What is a Transiting Exoplanet?

- Planet passes in front of its host star
- Do not see the planet directly, but it blocks some of its host star's light
- Measure brightness over time -> light curve
- The amount of stellar dimming indicates the relative sizes of the planet and star
- Can measure the planet mass from the wobble of the star due to the planet's gravity (Doppler effect -> radial velocity)
- Planet density => bulk composition (gas, water, rock)
- Study properties of planet in great detail when host is bright
KELT-North Telescope

- KELT – Kilodegree Extremely Little Telescope
- Operated by OSU, Vanderbilt, and Lehigh
- High-end 16 mega-pixel digital camera (or a tiny 42 mm telescope)
- Field of view: 26 x 26 degrees (~50 x 50 moons)
- Located at Winer Observatory in Arizona
- Has been monitoring skies since 2006
- Announced 3 planets already (KELT-1b, KELT-2Ab, KELT-3b)
Find the Planet in KELT Field 8
KELT-N Image Resolution

- Tiny telescope (42 mm aperture)
- Many stars at once in full image
- But, low resolution and blended stars

KELT-N image of KELT-6 (15’ x 15’)

Same field from typical telescope (from DSS)
Original KELT-6 Light Curve

- Period = 7.8 days
- Duration = 5.5 hours
- Depth = 6 mmag

Phased Light Curve

KELT-6b from KELT-N Telescope
What Caused Dip in Light Curve?

- Target EB + blended neighbor stars
- Neighbor EB (NEB) blended with target
- Blended EB
- Hierarchical triple
- Artifact
- Planet!
Follow-up Photometry at University of Louisville

- MORC24 telescope
- 0.6 meter telescope
- Operated by UofL
- Near Louisville, KY
KELT Field 8
Follow-up High Precision Light Curve

KELT-North Light Curve

Relative Magnitude vs. Phase

MORC UT 2013-02-24 (r)
Need Even More Resolution!
KECK 10 meter Telescope

KELT-6 / BD+312447

0.4"

NIRC2, K'
2012–12–07 UT
The KELT-6b Discovery Adventure

- Hint of planet in KELT light curve
- Maybe V-shaped?
  => suggests eclipsing binary stars

- No mass detected with 1.5 m TRES RVs
  => Wrong star? Spurious signal? Mass too low to detect?

- Longer 7.8 day orbit plus 5.5 hour transit
  => infrequent full transits from ground (not to mention clouds!)
Luck and Patience Prevailed!

- Caught the end of a transit from UofL telescope

- Asked for precious time on Keck for precision RVs +3 months => confirmed Saturn mass planet!

- Only two full transits observable in U.S. in 2013

- Clear sky at UofL Moore observatory both nights! => 5 full transits from 3 telescopes - confirmed! (longest full transits observed from ground telescope)
Global Fit and System Characterization

5 Full Light Curves
Phased and Binned

Eccentricity-Fit Orbit
RV Slope Removed
-0.239 m/s/day

HIRES RVs†

5 Full Light Curves
Phased and Binned
**KELT-6b: A (metal) poor cousin of HD209458b**

- KELT-6b is similar to the best-studied exoplanet, HD209458b
- EXCEPT, that it was formed in an environment poor in elements heavier than hydrogen and helium ("metal"-poor)

<table>
<thead>
<tr>
<th></th>
<th>KELT-6b</th>
<th>HD209458b</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Planet Mass (M_J)</strong></td>
<td>0.4</td>
<td>0.7</td>
</tr>
<tr>
<td>**Planet Radius (R_J)</td>
<td>1.2</td>
<td>1.4</td>
</tr>
<tr>
<td><strong>Gravity on “surface” (x Earth)</strong></td>
<td>0.8</td>
<td>0.9</td>
</tr>
<tr>
<td><strong>Star Mass (M_{sun})</strong></td>
<td>1.1</td>
<td>1.1</td>
</tr>
<tr>
<td><strong>Star Temp (K)</strong></td>
<td>6100</td>
<td>6065</td>
</tr>
<tr>
<td><strong>Planet Temp (K)</strong></td>
<td>1325</td>
<td>1400</td>
</tr>
<tr>
<td><strong>Metallicity (relative to Sun)</strong></td>
<td>50%</td>
<td>100%</td>
</tr>
</tbody>
</table>
Opportunity for Comparative Planetology

- KELT-6b is similar to the best-studied exoplanet, HD209458b—except it was formed in a metal-poor environment.

- “Metals” are an important component in the formation of planets and their atmospheres, and even play a role in the behavior of clouds and temperature profiles.

- Host star is bright enough for detailed studies and is amenable to a host of ground and space-based studies.

- KELT-6b offers the ability to do comparative studies:
  - Exoplanet atmospheres
  - How planetary systems form and evolve.
Evidence of Another Companion

Slope in HIRES RVs

KECK/NIRC2 AO

No Acceleration in CfA Dig. Sp. RVs
KELT-6b Summary

- KELT-6b is a metal-poor cousin of HD 209458b
- Host is bright enough for detailed planet studies
- Benchmark system for comparative analysis
  - Exoplanet atmospheres, in particular causes of temperature inversion
  - Evolution and emplacement of hot gas giant planets
- RV evidence of tertiary body

Karen Collins
University of Louisville
karen.collins@physics.louisville.edu