Andrea Isella
Department of Physics and Astronomy
Rice University
### The Solar System

<table>
<thead>
<tr>
<th>Planet</th>
<th>Distance from the Sun (AU)</th>
<th>Planet radius/Earth radius</th>
<th>Planet mass/Earth mass</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mercury</td>
<td>0.4</td>
<td>0.06</td>
<td>0.06</td>
</tr>
<tr>
<td>Venus</td>
<td>0.7</td>
<td>0.95</td>
<td>0.8</td>
</tr>
<tr>
<td>Earth</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Mars</td>
<td>1.5</td>
<td>0.5</td>
<td>0.1</td>
</tr>
<tr>
<td>Jupiter</td>
<td>5.2</td>
<td>70</td>
<td>319</td>
</tr>
<tr>
<td>Saturn</td>
<td>9.5</td>
<td>9</td>
<td>95</td>
</tr>
<tr>
<td>Uranus</td>
<td>19.6</td>
<td>4</td>
<td>15</td>
</tr>
<tr>
<td>Neptune</td>
<td>30</td>
<td>3.9</td>
<td>17</td>
</tr>
</tbody>
</table>

1 AU = 92,955,887.6 miles
A Jupiter-mass companion to a solar-type star

Michel Mayor & Didier Queloz
Geneva Observatory, 51 Chemin des Maillettes, CH-1290 Sauverny, Switzerland

The presence of a Jupiter-mass companion to the star 51 Pegasi is inferred from observations of periodic variations in the star’s radial velocity. The companion lies only about eight million kilometres from the star, which would be well inside the orbit of Mercury in our Solar System. This object might be a gas-giant planet that has migrated to this location through orbital evolution, or from the radiative stripping of a brown dwarf.
an Explosion of Discoveries

As of yesterday, astronomers have discovered 1642 planets outside the Solar system
Can we take pictures of these planetary systems?

Do they look like our own Solar System?

Are these planets habitable?
Can we take pictures of these planetary systems?

Do they look like own Solar System?

Are these planets habitable?
Only in a few cases and when the planets are far away from their star.
Can we take pictures of these planetary systems?

Do they look like our own Solar System?

Are these planets habitable?
Not really!
Can we take pictures of these planetary systems?

Do they look like own Solar System?

Are these planets habitable?
Most of them are not! They are either too cold or too hot.

A few might be habitable!
How do planets form?
A Planet Nursery

Orion Nebula

M 42

Orion Nebula
HL Tau
400 light years away
20,000,000,000,000,000 miles away
age? less than 1 million year
1 Million years

4.6 Billion years
Tiny tiny!
The Atacama Large Millimeter Array (ALMA)
The **Atacama Large Millimeter Array (ALMA)**

5,000 meters above sea level
The Atacama Large Millimeter Array (ALMA)

54 Antennas of 12 meters in diameter
12 Antennas of 7 meters in diameter
The Atacama Large **Millimeter** Array (ALMA)

ALMA observes light at wavelengths between 0.2 mm to 3 mm.

We cannot see this light with our eyes!
The Atacama Large Millimeter Array (ALMA)

NRAO = National Radio Astronomy Observatory
NSF = National Science Foundation
US Tax Payers!
The Atacama Large Millimeter Array (ALMA)

NSF contribution: $0.5 B over 11 years + $34 M yearly
$0.3 per US tax payer PER YEAR over a period of 15 years

NRAO = National Radio Astronomy Observatory
NSF = National Science Foundation
US Tax Payers!
HL Tau:
A new born planetary system
HD 163296:
A new born planetary system

24 December 2015
HD 163296: A new born planetary system

24 December 2015
HD 142527: A planetary system in formation around a binary star
HD 142527: A planetary system in formation around a binary star
The Composition of the Earth crust

- Oxygen: 47%
- Silicon: 28%
- Aluminum: 8.1%
- Iron: 5.0%
- Calcium: 3.6%
- Sodium: 2.8%
- Potassium: 2.6%
- Magnesium: 2.1%
- Others: 0.8%

© John Wiley & Sons, Inc.
HD 142527: A planetary system in formation around a binary star
HD 142527: A planetary system in formation around a binary star
HD 142527: A planetary system in formation around a binary star

COMETS VISITED BY SPACECRAFT

1P/Halley
16 x 8 x 8 km
Vega 2, 1986

81P/Wild 2
5.5 x 4.0 x 3.3 km
Stardust, 2004

67P/Churyumov-Gerasimenko
5 x 3 km
Rosetta, 2014

103P/Hartley 2
2.2 x 0.5 km
Deep Impact/EPOXI, 2010

19P/Borrelly
8 x 4 km
Deep Space 1, 2001

9P/Tempel 1
7.6 x 4.9 km
Deep Impact, 2005

Modified 2014-08-04. For the latest version of this image, visit planetary.org/cometscale
Tempel 1 and Hartley 2: NASA / JPL / UMD. Churyumov-Gerasimenko: ESA / Rosetta / NavCam / Emily Lakdawalla. Wild 2: NASA / JPL. Montage by Emily Lakdawalla.
Thank you!