COSMOS-3D: A Panoramic Survey of the Reionizaton-Era Universe
Program type: GO Large
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■ Scientific Justification

A Legacy Wide-Field Redshift Survey at the Epoch of Reionization.

HST has transformed our understanding of galaxy formation and evolution with extragalactic imaging surveys over the last three decades. There are two types of extragalactic surveys, ultra deep 'pencil-beam' surveys (e.g., HUDF), and wider but shallower surveys (e.g., COSMOS). The 'pencil-beam' survey enables the detection and characterization of faint galaxies. However, they lack the volume to probe the large-scale structure or detect the rarest galaxy populations. The Cosmic Evolution Survey (COSMOS; Scoville et al. 2007) allowed the first in-depth studies linking the formation and evolution of galaxies to their larger cosmic environments across cosmic time and substantially minimized uncertainties of key extragalactic measurements from cosmic variance. It also incorporates a wealth of multiwavelength data, from radio to X-ray, to facilitate studies of galaxy (and AGN) evolution over a wide range of energy and spatial scales. Leverage the rich multi-wavelength observations in the COSMOS field, the largest JWST Cycle-1 treasure program, COSMOS-Web, is adding multiple-band infrared imaging (from F115W to F770W) to this legacy field, which will extend views of galaxies and large-scale structures to an even earlier epoch and bridge deep pencil-beam JWST surveys (e.g., JADES) with shallower wide-area infrared surveys that will be made possible by future Roman Space Telescope (Akeson et al. 2019).

Studies of the earliest galaxies and supermassive black holes (SMBHs) and the epoch of reionization (EoR) is one of the fundamental mission goals of JWST. Surveys such as COSMOS-Web can detect early galaxies photometrically, but can not accurately map their 3-D distributions or connect galaxies to the evolution of the intergalactic medium (IGM) in the EoR. NIRSpec/MSA spectroscopic surveys of deep fields can reach to faint objects at $z > 10$, but are limited to small survey volumes. The peak era of reionization is at $z = 6-10$; the typical ionizing bubble sizes and galaxy correlation lengths both demand surveys over scales of > 10 comoving Mpc for proper sampling. Many fundamental questions related to EoR can be addressed with a wide-field (> 1000 arcmin^2) spectroscopic galaxy redshift survey focusing on this crucial redshift. From the JWST commissioning, the ERS and Cycle-1 observations, the slitless spectroscopic observations using NIRCam/WFSS mode (Greene et al. 2017) has been demonstrated to be the most powerful redshift survey machine for early galaxies (e.g., Sun et al. 2022; Kashino et al. 2022). It has the advantage of high survey speed and avoids the potential bias from photometric pre-selection, as shown by previous surveys such as 3D-HST (Brammer et al. 2012) and MUSE-Wide (Urrutia et al. 2019). The slitless mode is further aided by the realization that most young EoR galaxies have very strong rest-optical emission lines, allowing redshift measurements even for faint sources.

We propose to perform a slitless spectroscopic survey with NIRCam/WFSS in the COSMOS-Web field. This treasury program will deliver the largest (0.33 deg^2) ever infrared redshift survey for galaxies in the EoR and enable countless scientific investigations by the community for the next decade. We will use F444W filter ($\approx 3.9 - 5.0$ μm) for the WFSS observations in the long wavelength channel and obtain deep imaging at 2 μm with F200W in the short wavelength channel. We will also obtain F115W+F356W imaging after the WFSS exposure. At the same time, we will obtain MIRI parallel imaging in

F1000W+F2100W and provide the largest (482 arcmin^2) deep mid-infrared imaging survey at $\geq$ 10 μm, with the key science goal of detecting hot dust emission from early accreting SMBHs and dusty galaxies. This program will provide a panoramic view of the early universe by studying the emergence of early large scale structure, the tomography of EoR IGM and the history of early SMBH growth. In addition, this program will produce key additions to the multi-wavelength dataset in the COSMOS field, with slitless spectroscopy, mid-IR extension and time-domain coverage, and enable a wide range of investigations in extragalactic astrophysics and cosmology.