Default Parallels: The Science Potential of JWST Parallel Observations during TSO Primary Observations

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Abstract

The James Webb Space Telescope (JWST) will observe several stars for long cumulative durations while pursuing exoplanets as primary science targets for both Guaranteed Time Observations (GTO) and very likely General Observer (GO) programs. Here we argue in favor of an automatic default parallel program to observe, e.g., using the F200W/F277W filters or grism of NIRCAM/NIRISS in order to find high redshift (z > 10) galaxies, cool red/brown dwarf substellar objects, solar system objects, and observations of serendipitous planetary transits. We argue here the need for automated exploratory astrophysical observations with unused JWST instruments during these long-duration exoplanet observations. Randomized fields that are observed in parallel mode reduce errors due to cosmic variance more effectively than single continuous fields of a typical wedding cake observing strategy. Hence, we argue that the proposed automated survey will explore a unique and rich discovery space in the high-redshift universe, Galactic structure, and solar system. We show that the GTO and highly probable GO target list of exoplanets covers the Galactic disk/halo and high redshift universe, mostly well out of the plane of the disk of the Milky Way. Exposure times are of the order of the CEERS GTO medium-deep survey in a single filter, comparable to CANDELS in Hubble Space Telescope’s surveys and deep fields. The area covered by NIRISS and NIRCam combined could accumulate to a half square degree surveyed.

Key words: galaxies: active – galaxies: evolution – galaxies: high-redshift – Galaxy: stellar content – methods: statistical – space vehicles: instruments – surveys – techniques: imaging spectroscopy

Online material: color figures

1. Introduction

Given the high price tag and the limited life expectancy of the James Webb Space Telescope (JWST), the pressure is on the astronomical community to maximize this flagship’s efficiency. Two observational communities that will make maximum the use of this observatory and its revolutionary instrument suite are the exoplanet and the high-redshift galaxy population communities. Exoplanet direct imaging and transit studies require long, single-pointing exposures. Meanwhile, the other instruments on JWST will be left unused for science. Given reasonable use (i.e., no filter changes, long integrations to limit buffer use), these can be put to excellent use for solar system, Galactic, and extragalactic science (Figure 1).

In order to minimize resources allocated to this program, we propose a single strategy to simplify the generation of this legacy data set, “default parallels.”

Default parallels would be planned as follows:

1. Automatically examine in each nonprimary instrument’s field of view (FOV).
2. If there is a bright target that would saturate deep photometry, then perform a transit observation (i.e., a time series of imaging with repeated short integrations).
3. If there are no bright sources, then do a deep (extragalactic) observation in a band redder than H, or using grism observations.
4. If the number of intermezzos is above three or four, deep imaging with multiple filters is performed.
5. If not enough principal observation intermezzos are available for deep imaging, grism observations are performed.

The possibility of default parallels also would have to be calculated with the boundary conditions of no or few filter changes, no dithering, long integrations, and within JWST’s limited onboard data storage space. Given the existing exoplanet JWST Guaranteed Time Observations (GTO), ERS, and prospective General Observer (GO) observational expectations, it is possible that a default parallel program could observe up to a half a square degree—accumulated area—for deep galactic fields (m < 28) in either the F277W or F200W filters or grism.
filter from NIRISS and NIRCam, spanning a large range of sky coverage; these filters were selected because they are available on both instruments. We highlight double NIRISS and NIRCam observations as these can be homogeneous and wide field (2 × (3′ × 3′) FOV) with limiting magnitudes ranging from $m_{AB} \sim 27$ to 29 mag (depending on actual in-flight performance, etc.).

Mid-InfraRed Instrument (MIRI) observations (FOV $74'' \times 113'')$ in default parallels would provide separate unique, long wavelength coverage not available with any NIR instruments. Below are a few science cases for such observations.

2. Default Parallel Science Cases

2.1. Science Case A: High-redshift Galaxies

Long-stare NIRCam or NIRISS F200W/F277W observations would be beyond the H-band of Euclid or the F184 filter on WFIRST, or Hubble’s F160W filter. These images will effectively search for $H$-band dropout galaxies ($z > 11$). Without ancillary data, these observations would be of limited immediate use for high-redshift studies, but with solid $H$-band fluxes, this could be an excellent constraint on the luminosity function of $z > 11$ galaxy populations using the Lyman break technique (Steidel et al. 1996). Critical here is that the $H$-band observations can be a follow-up of these JWST parallel fields. The value of these preliminary search observations is a key investment for the discovery space of future follow-up observations.

A similar program of Hubble Space Telescope (HST)/WFC3 default parallels has been extremely successful in constraining the $z \sim 8$ and $z \sim 9$ brighter populations (Trenti et al. 2011, 2012; Bradley et al. 2012; Trenti 2014; Bernard et al. 2016; Calvi et al. 2016; Livermore et al. 2018; Morishita et al. 2018), taking statistical power from the essentially random pointings, and therefore sampling a large volume (Trenti & Stiavelli 2008).

The random sampling also resulted in useful lower-redshift ($z \sim 2$) clustering constraints (Cameron et al. 2019), which would have been difficult to obtain otherwise. Similar searches can be done with just JWST F200W/F277W observations using NIRISS/NIRCam, supplemented with WFIRST/EUCLID/HST near-infrared (J- and H-band) follow-up.

During exoplanet phase-curve observations and high-contrast imaging programs, there are nominally re-pointings to change filters (direct imaging) or data downloads (phase curves). During these significantly longer exposures, with sufficiently long intermezzos for re-pointings or data downloads, multiple filter observations can be considered for the nonprimary instrument’s default parallels, for example, during transiting observations that consist of the greatest time commitments. We assume that during sensitive exoplanet observations, a filter change on another instrument would be too disruptive and these should be reserved for breaks in the primary observation. If no break is available, the parallel would be a single F200W or F277W deep image, with the longest on-ramp integrations for minimal storage use. Multiple filter parallel observations (i.e., with primary observation breaks for filter changes in the parallel) would expand the search space to $z \gg 11$ sources. These would be of almost similar quality as dedicated deep fields, without the specifically optimized dithering strategy, however.

2.2. Science Case B: Brown Dwarf Population of the Milky Way

Similarly, a search for the lowest-mass substellar objects belonging to the Milky Way can benefit from observations such as the above default parallels. The randomized sampling of the Milky Way volume equally benefits constraints on the shape of the Milky Way (Pirzkal et al. 2005, 2009; Ryan et al. 2005, 2011, 2017; Holwerda et al. 2014, 2018; van Vledder et al. 2016). The near-infrared observations of JWST are sensitive to...
the lowest-mass objects (Y dwarfs) throughout the width of the Galactic disk and halo.

The randomized nature of the fields would allow for a first survey of Galactic disk and halo substellar objects, down to free-floating super-Jupiters (e.g., Ryan et al. 2017; Deacon 2018). These parallel searches for low/substellar objects benefit from color information (Holwerda et al. 2018), accurate astrometry, or grism information, but they derive their statistical power from the randomized fields.

2.3. Science Case C: Solar System Objects

The existence of default parallels increases the chance to discover or follow-up on solar system objects during deep stares. Meaningful, accidental science occurred during deep field observations with Spitzer, for example, when Spitzer/MIPS observations caught a passing asteroid (Meadows et al. 2004; Ryan et al. 2015). The likelihood of near-infrared telescopes catching solar system objects is decidedly nonzero (Kiss et al. 2008). Spitzer has performed several successful targeted observations of solar system objects (Stansberry et al. 2004; Fernández et al. 2013; Kelley et al. 2013; Trilling et al. 2016, 2017) as well as a study of solar system bodies in the ecliptic (Meadows et al. 2004). As such, serendipitous and targeted programs on JWST are fully complementary.

Kuiper Belt objects (KBOs) can be identified in default parallels. High-inclination KBOs, out of the ecliptic plane, are especially of interest (e.g., Batygin & Brown 2016). This would include objects similar to the KBO that was just visited by the New Horizons spacecraft, which has an R-band magnitude around 26–27, similar to the limiting magnitude for the default parallels program (Figure 5). Moreover, Petit et al. (2008) predict that ~1 KBO object should exist per deg$^2$ with an R-band magnitude brighter than 23–23.5. Petit et al. (2011) further estimated an observable population of KBOs with $m_r \sim 23–24.5$ per deg$^2$. By covering a large number of deep, randomized fields, the default parallels program would have a significant possibility of discovering and quantifying the distribution of solar system objects.

KBO require at least two epochs for identification, and we point out that many of the exoplanet observations are scheduled in multiple epochs as well. There will have to be some serendipity here (parallel on the same pointing and position angle). However, if the JWST default parallels represent a single epoch (e.g., F200W observations) the follow-up with EUCLID/WFIRST or HST could represent both the necessary secondary epoch as well as the H-band observation for the H-band dropout of high redshift galaxies.

2.3.1. Small Body Discovery and Characterization

As has been shown by the Kepler, K2, and Transiting Exoplanet Survey Satellite (TESS) surveys—as well as the prediction from JWST yield estimates—almost every FOV near the ecliptic is likely to be dominated by “asteroid trails” from main belt and outer solar system small bodies (Wright et al. 2010). Default parallels would provide a fourfold benefit to the planetary and astronomical communities:

1. During deep imaging, the moving object trails would be used for discovery space. There are likely to be hundreds of thousands of faint solar system objects that have not yet been discovered, especially those emitting at the JWST-MIRI wavelengths (15–24 μm).

2. Grism (WFSS) observations with the nonprimary instruments to spectroscopically characterize moving objects in the solar system: KBOs, asteroids, and comets.

3. The randomized FOV will provide direct capture of the distribution and population of small bodies in our solar system—especially at high ecliptic latitudes, such as high-inclination, scattered objects (Brown & Batygin 2016).

4. Because moving object trails are expected to be a significant source of astrophysical noise in the GTO/ERS/GO observations, having more detections of these sources would provide necessary information for mitigating these aberrations.

2.4. Science Case D: Star Formation Across Cosmic Time

MIRI 24 μm observations study star formation across cosmic time (Brown et al. 2017; Clark et al. 2018), similar to Spitzer/MIPS or WISE/W4, but with sufficient resolution to resolve star formation regions. The 22–24 μm emission in a galaxy is strongly correlated to the total star formation and can be used to accurately map local (z < 3) star formation rates (see, e.g., Cluver et al. 2014, 2017). Deep MIRI parallel observations will reveal where the star formation is in the galaxy populations caught by the parallel observations. A similar consideration is being made for the SPICA science cases using this wavelength regime (e.g., Bonato 2015; Gruppioni et al. 2017).

Active galactic nucleus (AGN) information is encoded in this filter as well (Jarrett et al. 2011). When MIRI is not the primary instrument for the exoplanet observations (see Figure 3), onboard data storage of MIRI default parallel imaging would not be a strong constraint. It could be the first field observations to supply star formation and AGN studies with preliminary targets. The randomized nature of the pointings allow one to constrain the numbers of rare-and-bright sources.

2.5. Science Case E: Default Parallel Time-series Observations

Brown dwarf and exoplanet atmospheric characterization requires both high-cadence (2–200 s integrations) and long wavelength coverage (1–10 μm). To discover molecular abundances in colder, smaller atmospheres, predictions show that we need JWST to be able to attain spectroscopic precisions
on the order of 10–50 ppm—what is referred to as “sub-50 ppm
precision.”

Currently, it is unknown to what precision JWST will be able
to measure atmospheric features in the face of temporal,
systematic noise sources; this is referred to as the “noise floor”
(Greene et al. 2016; Batalha et al. 2018a). If a bright star is
known in the FOV of any nonprimary instruments, while a
time-series observation (TSO) is occurring on primary, and
there are no immediate technical objections to conducting a
second time series of a bright object ($K < 15$), then default
parallels could be used to characterize the star or possibly
detect a transient source. This will have a range of long-term
uses from exoplanet studies to stellar characterization. The
exoplanet community is attempting to attain precisions on
their exoplanetary atmospheric signatures below 50 ppm (possibly
<20 ppm; Barstow & Irwin 2016; Barstow et al. 2016, 2017; Kreidberg
2017; Batalha et al. 2016; Greene et al. 2016; Batalha et al. 2018b; Bean et al. 2018).

With randomized FOV to observe bright objects, a critical
factor in predicting the efficacy of future TSO observations is
how well each stellar type (FGKM), over several wavelengths,
can attain sub-50 ppm precision. Both the commissioning
and ERS programs are attempting to understand this yet unknown
JWST capability, but only a single target can be observed per
program.

Bright enough targets for TSO observations are not typically
close enough for both to fall into a second JWST instrument
FOV. However, even one bright TSO target observation in the
proposed default parallels program will double the number of
targets observed for long temporal baselines (>10k s). This
critical information (sub-50 ppm efficacy) cannot be attained
without successfully applying for a risky proposal (near
saturation) in the usual GO program platform. Even one TSO
target in a parallel would inform the sub-50 ppm efficacy for
the entire exoplanet community.

To date, several teams predict the need for detection of
atmospheric features near 10 ppm precision (Barstow & Irwin
2016; Barstow et al. 2016, 2017; Kreidberg 2017; Batalha et al.
2018a, and others). With the wealth of possible planetary
candidates from the TESS satellite (Ricker et al. 2015), the odds
of two TSO observations near each other improve dramatically
(Sullivan et al. 2015). This information will provide crucial
input into in the planet formation and atmospheric predictions
community as well. A default parallel program with a stellar
characterization/TSO component, i.e., if a bright star does fall
into a second instrument’s view the program would switch to
TSO, would greatly inform the community to what level of
precision JWST predictions can reach.

Depending on the brightness of the object ($m_K \sim 5, 8, 10, 12$),
if imaging is expected to saturate, default parallels could perform
gism TSO or WFSS observation instead of imaging for both
NIRISS and NIRCam. This would minimize the risk of saturation
and maximize the potential for stellar characterization at longer
wavelengths, building up a template selection for JWST for all
users.

An equally necessary benefit of default parallel TSO
observations is that the greatest source of uncertainty with
high-precision transiting exoplanet observations is that the
stellar spectra are not as well characterized as is necessary to
produce exoplanetary absolute abundance measurements.
Stellar characterization through grism default parallels would
benefit stellar, brown dwarf, and exoplanet observations by
developing a database of stellar templates for the entire JWST
program to use.

2.6. Science Case F: Grism Observations

As an alternative to the imaging options presented above,
gism observations for the same science cases (Galactic brown
dwarf population, high-redshift galaxy populations) could be
considered. Deep grism stares would identify brown dwarfs
(Holwerda et al. 2014; Ryan et al. 2017; Deacon 2018) as well as
as $z \sim 11$ galaxies (Oesch et al. 2016), of which there is a
remarkable dearth (Oesch et al. 2018). The WFC3 Infrared
Spectroscopic Parallel Survey (WISP) default parallel grism
survey with HST/WFC3 (Atek et al. 2010) has successfully
characterized the intermediate-redshift population (e.g., Atek
et al. 2011, 2014; Bedregal et al. 2013; Malkan & WISP Team
2013), predicted more use of grism spectroscopy in NIR
surveys (Colbert et al. 2013), and identified some Milky Way
halo objects (Masters et al. 2012). Grism observations also hold
the potential to cleanly separate AGN and star formation
contributions in intermediate-redshift galaxy populations
(Trump et al. 2011; Bridge et al. 2016).

All four of the instruments on JWST employ slitless
spectroscopic modes. In particular, NIRCam ($R \sim 1600,
2.4 < \lambda < 5 \mu m$) and NRIISS ($R \sim 150, 0.8 < \lambda < 2.2 \mu m$)
grisms both have a wide-field mode similar to the HST WFC3
and ACS grisms. Leveraging parallel JWST observations, as
has been done with HST grism surveys, will be an important
undertaking to maximize scientific results. For example, doubly
ionized oxygen has recently been detected at $z \sim 9$ using
ALMA (Hashimoto et al. 2018), and the ability to spatially
resolve [O II] out to $z \sim 12$ may revolutionize our
understanding of star formation in the earliest galaxies, less than 250
million years after the Big Bang. We will also be able to probe
the [O III]/Hβ ratio out to $z \sim 9$, facilitating testing of theories
about black hole seeds in the early universe and whether the
existence of low-luminosity AGN, which have been found in
significant numbers at $4 < z < 6.5$ (Giallongo et al. 2015)
played a significant role in reionization.

The longer exposures without many intermezzos for default
parallels would lend themselves preferentially for grism
observations.
3. Exposure Times and Survey Area

We consider default parallel imaging as the simplest science case, single-band observations. A TSO default parallel is likely rare, and grism observations with single orientations are more difficult to simply predict the scientific yield, but should be similar to a multiband survey.

The mean exposure time for the GTO direct imaging is 2.5k s and for the GTO transiting programs is 22k s. Figure 2 shows the distribution of exposure times asked for in the GTO programs. One expects GO observations to span lower integration times. The transiting programs offer the best options for a series of deep fields, possibly using multiple filters (if the transit observations include scheduled breaks, long enough to allow for filter changes).

A couple of thousand seconds of exposure time with NIRCam or NIRISS can reach depths of $m \sim 28.0$ in F200W/F277W and $M_{UV} \sim -19.5$ galaxy at $9 < z < 13$ (see CEERS proposals, PI: Finkelstein; Finkelstein et al. 2017). The *JWST* default parallel observations provide the redward band for $H$-band dropout selections using *HST*, *WFIRST*, or *EUCLID* auxiliary/follow-up data.

These default parallel observations are equivalent to the GTO’s medium depth imaging surveys. Default parallels with the GTO transit observation programs could rival dedicated medium-deep fields, and over randomized FOV.

There are totals of 17k and 10k s available with both NIRISS and NIRCam as the parallel instruments over 19 fields (Figures 3 and 4). Only one field looks to have too low of a
Galactic latitude to be of extragalactic use, and four may suffer from stellar crowding ($b < 15^\circ$).

This default parallel opportunity alone would be between 275 arcmin$^2$ to almost a half a square degree survey, depending on the primary observation orientation angle constraints and the number of approved GO proposals. If the orientation angle is kept fixed, then the resulting parallel observation will be much deeper; if there is significant variation, the parallels will provide a wider survey (Figure 5).

Each of the HST deep surveys of the high-redshift universe (CANDELS, Frontier Fields, etc.) are less than 400 arcmin$^2$ each. Three GTO programs are the first deep, multiwavelength program with JWST to showcase all the instruments capabilities: the Cosmic Evolution Early Release Science (CEERS, PI: S. Finkelstein; Finkelstein et al. 2017), the JWST Advanced Deep Extragalactic Survey (JADES; Williams et al. 2018; Rieke et al. 2019), and the North Ecliptic Pole (NEP; Jansen & Windhorst 2018) GTO deep fields.

In a single filter, default parallels would expand the discovery space significantly (Figure 5). The value of these observations will be in both comparing the known source fields to default parallels’ randomized FOV, and plausibly...
4. Discussion

Parallel-mode observed random pointings reduce cosmic variance more effectively than single continuous fields of a typical wedding-cake observing strategy (Trenti & Stiavelli 2008). Hence, we argue that the opportunity for a default parallel survey will explore a unique and rich discovery space of high redshift, TSOs, solar system objects, and Galactic structure.

Random, parallel fields can counter two issues that confront high-redshift searches: cosmic variance and human bias in deep field selection. Cosmic variance remains a dominant source of uncertainty in the relatively small areas surveyed by instruments like HST and JWST (Driver & Robotham 2010). To counter that, larger continuous areas (>1°) can be considered, but these remain observationally expensive. A randomized sampling does an equal or better job of countering cosmic variance (Trenti & Stiavelli 2008). The current deep observations by HST, e.g., CANDELS (Grogin et al. 2011; Koekemoer et al. 2011), are all focused on those fields for which much needed ancillary data are already available. This perpetuates a bias for low Galactic cirrus regions identified decades ago. In essence, the choice for JWST fields was locked in at that time. Deep, randomly chosen fields can act as a control on deep fields dictated by legacy. Our nominal case is one that uses only the F200W or the F277W filters to perform a uniform default parallel survey. However, if there are no issues with roll angle, a series of filters can be adopted (e.g., F150W, F200W, F277W, and F356W) to combine into a photometric redshift search for high-redshift galaxies. If, for example, a transiting observation is done with intermissions, then that time can be used to switch filters in the nonprimary instruments. The principle idea for default parallels is to be a program that is executed with only a few simple rules dictating its observation strategy for ease of implementation.

There are several objections to a default parallel program that is only a single design. The program would use resources for JWST, both human and spacecraft (onboard storage and power), as well as MAST archive storage and support. Some of these are trivial but some are not and need a solid reason for their commitment. A single program would cost less but also is less flexible in its science case. It would minimize parallel use from the pool of available time for which JWST users could propose. We argue here that at present these are spacecraft hours that are not being considered since parallel observations are not allowed in concert with any nonimaging observation.

These deep exposures are also default parallel opportunities for dark exposure time. These are critical measurements of the detectors themselves, and time or parallel-mode time will need to be scheduled for separately. This need not be mutually exclusive: both a dark and a parallel observations could potentially be done during the same primary program. Only the onboard data storage limits this dual use. Figure 6 shows the science time and remaining onboard memory for the ERS programs. Most use less than 50% of the storage capability of JWST, even for long exposures (>20 hr) with no primary

![Figure 6](image_url)
| Program ID | Instrument | Target       | Science (hr) | Charge (hr) | Volume (GB) | Rate (GB hr$^{-1}$) | Available (%) |
|------------|------------|--------------|--------------|-------------|-------------|----------------------|---------------|
| 1274       | NIRCAM     | HD209458     | 6.72         | 10.07       | 56.2        | 8.4                  | 3             |
| 1185       | NIRCAM     | HD189733     | 5.47         | 8.29        | 45.7        | 8.4                  | 21            |
| 1366       | MIRI       | WASP-43      | 24.68        | 29.59       | 43.1        | 1.7                  | 26            |
| 1274       | NIRCAM     | HD189733     | 5.0          | 8.28        | 41.8        | 8.4                  | 28            |
| 1274       | NIRCAM     | HD149026     | 7.51         | 10.56       | 37.8        | 5.0                  | 35            |
| 1274       | NIRCAM     | WASP-107     | 7.83         | 10.56       | 36.5        | 4.7                  | 37            |
| 1185       | NIRCAM     | WASP-107     | 7.87         | 10.4        | 34.6        | 4.4                  | 40            |
| 1274       | NIRCAM     | HD209458     | 7.54         | 10.4        | 34.5        | 4.6                  | 40            |
| 1185       | NIRCAM     | GA28 (x3)    | 8.87         | 10.56       | 33.9        | 6.1                  | 34            |
| 1366       | MIRI       | WASP-43      | 11.48        | 15.54       | 43.1        | 1.7                  | 26            |
| 1274       | NIRCAM     | WASP-107     | 12.54        | 16.61       | 41.8        | 4.7                  | 37            |
| 1274       | NIRCAM     | GA28 (x3)    | 13.54        | 17.46       | 39.8        | 6.1                  | 34            |
| 1185       | NIRCAM     | GA28 (x3)    | 14.54        | 18.48       | 37.9        | 4.7                  | 37            |
| 1274       | NIRCAM     | GA28 (x3)    | 15.54        | 19.46       | 35.9        | 2.7                  | 30            |
| 1185       | NIRCAM     | GA28 (x3)    | 16.54        | 20.48       | 33.9        | 4.7                  | 37            |
| 1274       | NIRCAM     | GA28 (x3)    | 17.54        | 21.46       | 31.9        | 2.7                  | 30            |
| 1185       | NIRCAM     | GA28 (x3)    | 18.54        | 22.48       | 29.9        | 4.7                  | 37            |

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Table 1 (Continued)

| ProgramID | Instrument | Target | Science (hr) | Charge (hr) | Volume (GB) | Rate (GB hr⁻¹) | Available (%) |
|-----------|------------|--------|--------------|-------------|-------------|----------------|--------------|
| 1201      | NIRISS     | GH1132 (x4) | 2.28        | 4.1         | 1.8        | 0.8            | 97           |
| 1201      | NIRISS     | GH436   | 1.6         | 4.64        | 1.3        | 0.8            | 98           |
| 1201      | NIRISS     | HATP1   (x2) | 0.25        | 0.87        | 0.2        | 1.0            | 100          |
| 1201      | NIRISS     | HD209458 (x2) | 0.22        | 0.84        | 0.2        | 1.0            | 100          |

instrument excluded. The remaining free space allows in principle for default parallel observations, dark frames, or both for the remaining instruments. We list the primary instrument, science and charged time, and remaining storage in Table 1 for the ERS exoplanet programs.

These observations would not be of the same quality as dedicated observations: dithering strategy—if any—will be dictated by the primary science instrument. Integration times (to limit buffer usage) could be modified to minimize data storage (i.e., DEEP8 observations). The filter choice must be fixed, because filter changes are not possible during a TSO, due to the incurred associated dither (i.e., vibrations from filter wheel motions). In the case of long-period transiting campaigns (i.e., phase-curve observations) and high-contrast imaging with multiple roll angles, then multiple filter information might be obtained in the parallel instrument as well. In the case of grism default parallel observations (if these are added to the program), roll angles will be constrained by the primary observation and no second angle will necessarily be available.

These data will not take the place of dedicated high-redshift observation campaigns that are on the docket for fields with a wealth of complementary (existing) data. Examples of similar programs with HST (ACS snapshot and the WFPC2 B-band pure parallel survey) build a legacy archive that often only reveal their use much later.

For example, the original ACS “schedule-gap” SNAP program (14840, PI: Bellini; Bellini 2016a, 2016b; Bellini et al. 2017) fortuitously monitored the NGC 4993 progenitor of the 2017 LIGO kilonova, which constrained the prenova mass (Cowperthwaite et al. 2017; Levan et al. 2017; Pan et al. 2017). Similarly, a dedicated WFPC2 default parallel program produced long-term value for the archive (Casertano 2002; Wadadekar et al. 2006). Such long-term value has shown to be a critical component of the HST’s legacy and scientific success (e.g., Peek 2017).

The current, accepted JWST Parallel program does not permit parallel observations during transiting exoplanet observations or with multiple instruments. Individually requested parallels would require each team to decide the observation strategy per parallel field. Default parallels would use an objective, community-designed decision tree to dictate the maximum scientific efficiency per default parallel FOV, during an exoplanet primary.

We argue here that the long exposure times necessary for exoplanet observations are an opportunity that cannot be left fallow. Either through an automated observing program—the proposed default parallels or as part of a vigorous and supported proposal process, the parallel time during exoplanet primary observations is a rich resource that needs to be exploited.

Although direct and transiting exoplanet observations are highly likely to occur throughout the lifetime of JWST, if we wait to enact this default parallel program after Cycle-1, we would lose access to parallel observations for the majority of GTO/ERS observations, the only currently existing, approved programs. This would then push back any future follow-up and characterization of plausible detections in our default parallel fields, limiting the value of each FOV. The sooner the JWST project enacts a default parallel program, the greater the legacy of these fortuitous observations will be.

We propose default parallels as a low-cost program to deliver a homogeneous and practical data set to serve a wide variety of science cases, building on the statistical strength of random sampling.

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