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## **HIR4: Cosmology from the cross-correlation of extragalactic radio and optical surveys with simulated neutral hydrogen full sky using Horizon Run 4**

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We are currently living a blooming era of wide field optical cosmological surveys, either spectroscopic such as Dark Energy Spectroscopic Instrument (DESI) or photometric such as the ongoing Dark Energy Survey (DES), the future Large Synoptic Survey Telescope (LSST) or the future imaging component survey of EUCLID. By analyzing the distribution of matter clustering, we can use the growth of structure, in combination with measurements of the expansion of the Universe, to understand dark energy or to test different models of gravity. Radio surveys will map the matter distribution at high redshifts, especially covering the current redshift desert between early and late expansion, crucial to discriminate between current cosmological theoretical models. The distribution of cosmological neutral hydrogen will provide a new window into the large-scale structure of the Universe with the next generation of radio telescopes and surveys. The observation, through 21cm line emission, is confused by instrumental noise and foreground emission. I will introduce the simulated neutral hydrogen full sky catalogues that we have created, using the Horizon run 4 simulations (HIR4). The simulations HI intensity maps include realistic foregrounds and expected noise for Tianlai, one of the SKA Observatory (SKAO) precursors. In particular, I will show the prospects of measuring the growth rate of structures with only HI intensity mapping information around redshift  $z=1$  and how by cross-correlating the neutral hydrogen information with optical galaxy catalogues, such as DESI, helps us by alleviating the effects of noise and foregrounds.

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