IPAC Meeting March 2014

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    - **Key Science Drivers**
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      - *Spectroscopy of Super Earths (Eliza Kempton)*
      - *Atmospheric Dynamics and Weather (Heather Knutson)*
      - IR Photometric Transit Validation, Characterization, and Search for Additional Planets (Drake Deming)
      - *Discussion*
    - **Transit Best Practices**
      - *HST Best Practices (David Sing)*
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      - *Kepler Best Practices (J. Christiansen)*
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      - *Spitzer (IRS and MIPS) Best Practices (Ian Crossfield)*
      - Precision Characterization of Atmospheres with HST (Laura Kreidberg – lunch-time science talk)
      - *Spitzer/IRS Best Practices (Jeroun Bouwman)*
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    - JWST Operations (M. Clampin, J. Stansberry)
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      - *Challenges in Photometric Precision (M. Swain)*
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  - **Meeting Minutes and Notes - Wednesday**
    - **Potential Targets for JWST**
      - *Ground-based RV and Transit Candidates (J. Bean)*
      - *Kepler and K2 Candidates (S. Howell)*
      - TESS Candidates (George Ricker)
      - *M-star Candidate Models (Courtney. Dressing – Charbonneau student)*
      - CHEOPS Candidates (D. Ehrenreich - webex)
      - *GAIA Candidates (Alessandro Sozzetti)*
      - Science Precursor/Planning Needs (David Ciardi)
      - *Stellar Variability Challenges (Peter McCullough)*
      - *IRAC Snapshot Phase Curves (Jessica Krick)*
      - *Discussion*
    - **Instrument Modes for Transits**
      - *NIRSpec (P. Ferruit and S. Birkman)*
      - *NIRISS (R. Doyon, D. Lafreniere)*
      - *NIRCam (Tom Greene)*
      - *MIRI (Tom Greene, P. Lagage)*
      - *Instruments Discussion*
      - *Multi-instrument Characterization Discussion*
    - **Meeting Minutes and Notes - Thursday**
      - *Smallest Characterizable Atmosphere with JWST (D. Deming, W. Traub)*
      - *Discussion*
      - *Laboratory Testbeds (G. Vasisht given by Chas, Roger Smith was also deeply involved)*
      - *Data Simulations and Data Challenges (Stephan Birkmann, Jeff Valenti)*
      - *Data Pipeline Challenges (P. Deroo)*
      - *Discussion*
    - **Community Engagement**
      - *Status of JWST Science Timeline (J. Lee)*
      - *Exoplanet Needs from Commissioning and Early-Release Science (R. Doyon - discussion)*
      - *Ideas for Community Grand Challenges (J. Valenti - discussion)*
      - *White Paper Plans/Preparation (M. Clampin, C. Beichman)*

March 10-13 Meeting at CalTech/IPAC

Convener: Chas Beichman

Workshop Website (use "JWST_transits" + "ipac*March2014" to get in)

Agenda and list of Speakers/Attendees (January 28 version)

Agenda Timeline (html page)

Instrument and Observatory Outbriefs

- MIRI
- NIRCam
- NIRSpec
- NIRISS
- Observatory

Meeting Minutes and Notes - Tuesday

Goals and Introductory Stuff (Beichman, Lunine)

Exo-planet studies are one of 4 main pillars of JWST science: **Should shoot for/expect approximately 25% of JWST time**

White-paper plan:

- Section rapporteurs shold prepare 2-3 page + 2-3 figure summaries from each section (see Chas' email for names)

Key Science Drivers

Spectroscopy of Giant Planets (Jonathan Fortney)

JWST can vastly improve P/T profile retrievals (factors of several improvement in uncertainties) and mixing ratios (from ~2 orders of magnitude down to a factor of a few uncertainty).

- Is atmospheric metal enrichment a hallmark of giant planets?
- Do giant planets share abundance ratios across systems, sizes?
- Are atmospheres far from radiative equilibrium?
- What are the gray opacity sources? (Clouds?)

JWST covers huge range of relevant absorbers:

- NH_3, CH_4, H_2O, CO, CO_2 (major/common)
- HCN, C_2H_2, C_2H_4,C_2H_6
- Unknown unknowns: Phosphorous? Sulfur?

Temperature map uncertainties

- Dayside temperature variations
- Patchy clouds

Spectroscopy of Super Earths (Eliza Kempton)

Super Earths (1 - 10 M_E; 1 - 2.5 R_E) are the most common type of planet in current list (Kepler primarily)

Super Earths are distinct from those in our solar system, and seem to have diverse bulk properties (Mercury-like to water planets) (Howard et al, Nature 2013)

Only 3 orbiting bright stars

Transmission (transit)

- Composition
- scale height
- clouds
- planetary mass/gravity (?)

Emission (eclipse) spectroscopy summary

- composition
- P-T structure
- global emergy budget
- clouds

GJ1214b - mini-Neptune or water world?

Appears to be a high cloud layer, no H2O above them.

Goals for JWST

- Constrain compositions for a diverse set of super-Earths
- Differentiate between cloudy and high-molecular weight atmospheres
- Constrain cloud properties
- Classification of super-Earth (and smaller) exo-planets
- choose between low-cost and high-reward targets

Transmission Depth ~ 20H R_Pl/R_star^2

Eclipse Depth ~ Flux_Pl / Flux_star

Atmospheric Dynamics and Weather (Heather Knutson)

Exotic climates:

Tidally-locked (periods of a few days)

very broadly-organized circulations (as opposed to strong zonal banding in fast-rotators)

Good, because our ability to resolve small-scal structure is poor.

Habitable planets around M-stars are likely to be tidally locked, so this case is actually very important/interesting.

Climate Models

Adapted from solar-system models

Trade-offs (resolution, time step, ...) may be better tuned to solar system object than to the exo-planet of application...

Climate Model Tests

- day/night temperature difference, phase (single emission band adequate to address this)
- very high-SNR eclipses can give 2-D maps (star limb at different angles for ingress and egress).
- temperature structure vs. altitude (need multi-wavelength - HD189733b, 0.3% eclipse depth, 1200K day, 1000K night)
    - WASP 43-b (K.B. Stevenson paper? Models?)
    - Temperature and composition from quite low-R spectral phase curves

Terrestrial planets

- Atmospheres will tend to moderate thermal phase curves relative to airless or thin-atmosphere case
- Clouds still important complication
- Habitable zone of M star would require ~photon-limited precision over timescale of a few weeks.

IR Photometric Transit Validation, Characterization, and Search for Additional Planets (Drake Deming)

HD209458b MIPS 24um (Richardson et al. 2006 ApJ) – no limb darkening, so very good radius determinations.

Atmospheric composition (Fraine et al. 2014, in prep).

Validate weak transits, distinguish transits by M-stars.

Transit timing variations (TTV) (i.e. finding additional planets that perturb the orbit of the known planet) – might only be important enough to do w/ JWST for a system with a known habitable planet.

Transits for M stars, BDs, get higher SNR in the IR than visible.

Implications for JWST

- NOT: reject TESS false positives
- PROBABLY NOT: precise radius determinations
- PROBABLY NOT: TTV confirmation/characerization, except
- Maybe: Habitable zone companion search (VERY long time-spans required, though)
- Spectroscopy will probably be much more commonly used

Discussion

Would be good to start/support a laboratory effort to get absoprption coeffs for relevant species and temperatures.

There is a broad problem with lack of RV/mass measurements for transiting planets, and NASA needs to be encouraged to address this problem.

There are 4 projects in development to get RV for M-dwarfs using IR spectra (groundbased).

Differential phase curves (one wavelength vs. another w/in a single instrument) could provide much higher precision, but you do lose some science if forced to this. Also, emission spectroscopy you may need the absolute level (T_B is relevant), but perhaps color temperature could fill in for that?

Stellar variability will also set a noise-floor for longer-period planets/phase curve studies. Would need some kind of simultaneous monitoring to beat this effect.

Stability tests pre-launch: By splitting light from a single source into many images you can use the average behavior of those sources to track input variation, and use the residual variations to characterize IPSV, etc.

Are there unique/new characterizations that can be done using the relatively high spectral resolution of JWST? Most results (and models) so far focus on relatively low-resolution spectra (R < few hundred).

Transit Best Practices

HST Best Practices (David Sing)

Notes lost due to internet dropout.

HST/WFC3 Best Practices (A. Mandell)

Spectral binning begins to erode SNR if you take it too far.

With WFC3 grism data binning more than ~6 channels starts to have a negative impact.

Kepler Best Practices (J. Christiansen)

Thermal stability critically important, and for many seemingly unrelated observatory subsystems.

Timing and time-tags in the data are very important. Clearly document how all this works.

Spitzer/IRAC Best Performance (Sean Carey)

IRAC detectors very similar to Spitzer 8um IRAC detectors.

Coadding of multiple integrations works up to a point (1/f noise eventually comes in).

Achieved nearly photon-noise limited performance.

Pre-flashing (observing very bright extended source) helped with transient response problem caused by charge trapping at 8um.

Persistence correction - was possible to fit pre/post event slope.

Pointing variations + IPGV (IPSV) magnified by PSF under-sampling caused significant noise.

Pointing variations can become important if they are a significant fraction of a pixel size.

IRAC 4-hr exoplanet data workshop at Boston AAS meeting.

Spitzer (IRS and MIPS) Best Practices (Ian Crossfield)

MIPS dither pattern was a headache for transits.

Detector systematic (slow) response variations also important.

Very few data sets from these instruments (cryogen depletion by the time transits were being found).

Precision Characterization of Atmospheres with HST (Laura Kreidberg – lunch-time science talk)

15 transits of GJ 1214b (Kreidberg et al. 2014 – 30 ppm

- Transit depths very consistent over all 15 observations
- Spatial scanning, perp to dispersion direction, was critical:
    - Gave higher dynamic range
    - 60% duty cycle (5x higher than in staring mode)
    - w/in 10% of photon noise limit

3 phase curves (plus 3 transits, 2 eclipses) of WASP 43-b (K. Stevenson etal. in prep)

- emission spectrum as function of longitude
- 1.4um H_2O feature

5 eclipses combined for high-SNR emission spectrum

- 1.4 um H_2O feature at ~7-sigma
- Very bland atmosphere: no clouds, no temperature inversion at altitudes probed

HD97658b Super Earth, H=5.8, 2, 2 WFC3 transits (Knutsen et al. in prep)

- 1.1 – 1.6 um spectrum ~featureless, but w/ significant variations w/ wavelength

Exo-Earth: Need ~10 ppm per wavelength channel to detect H_2O in Earth atmosphere.

Spitzer/IRS Best Practices (Jeroun Bouwman)

IRS detector a good model for MIRI detector

long-slit configuration

Only 2 published exoplanets:

- HD189732 – C_2H_2, HCN, CO_2 detected. Bouwman, Crossfield etal. in prep.
- HD209458
- 8 – 15 micron spectra
- Broad ~Planckian emission
- Slit-loss correction of <10 of % applied (pointing drifts/jitter)
- flat-field

Pointing knowledge was very important for correcting slit losses – used PU areas of detector to monitor it in real time.

Were 10x worse than photon-noise limit, much of that perhaps due to slit-loss problems.

Discussion

JWST Operations (M. Clampin, J. Stansberry)

Discussion

Need to edit this section, highlight actions... JAS

Beichman: Would WFSC measurement (nominally every 2 days) be deferred for a long phase curve observation?

Rieke: Science target could be used for WFSC measurement. Mark: Yes.

Beichman: Can JWST do table-driven slews. Mark: No. Would require software changes.

Beichman: NIRSpec could benefit most from scanning because it is sampled poorly. Ferruit: NIRSpec has a square aperture, so scanning leads to slit losses.

Bean: Does NIRISS have order overlap? Doyon: No. Greene: Overlap possible when scanning.

Beichman: What is the maximum exposure duration due to the NINT < 65535 limit? Stansberry: Depends on instrument and subarray. Greene: 2.7 hour limit for smallest NIRCam subarray.

Deroo: Does data rate limit observation duration? Stansberry: Only a problem for NIRCam. Working to solve this issue by reading fewer detectors.

Greene: Can multiple exposures be queued up? Stansberry: Yes, but requires script interactions. Jeff: Not the same as queuing integrations. Peter: Is the gap less than a minute.

???: Will observer know when HGA moved? Valenti: JWST has an engineering database with that information. Beichman: Note HGA moves in data products. Flag affected integrations. Valenti: We can work on doing that.

Greene: Can HGA moves be scheduled away from ingress and egress? Valenti: Difficult giving event-driven operations. Acceptable solution was to integrate through HGA moves, which minimizes duration of data gaps, interruption/disruption of detector clocking.

???: Will downloads be DSN? Jeff: Yes. ???: Will other DSN users preempt? Mark: No. ???: 34 m or 70 m DSN? Lunine: Must be 34 m.

Albert: What is the frequency of pointing corrections? Stansberry: 16 Hz centroid measurements. Albert: Not every half hour like Kepler? Doyon: It's continuous.

Beichman: What if first preceding observation fails? Stansberry: Observatory waits. **Beichman: Would be good to start taking data immediately.** Valenti: Need to make sure data recorder won't fill. **Peter: Observatory should slew to exoplanet star right away**. **Valenti: Balzano says that is the plan. Stansberry: Kinzel says that is *NOT* the plan. [NEED TO CHECK]**

Lunine: Could ETC have an exoplanet mode? Stansberry: May not have required knowledge before launch. Hines: Coronagraphy ETC has three limiting cases. Valenti: ETC has concept of observing scenarios. **Beichman: ETC observing scenario would reduce clculation errors by observers.**

Ferruit: ETC should handle the case where the brightest part of the spectrum saturates after two frames but integration continues to improve S/N elsewhere in the spectrum.

Beichman: Isn't that the worst way to do a clock correction?

Christiansen: Kepler users wanted very precise times for asteroseismology. Long time baselines. Calmpin: Took an action to ask spacecraft folks why time update is done this way.

Swain: Does absolute time drift affect detector cadence? Stansberry: No. Carey: Does time stamp come from instrument or spacecraft? Ressler: MIRI repackages times from spacecraft. Rieke: Not true for NIRCam.

Rieke: Should slew to target immediately after preceding visit and start reading out detectors in the desired science mode. McCullough: Should make best effort to store and downlink data obtained while waiting for nominal start of exposure. Very valuable.

Beichman: Huge debates over units of time. Christiansen: Kepler made up their own time units. McCullough: Spitzer users had to beg for software to calculate time. Christiansen: Advocates for TDB.

Crossfield: What happens to stability at exposure breaks? Valenti: As in HST and Spitzer data, the start of each exposure will have a transient due to trap filling, etc.

Ferruit: What is the maximum amplitude possible for FSM offsets? Clampin: 50-60 mas?

Kreidberg: Can readout modes be changed as we learn more about the detectors? Valenti: The readout mode

Beichman: What is the status of parallel science? Valenti: Efficiency working group is developing science case for parallel science. Next step will be engineering concept and cost estimate. Then decision whether to proceed. Greenhouse: Flight segment is capable of parallel science. The question is whether the ground system will support it. Beichman: Parallel science could make exoplanet program more attractive.

???: Will we get every frame on the ground? Valenti: Yes. Rieke: Cannot download every frame from all 10 NIRCam detectors. Valenti: For subarrays with one amplifier for 1 or 2 detectors, we can download every frame. Rieke: Brightest targets require four amplifiers.

???: How can we obtain exposure times longer than 2.7 hours? Valenti: Use larger subarray. ???: Goal is to improve efficiency. Valenti: Goal is to avoid saturation (reset, read, read). Robberto: Could add delay between each integration, which would increase exposure duration for the same number of integrations. Ferruit: Yes, for example by increasing the number of resets before each integration.

Beichman: Can observers choose a sweet spot to place their target? Hines: MIRI template does not have that capability. Beichman: Don't care if observer can choose, but want repeatability. Hines: Templates should achieve that result.

Detector Problems and Features

HgCdTe/ASIC (M. Rieke)

Would be good if our exoplanet subarrays included some reference pixels...

End up w/ SW & LW FOVs skewed, though. How to include ref pixels for grism + SW imaging? grism + SW WL+8 imaging?

New saturation limits for W filters (imaging and grism) accounting for new detectors, OTE reflectivity of 0.94, but pessimistic grism throughput.

32x2048 grism subarray, 32x32 imaging subarray

~2.7 K-band limit for grism, 7 L-band limit for imaging (some math error in this table, though - Marcia will fix)

Reset mode is pixel-by-pixel, with a full frame-time elapsing between the reset and the first read.

Efficiency for NFrames=1, NGroups=2 is 33% if you do CDS slope, is 67% if you eat the kTc noise (frame2-bias)

ASIC microcode does not support read-reset of a pixel in a single clock cycle (that reset mode would result in 100% efficiency).

Latents are modest, are smallest for 5um parts, intermediate for 2.5 um parts, worst for 1.7 um parts (WFC3)

Popcorn noise (ramp jumps up and then sometimes back to baseline w/in a ramp) are actually spontaneous gain changes (not DC offsets).

MIRI Si:As Detectors (M. Ressler)

MIRI arrays are direct descendents of IRAC LW arrays

Outputs are interleaved by columns (4 outputs)

Added reference pixels and reference output, but using those is proving difficult.

Detector is relatively transparent < 6um, results in diffraction patterns off In bump matrix: cross-shaped PSF superposed on OTE PSF.

Subarrays all include column 1 of the detector (just injects dead time if you move the subarray off that). Optical design matched to this (coronagraphs etc. are all near column 1)

Nice exposure/integration/group/frame schematic.

NFrames always = 1 for MIRI

Peculiarities

- Silicon freeze-out: very few free carriers, pixel response times are relatively slow
- Response drifts (slope increases over time)
- Reset anomaly (looks like column variations + 'tree-rings' in the dark frame
- Latents/persistence (few seconds to 10s of minutes timescales). Thermal anneal repairs the latents (~10K temperature rise), minmal noise impact post-anneal.
- CR strikes in readout; readout glow; column pull-down from shorted pixels; bright-source pull-down effect.
- Subarrays really upset the detector - leave latent-like artefacts that persist for ~20 minutes

The good: MIRI detectors are cosmetically great (~200 bad pixels)

Challenges in Photometric Precision (M. Swain)

Notes lost due to internet dropout.

Discussion

Meeting Minutes and Notes - Wednesday

Potential Targets for JWST

Ground-based RV and Transit Candidates (J. Bean)

Targeting brightest stars, maximizing photon-limited SNR may not be best appproach.

Targeting systems w/ most measurable features might be more fruitful (this proposal spurred some controversy though). E.G. objects around smaller stars.

Systematic uncertainties can impact spectra from even very bright targets (e.g. HD97658b).

Targets should have known masses — leverages the impact of JWST result.

M-dwarf Planet Survey

- MEarth Project (Charbonnaeu) Hopkins/AZ and Cerro Tololo (Berta Irwin, Charbonneau (2013))
- APACHE (Italy)
- SPECULOOS (Chile, in development)
- Kepler 2 will include a bunch of M stars

RV Surveys for M stars (very faint in V, Red - nIR better for SNR)

- CRIRES 5 m/s resolutoin (Bean et al 2010)
- Telluric line contam the main problem
- Need new instruments (1 m/s, isolated + fiber fed, on-sky ~2017)
  - CARMENES
  - HPF
  - Maroon-X
  - Spirou

Kepler and K2 Candidates (S. Howell)

Kepler candidates P = 0.5 – 1000 days, R = 0.2 – 20 R_E

50% of Mdwarfs have a terrestrial-sized planet in the habitable zone (Dressing and Charbonneau, 2013)

Kepler candidate properties depend on the assumed/measured stellar properties of the 150k stars in their sample. Those properties change as more data on the stars is acquired, and that changes the planet radii, temperatures,...

Targets are generally pretty faint for JWST work

Kepler-2 (resurrection of Kepler – Howell et al. 2014, PASP)

- Using remaining 2 wheels + solar radiation pressure: jitter on the level of about 0.5 pixel (0.01 pixel for original Kepler)
- 9 ecliptic-plane fields w/ 75-day visits to each. Ecliptic chosen to avoid need to use fuel to counter-act RP torque when solar panels aren't symmetric wrt S/C - Sun line.
- Expect to get to about 80ppm precision, have demonstrated that for m_Kep 9 - 13
- m_R 11 – 16 Mstars, ~4000 M stars per field
- Expect about 50 Mstar companions per year discovery rate
- Expect about 50 F – K star companions per year as well

TESS Candidates (George Ricker)

MIT + Goddard + Orbital + NASA Ames + SAO + STScI

Goals/Expectations:

Discover ~350 Earths/super-Earths orbiting nearby bright stars, 17 in Habitable Zone, 7 in HZ and JWST CVZ

Expect ~1400 sub-neptunes; ~1000 giant planets

FGK 4 – 12 mag; Mdwarfs w/in 60 pc

Mission Overview:

Launch 2017; High-Earth orbit.

570 sq deg FOV, full-frame images every 30min, postage-stamps (few % of FOV) a 1-min cadence. ~All-sky, 2-year duration.

Highest coverage coincides w/ JWST CVZ.

M-star Candidate Models (Courtney. Dressing – Charbonneau student)

Local population strongly dominated by M-dwarfs

Small size means stronger transit/eclipse signals from planets

Sample: 2200 stars w/in ~20 pc based on various catalogs

Companion rates: from Kepler

Predict:

- ~8 transiting planets per 0.5 mag bin, Kmag 8 – 12
- nearest transiting Earth-like planet predicted to be ~9pc from Earth

NOTE: These models are probably useful for predicting TESS production of candidates, but isn't a direct prediction based on qualities of any particular expected survey.

CHEOPS Candidates (D. Ehrenreich - webex)

Goal to detect Earth – Ice-Giant sized planets, Launch 2017 ESA

Under-dense planets are easier to characterize

JWST characterization space is huge compared to what can be done w/ HST

CHEOPS will follow-up known systems

Ground-based transits

ground-based RV candidates

Kepler-2, TESS

20% of time will be open to guest observers

TESS/CHEOPS synergy will provide better candidates for characterization with JWST

Definition Study Report avail at sci.esa.int/cosmic-vision/

GAIA Candidates (Alessandro Sozzetti)

Intermediate data releases

Launched 12/2013

L+22, +28, +40, +65 months

10 uas precision at end of mission ($m_G < 13$), <100 uas $m_G < 18$, < 1mas $m_G < 20$

Sozetti 2011 exoplanet discovery space w/ GAIA

Identifying candidate transits for JWST study is challenging, will require dedicated follow-up.

- Saturns w/ P > 60d (~cold compared to some current exoplanets, only some will transit, high-eccentricy bias?)
- Host stars w/ full range of spectral types, metallicities, ages, V < 14
- Possibly transiting hot jupiters, V > 14

Science Precursor/Planning Needs (David Ciardi)

Current precision of orbital periods gives <1 hour uncertainties for the bulk of (non-Kepler) transit systems (excludes systematic uncertainties/errors)

Secondary eclipses much worse problem:

- eccentricity, argument of periastron not known except for systems with observed eclipses or RV constraints on eccentricity
- If eccentric and inclined, can have a transit (near periastron) but no eclipse (if eclipse near apoastron)

RV information can really help with eclipse timing prediction problem, detection of eclipses may also contribute but is hard.

Stellar variability can really impact phase curve measurements, should be known for targets of such proposals.

> TESS will characterize stellar variability on relevant timescales, so will provide some useful variability characterization along w/ candidates.

Smallest known planets are around the quietest stars (detection bias), so JWST may actually be easier to use for smaller planets (on average).

Variability is weaker at longer wavelengths (spot contrast is low beyond the Planck peak), so even variable stars may be OK to observe w/ JW at longer wavelengths.

Stellar Variability Challenges (Peter McCullough)

Effects important for transits and phase curves, but less so for eclipse

Ideal hosts: Bright, small, stable

Effects summarized e.g. in Pont et al. 2013

- Star spots can affect normalization (i.e. derived R_P), and can have molecules (e.g. H2O) in them...
- IR (~L-band) data can allow you to measure spot temperatures, constrain stability of molecules
- Nice example of transits observed by HST and Spitzer (planet in polar orbit around star...???)
- Even bland star spots can have effects that mimic spectral features

HD189733 (K, T=5000K, spotted though, 5% coverage so 2x larger than planet, ~4000K spot T)

> See McCullough et al. 2014

IRAC Snapshot Phase Curves (Jessica Krick)

Spitzer program 80016

Is it possible to recover phase curves using many separate, randomly-spaced observations?

40 observations of a single known-transiting system

Analyze using gain-map correction data (gain variation is about 7% w/in an IRAC channel-2 pixel)

Pointing reconstuction doesn't use the target itself (advantageous, but not clear/stated why) (or maybe it does use the target itself...)

> Position of the source determined to well under 0.1 pixel, gain-map sweet spot is about 0.3 pixel across.
>
> Non-linearity can potentially impact accuracy of the gain-map correction.

Discussion

Emphasize need for M-dwarf RV progress in the white paper (Lunine)

Statistical models showing uncertainty in eclipse **timing** (using known distribution of eccentricities as an input) might be a good way to leverage NASA resources to get RV measurements for a significant sample of JWST transit/eclipse candidates.

Instrument Modes for Transits

NIRSpec (P. Ferruit and S. Birkman)

'Slit' (1.6" square) mode probably most useful for transits

IFU (3"x3") probably very sensitive to positioning errors due to its design, unlikely to be very useful

Prism (R = 30 - 300) 0.6 – 5.2 um; R=~1000; R = ~300 resolution modes available w/ slit, IFU, MOS

Spectral gap between detectors is 145 pixels, but only impacts high-res spectra (med- and low-res fall on single detector).

Spectra are aligned with detector coumns (i.e. can't really use stripe-mode subarrays...)

Somewhat restrictive subarray configuration rules, smallest subarray is 1024 total pixels

Idle mode is full-frame, 2 resets, between **exposures**. Using many **integrations** is therefore desirable to avoid upsetting detectors mid-observation.

32 pixel high is effective narrowest aperture due to spectrum curvature; 32=2048 is expected subarray for bright targets.

PSF is highly undersampled shortward of about 3 microns.

ADC saturates before the detector - DO NOT WANT TO SATURATE THE ADC! (~= 77k e-). Defined saturatoin at 85% of that level.

www.cosmos.esa.int/seb/jwst/exoplanets for summary charts of NIRSpec Exo-planet

Different gratings put source on slightly different locations on the detector - might be better to do any single transit observation using a single grating setting.

Considering running at higher detector bias so that pixels (rather than the ADC) saturates. Saturation increased by up to 2x, but more hot pixels. Bias change requires many hours of settling. Would prefer 'campaign-mode' if high-bias is implemented, to minimize inefficiency of waiting for setttling.

Considering a TA implementation using the target itself, for the 1.6" aperture only (can get direct images that allow this).

NIRISS (R. Doyon, D. Lafreniere)

R=700 grism slitless is designed for transits (Single Object Slitless Spectrograph)

Weak cylindrical lens + grism spreads light in cross-dispersion direction by about 20 pixels

0.7 – 2.2 um grasp in 1st order (2nd order overlap set long LW limit)

Current grism has peak throughput of about 40% - will swap for new part w/ ~80% throughput

New grism will be rotated 90deg to kill ghosting problem - doesn't this mean they can't use stripe-mode subarray?

NIRSpec is much more sensitive < 1um due to it's grism performance

Saturation (will these get worse by 1.5 mag due to 90deg clock change plus 0.75 mag due to higher throughput?

- at about J=8.1 (2 frames, 70k e-) for 256x2048 that includes entire 1st-O spectrum
- at about J=7 for 80x2048 subarray that clips spectrum < 0.9 um

These limits include higher throughput of new grism and dispersion // to columns (single-output subarray).

Wheel repeatability means spectral trace may tilt a bit differently for different visits (2-3 pixel wander at the ends of the spectrum)

Data simulations: See Kaltenegger et al. 2009.

NIRISS Optical Simulator coming together, includes flux monitor on source brightness.... (interesting!)

NIRCam (Tom Greene)

Do we need ancillary imaging from off-module for pointing reconstruction, esp. for the grism data? Photometry we may be able just use the target to get centroids.

Intra-pixel response (Deming 2009 PASP - NIRSpec part) varies significantly, but well-sampled PSF in NIRCam will help a lot. Even NIRSpec does 10^-4 repeatability w/ no correction for IPSV/IPRV.

What about using the Lyot stops and even ND spots to do really bright targets?

MIRI (Tom Greene, P. Lagage)

R ~ 2000 IFU probably best for transits

3 1024^2 Si:As detectors: 1 imager, 1 SW spectra (< 12um), 1 LW spectra (>12 um), 7K operating temperature

Nyquist sampled > 6.9um

LRS < 14 microns (optics opaque longward of that).

Instruments Discussion

Would like to see map of efficiency vs. stellar magnitude

This will really only matter for very brightest sources. Once you get to 5 groups in an integration, efficiency is 80%.

Loic Albert (NIRISS) showed a nice plot of senstivity or SNR vs. stellar mag and wavelength. Need that for all instruments.

Actually, NIRSPec has similar plots, very nice summary of performance.

NIRSpec guesses their IFU will not be well suited for high-precision photometry.

MIRI MRS is also an IFU, with potential for jitter induced photometry variations. That possible systematic error source should be characterized.

Multi-instrument Characterization Discussion

xxx

Meeting Minutes and Notes - Thursday

Smallest Characterizable Atmosphere with JWST (D. Deming, W. Traub)

Really care about the *coldest* and *densest* planet if trying to think about difficulty of characterization of the atmosphere:

- Transmission signal ~ T_atm / rho_planet
- Eclipse signal ~ T R^2

Restrict consideration to Earth-like: rho= 5g/cc, T=300K

Thermal emission from secondary eclipse

MIRI 11.3um, 1 R_E, 13pc: >~ 0.36 uJy,

GJ1214-like host: 90 min eclipses

Need 4 eclipses to get 3.2 sigma (eclipse depth is 2.e-4)

Question/Comment: Neglects photon-noise from the host – that's probably the dominant noise source, so this estimate may be very (very) optimistic.

Transmission detection of H_2O - scale WFC3 performance by factor of 2.4, as if it were on JWST

Expect 12ppm based on this scaling (somewhat pessimistic because it neglects low duty-cycle (~50%) of WFC3)

Discussion

Performance predicted from JWST simulator (Clampin) and presented in Batalha 2013 may be somewhat optimistic.

ExoP white paper should discuss applicability of JWST sim for predictions of acievable SNR/ppm levels, recommend best practices.

Important to distinguish between raw detection limits and differential (i.e. spectral shape) limits.

Laboratory Testbeds (G. Vasisht given by Chas, Roger Smith was also deeply involved)

CalTech testbed (Clanton et al. 2012)

- H1RG 1.7 um cut-off detector, Leach controller
- Can project various types of scenes onto the detector
- Can move source positions at few-hundredths of pixel shift

Can get down to about 50ppm (Allend deviation 5e-5) in 10^4 sec (not sure what count rates) when data is de-correlated

No flat-field applied (HST data is frequently used w/o flat-field)

Averageing multiple sources (proxy for having a source spread out e.g. by a lens or grism) gives floor at about 15ppm

Jitter of a few 10ths of pixel gives photometry changes of 1 – 2 %

Can also combine 2 sources with contrast up to about 1000 with different spectral shapes

'Spectrum' is simulated w/ a scanned monchromatic source and a spatial mask

getting about 80k e- in few tenths of a second

stability of source < 0.1%

Include 'jitter'

Take data in ~100sec exposures composed of many very short (single-frame?) ramps

See transients in response over the 100 sec of ~< 0.1%

Get down to < 100ppm in 100sec (but 100 sec is the length of the exposures, so can probably push past that).

Future Improvements:

H2RG (SW? LW?)

ASIC

NIRISS also working on a testbed

Data Simulations and Data Challenges (Stephan Birkmann, Jeff Valenti)

Simulations (Birkman)

Agree on a set of simulation guidelines/assumptions (can improve these systematically as we gain knowledge)

Present summary results in a consistent way, E.G. as PPM vs. wavelength for standard integration/exposure time.

Choose 2 participants per IDT to participate in defining these inputs and getting the work going

Data Challenges (Valenti)

Desire to have data simulator released (and documented at some level)

That allows assessment of derivatives of performance vs. various assumptions (IPSV, jitter, ...)

Include actual calibration products? (flats, darks, latents, IPSV, ...)

Is there value in implementing simulator that includes known effects but not those that we don't know about?

Is it better to rely on test-bed results instead?

IDT folks seem to feel they need to participate in both the sims and the data challenges.

Data Pipeline Challenges (P. Deroo)

No data pipeline delivers the needed phtometric precision – speciallized post-processing required in every case.

Users/observers should do a better job of desribing in detail all steps in their calibrations/reductions/extractions.

There is interest, based on experience, in being able to retrieve detailed instrument and even S/C TLM to look for correlations with systematics in the data.

We may want to take inputs from science user groups (such as ExoPlanet WG) re. what things would be good to include in FITS headers.

Perform null-test observations during commissioning or ERS using a Kepler target shown to be stable to ~10ppm (8hr transit baseline; 4 day phase-curve baseline)

Discussion

Community Engagement

Status of JWST Science Timeline (J. Lee)

Commissioning-phase data are embargoed until there is a report formulated and allows their release.

GTO ddln/target select: 3/2017

4000 hrs (~10% of JWST time)

GO Call 11/2017, ddln 2/2018

Cycle-1 Early-release science/First-look concept (JSTAC Recommendation)

1st Look: Non-proprietary data sets that can be used to demonstrate basic capabilities of JWST instruments

ERS: DDT time (expect community input/proposals will be allowed)

Scope, method of selection of modes/targets is TBD.

ERS/1st Look can be thought of as similar to the Spitzer & Herschel *Science Verification* phases.

There are about 6000 hrs per year available for science after calibration programs and overheads.

Spitzer uses about 25% of its time for exo-planet science.

There is also an *ERO* program envisioned, with time coming from project (short, flashy observations - PR).

Why is there no large-scale/treasury program call pre-launch?

Probably premature/risky until on-orbit performance has been demonstrated to some degreee?

Programs can be adjusted if on-orbit performance comes in below expectations.

Such programs would be sensible if they are limited to easier modes and targets.

Exoplanet Needs from Commissioning and Early-Release Science (R. Doyon - discussion)

Commissioning: do Peter Deroo's null-test target in a couple of instruments/modes.

ERS:

~2 targets observed in a couple of basic observing modes. Perhaps use Kepler-2 or RV target lists.

- HD20948 full spectrum (too many modes/time?)
- Do just L-M band spectrum since that is unique to JWST relative to HST/Spitzer
- Pick a very stable host star

Pick one instrument from the H2RG crowd since limits will be pretty similar? No - different output responses (e.g. NIRSpec reset modes)

Do an eclipse observation using 3-5 um spectra, compare that to existing Spitzer/IRAC eclipse data

- A bit easier (higher contrast)
- Do the Spitzer cold-mission targets (4-bands), and include MIRI?

Marcia et al. will get buy-in from the SWG, but come back to ExoP WG for more inputs (target, mode selection, ...)

JSTAC will eventually recommend how ERS/ERO programs will be selected.

Would be good if targets were in/near the CVZ for robustness against schedule changes.

Go for something from each of the 4 instruments on a single target?

- Short events would be good, to limit total time needed
- ~50 hot jupiters w/ Spitzer eclipse results
- Want something with a significant signal – some hot Jupiters look pretty isothermal (weak spectral features/black-body like)

Key instrument modes for an ERS transit:

- NIRISS emission .6 - 2
- NIRSPec 1 grating in 2 - 5 um
- NIRCam grism to get rest of 2 - 5 um
- MIRI LRS

Do a longer wavelength transit for GJ1214?

No – too 'sciency', will be done in GO1 anyway.

Yes – a limited observation on a significantly more demanding target.

Is there a need to consider brown-dwarf science needs during ERS?

No - demands are significantly less demanding

Maybe - have a workshop on detecting variability in cool objects (depends much more on absolute stability, not differential measurements)

GO teams should engage the GTO/IDT teams

Will result in better overall science return

GO teams will benefit from IDT expertise.

What about making the out of transit data immediately public, but keeping the transit itself proprietary?

There was a lot of positive reaction to this concept. It is similar to coronagraphy PSF reference star concept.

Ideas for Community Grand Challenges (J. Valenti - discussion)

See notes above – given in concert w/ Stephan Birkman's talk.

White Paper Plans/Preparation (M. Clampin, C. Beichman)

Deadline for drafts of sections are due April 18.

See charts above for subsection authors, rough outline, schedule detail, etc.