Venus: The Nearby Exoplanet Laboratory

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Venus: The Making of an Uninhabitable World

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“If Venus did not exist in our solar system, we would not dare to imagine it”
- Francois Forget
New Kepler Planet Candidates

As of July 23, 2015

Size Relative to Earth (Radius)

Orbital Period in Days

Total = 4,696
New Kepler Planet Candidates
As of July 23, 2015

Total = 4,696
The Venus Zone

- Outer edge defined by runway greenhouse
- Inner edge defined by atmospheric mass loss

The Venus Zone

- Define $\eta(\text{Venus})$ as fraction of stars with at least one terrestrial planet within the Venus Zone

- For M stars: $\eta(\text{Venus}) = 0.32 \pm 0.05/0.07$
- For GK stars: $\eta(\text{Venus}) = 0.45 \pm 0.06/0.09$

Venus/Earth Spectra

### Table 1

**System Parameters for Kepler-1649**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Transit and Orbital Parameters</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Orbital period $P$ (d)</td>
<td>$8.689090 \pm 0.000024$</td>
<td>A</td>
</tr>
<tr>
<td>Midtransit time $E$ (HJD)</td>
<td>$2454966.2348 \pm 0.0026$</td>
<td>A</td>
</tr>
<tr>
<td>Scaled semimajor axis $a/R_*$</td>
<td>$60.6 \pm 8.1$</td>
<td>A</td>
</tr>
<tr>
<td>Scaled planet radius $R_p/R_*$</td>
<td>$0.0391^{+0.0014}_{-0.0022}$</td>
<td>A</td>
</tr>
<tr>
<td>Impact parameter $b = a \cos i/R_*$</td>
<td>$0.34^{+0.15}_{-0.34}$</td>
<td>A</td>
</tr>
<tr>
<td>Orbital inclination $i$ (deg)</td>
<td>$89.57 \pm 0.32$</td>
<td>A</td>
</tr>
<tr>
<td><strong>Derived stellar parameters</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Effective temperature $T_{\text{eff}}$ (K)</td>
<td>$3240 \pm 61$</td>
<td>B</td>
</tr>
<tr>
<td>Spectroscopic gravity $\log g$ (cgs)</td>
<td>$4.98 \pm 0.22$</td>
<td>B</td>
</tr>
<tr>
<td>Metallicity [Fe/H]</td>
<td>$-0.15 \pm 0.11$</td>
<td>B</td>
</tr>
<tr>
<td>Mass $M_*$ ($M_\odot$)</td>
<td>$0.219 \pm 0.022$</td>
<td>C</td>
</tr>
<tr>
<td>Radius $R_* ($$R_\odot$)</td>
<td>$0.252 \pm 0.039$</td>
<td>C</td>
</tr>
<tr>
<td><strong>Planetary parameters</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Radius $R_p$ ($R_\oplus$, equatorial)</td>
<td>$1.08 \pm 0.15$</td>
<td>A,B,C</td>
</tr>
<tr>
<td>Orbital semimajor axis $a$ (AU)</td>
<td>$0.0514 \pm 0.0028$</td>
<td>D</td>
</tr>
<tr>
<td>Incident Flux ($S_\oplus$)</td>
<td>$2.30 \pm 0.65$</td>
<td>D</td>
</tr>
</tbody>
</table>

**Note.** —

A: Based on *Kepler* photometry.
B: Based on an analysis of the Palomar spectra.
C: Based on stellar evolution tracks.
D: Based on Newton’s version of Kepler’s Third Law and total mass.
Kepler-1649b: A Possible Venus Analog

SURFACE AIR TEMPERATURE

SURFACE AIR TEMPERATURE (C)

Data Min = 70.6, Max = 287.0, Mean = 128.7

Transiting Exoplanet Survey Satellite (TESS)
Transiting Exoplanet Survey Satellite (TESS)

Transiting Exoplanet Survey Satellite (TESS)

Venus Zone

C3PO
- 3 year ext
- 1 year ext
- primary mission

The Exoplanet Case for Venus

Stephen R. Kane¹, Giada Arney², David Crisp³, Shawn Domagal-Goldman⁴, Lori S. Glaze⁵, Colin Goldblatt⁶, David Grinspoon⁷, James W. Head⁶, Adrian Lenardic⁷, Cayman Unterborn⁸, Michael J. Way⁹

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Key points:
1. The field exoplanetary science is now routinely providing discoveries of terrestrial-size planets and the characterization of their structure and atmospheres is becoming a primary focus.
2. The boundaries of habitability are best understood through the study of the extreme environments present on Earth and Venus.
3. There are many outstanding questions regarding our sister planet Venus that are critical to answer in order to better constrain models for exoplanets.