COSMOS-3D: A Legacy Spectroscopic/Imaging Survey of the Early Universe
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■ Scientific Justification

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The *Hubble Space Telescope* has transformed our understanding of the Universe with extragalactic imaging surveys over the last three decades. There are two types of extragalactic surveys: ultra-deep 'pencil-beam' surveys (e.g., HUDF, Williams et al. 1996), and wider but shallower surveys (e.g., COSMOS, Scoville et al. 2007). The 'pencil-beam' surveys enable 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) has 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 measurements arising from cosmic variance. It incorporates a wealth of multi-wavelength data, from radio to X-ray, to facilitate studies of galaxies and active galactic nuclei (AGN) over a wide range of energy and spatial scales. Leveraging the rich multi-wavelength observations in the COSMOS field, the largest JWST Cycle-1 treasury program, COSMOS-Web (Casey et al. 2023), is adding multi-band infrared imaging in 1–5μm to this legacy field, which will extend our view of the Universe to an even earlier epoch, and bridge deep pencil-beam JWST surveys (e.g.,JADES, Eisenstein et al. 2023) with shallower wide-area surveys by e.g., the future Roman Space Telescope (Akeson et al. 2019).

Studies of the earliest galaxies and supermassive black holes (SMBHs) and the epoch of reionization (EoR) are the most fundamental mission goals of JWST. Surveys such as COSMOS-Web can detect early galaxies photometrically, but can not accurately map their 3D distributions. While NIRSpec/MSA spectroscopic surveys of deep fields can reach faint objects, their limited survey volume and shutter conflicts prevent us from revealing all the early cosmic structures. To understand the emergence of early galaxies and SMBHs from the peak of their activities at $z \sim$2–3 to the EoR at $z \sim$6–10 (Planck 2020) through measurements such as galaxy correlation lengths and ionizing bubble sizes, we need surveys over scales of $\gg 10$ comoving Mpc for proper sampling. Many fundamental questions can only be addressed with a wide-field (> 1000 arcmin^2) spectroscopic galaxy redshift survey charting the entire cosmic history. Since the JWST commissioning, the NIRCam's wide-field slitless spectroscopy (WFSS) (Greene et al. 2017) has been demonstrated to be the *most powerful* redshift survey machine for the early Universe (e.g., Matthee et al. 2023a; Oesch et al. 2023) with its high survey speed and free from photometric pre-selection enabling us to reveal the whole structures from the EoR to the present epoch.

A large legacy wide-field spectroscopic survey is, thus, what is critically needed. **We propose to perform a slitless spectroscopic survey 'COSMOS-3D' with NIRCam/WFSS targeting the COSMOS-Web field together with deep parallel MIRI imaging**. This will establish a treasury dataset covering the largest ever field (0.33 deg^2) in the infrared, with secure grism redshifts, enabling countless scientific investigations by the community for the next decade. The survey uses WFSS F444W ($\sim$3.9–5.0 μm) to cover the key rest-frame optical and infrared emission lines of early systems ranging from strong PAH features at $z \sim$0.2–0.5, to line emission of Paα and Paβ at $z \sim$1–3, He I and [S II] at

$z \sim$2.5–4.5, Hα and [N II] at $z \sim$5–6.5, up to [O III] and Hβ for $z \sim$7–9, along with MIRI F1000W+F2100W to extend the deep mid-infrared ($\geq 10\mu$m) coverage, critical to unambiguously determine the nature of early AGN demographics via their hot dust emission. The large MIRI coverage (482 arcmin^2) in the early JWST operation is urgent due to its declining sensitivity. The simultaneous F115W and F200W observations complete the full NIRCam filter ($\sim$1–5μm) coverage of the field, as well as adding the time-domain dimension for the studies of the earliest SMBHs. This program will provide a panoramic view of the early Universe and address the following key scientific questions:

1. **How did the early massive galaxies emerge? Do they pose a challenge to modern cosmology?**
2. **How did the early SMBHs emerge? What is the nature of the puzzling 'Little Red Dots' unveiled by JWST?**
3. **How did the entire 'Cosmic Web' of the Universe emerge? How did the Universe reionize? How did galaxies and SMBHs evolve in that context?**