expansion's variations.

BAO are often traced by visible matter distribution in optical/IR redshift surveys. These surveys are performed by photometry or involving photometric targeting followed by a spectroscopic redshift measure. Then, redshift is converted to distance in order to make maps of surveyed volumes and extract statistical properties. Since the eighties, instruments and technics have been developed to improve precision, exposure time, number of analyzed objects per exposure, the field of view, and maximal measured redshift. Thus, above $z = 2$ the cumulated data from many surveys gave a high precision measurement of the expansion. This volume includes the beginning of the acceleration epoch. A better constraining for DE or any other potential modified gravity theories during the pre-acceleration epoch requires at least the same level of precision for higher redshift. Surveys above $z = 2$ often entail using quasars as direct tracers or mapping neutral hydrogen on their line of sight with the Ly-α line. Because quasars are rare, their lines of sight are dispersed. This discontinuity in the survey's field of view, deteriorates the construction of power spectrum DESI Collaboration et al. (2016). So, here is the need for new experiments that improve the cosmological parameter extraction above $z = 2$. Today, flagship optical/IR experiments such as Euclid, LSST, and DESI aim to increase surveyed volumes above $z = 3$ and it will produce an unprecedented amount of data. In parallel, non-optical techniques are under development.