WFIRST can do it too:

On the discovery of transiting planets and binary stars with WFIRST

Avi Shporer
Sagan Fellow, JPL
Eclipse/transit survey 101:
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- Many **epochs**:
  System is out-of-eclipse most of the time
Eclipse/transit survey 101:

- Many **epochs**: System is out-of-eclipse most of the time

- Many **stars**: Most binary systems will not show eclipses
WFIRST as an eclipse survey:
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# Epochs:
6 seasons x 72 days/season x 96 epochs/day - lunar passage = ~33,000
WFIRST as an eclipse survey:

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# Stars
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**# Stars**
- \( \leq 1\%: \) 50 M
- \( \leq 0.1\%: \) 1 M
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Precision:
- \( \sigma(H) \approx 10^{(2/15)(H-15)} \) ppt
- \( \sigma(H=15) \approx 0.1\% \)
- \( \sigma(H=21) \approx 1\% \)
WFIRST as an eclipse survey:

**Opportunity!!!**

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WFIRST as an eclipse survey:

Opportunity!!!

Noise = 1 %
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Transiting planets with WFIRST
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Why do we need more (hot Jupiter) planets?
Transiting planets with WFIRST

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Fainter host stars
Transiting planets with WFIRST

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273 Known transiting planets with measured distance (NASA Exoplanet Archive)
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Why do we need more (hot Jupiter) planets?
Fainter host stars $\iff$ more distant host stars
$\implies$ Planets orbiting a different stellar population

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Planets orbiting a different stellar population
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Planets orbiting a different stellar population

- Beyond the solar neighborhood
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Transiting planets with WFIRST

*Planets orbiting a different stellar population*

• Beyond the solar neighborhood
Beyond the solar neighborhood
- Galactic disk

Transiting planets with WFIRST

Planets orbiting a different stellar population
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Planets orbiting a different stellar population

• Beyond the solar neighborhood
  - Galactic disk
  - Galactic bulge
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\[
\text{Depth} = \left( \frac{R_{\text{Jupiter}}}{R_{\text{G}_2}} \right)^2 = 1 \%
\]
Transiting planets with WFIRST

Planets orbiting a different stellar population

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Depth = \left( \frac{R_{\text{Jupiter}}}{R_{\text{M}2}} \right)^2 = 4 \%
Transiting planets with WFIRST

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  - M4: V-H = 5.0, G4: V-H = 1.5

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  - short periods, short eclipses
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Science cases:
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Planets orbiting a different stellar population

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• Planet occurrence:
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  - Hot Jupiter occurrence beyond the solar neighborhood.
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• Planet occurrence:
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Science cases:

169 planets
$P < 10 \, \text{d}$
$R_P > 0.5 \, R_J$

Hot Jupiter host metalicity (NASA Exoplanet Archive)
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  - Transit *and* microlensing occurrence with same instrument.
Transiting planets with WFIRST

Planets orbiting a different stellar population

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  - Transit and microlensing occurrence with same instrument.

Science cases:
WFIRST SDT Report (Spergel+2015)
Transiting planets with WFIRST

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- M-dwarfs:
  - Hot Jupiter “desert”.

radius-flux correlation (and radius-a_tide/a_grav correlation).
Transiting planets with WFIRST

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- **White dwarfs:**
  - Planetary systems future fate.
Transiting planets with WFIRST

Planets orbiting a different stellar population
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The challenges (partial list):
Transiting planets with WFIRST

Planets orbiting a different stellar population

The challenges (partial list):

- Blending:
Transiting planets with WFIRST

*Planets orbiting a different stellar population*

The challenges (partial list):

- **Blending:**
  - Pixel centroid analysis.
Transiting planets with WFIRST

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Batalha+10 (see also: Bryson+13)
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- **Eclipsing binary stars as false positives:**
Transiting planets with WFIRST

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The challenges (partial list):

- **Blending:**
  - Pixel centroid analysis.

- **Eclipsing binary stars as false positives:**
  - Color dependent depth variation \((W, Z)\).
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- Blending:
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- Blending: Pixel centroid analysis.
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Transiting planets with WFIRST

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The challenges (partial list):

- **Blending:**
  - Pixel centroid analysis.

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  - Color dependent depth variation (W, Z).
  - Secondary eclipse deeper in NIR.
Transiting planets with WFIRST

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- **Blending:**
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- **Eclipsing binary stars as false positives:**
  - Color dependent depth variation ($W$, $Z$).
  - Secondary eclipse deeper in NIR.

- **Photometric stability between exposures.**
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Resources:
WFIRST-AFTA SDT Report
Gould+2015, JKAS, 48, 93
LSST Science Book 2009
https://wfirst.ipac.caltech.edu

WFIRST meeting, Pasadena, March 1, 2016