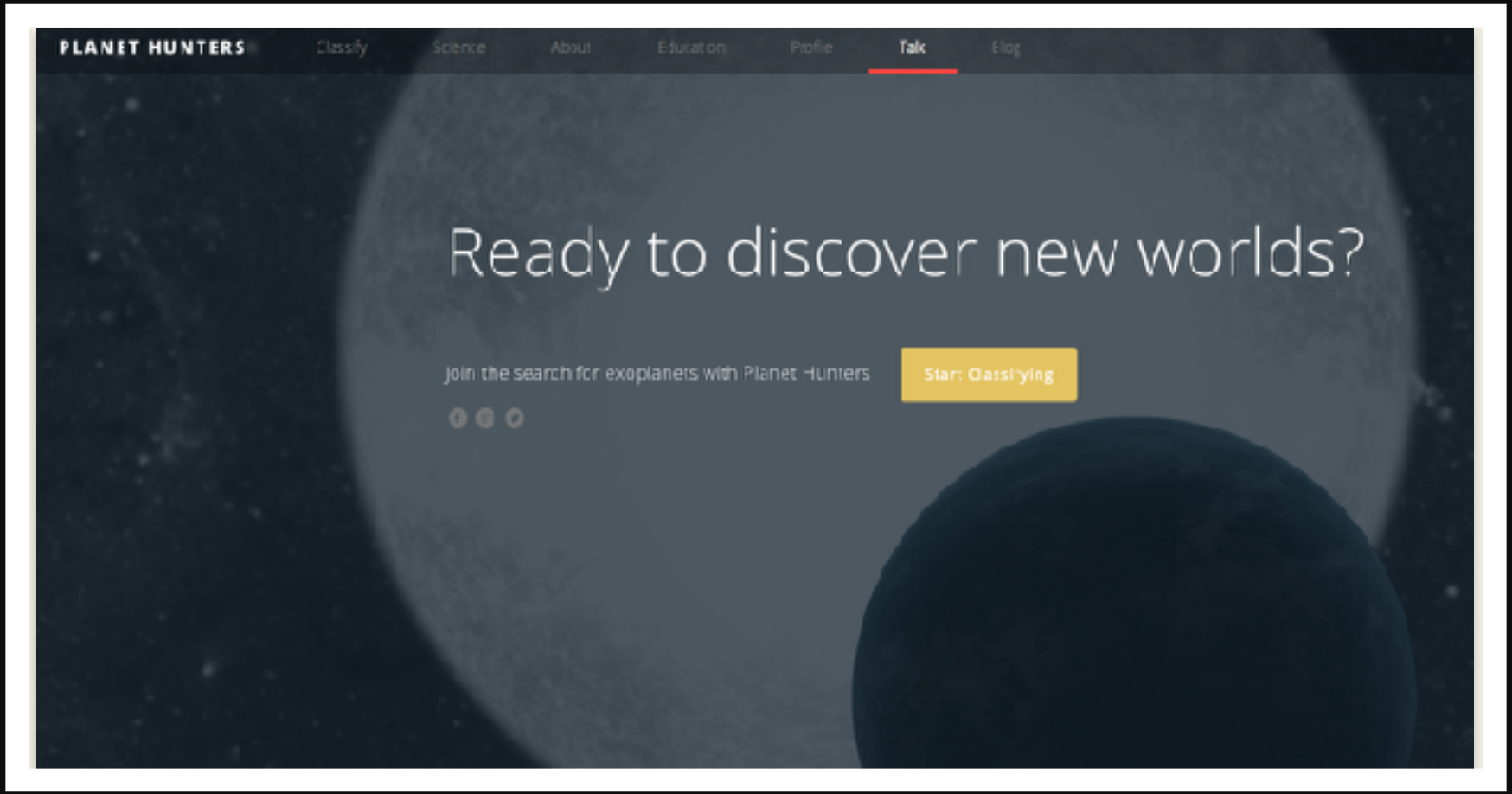
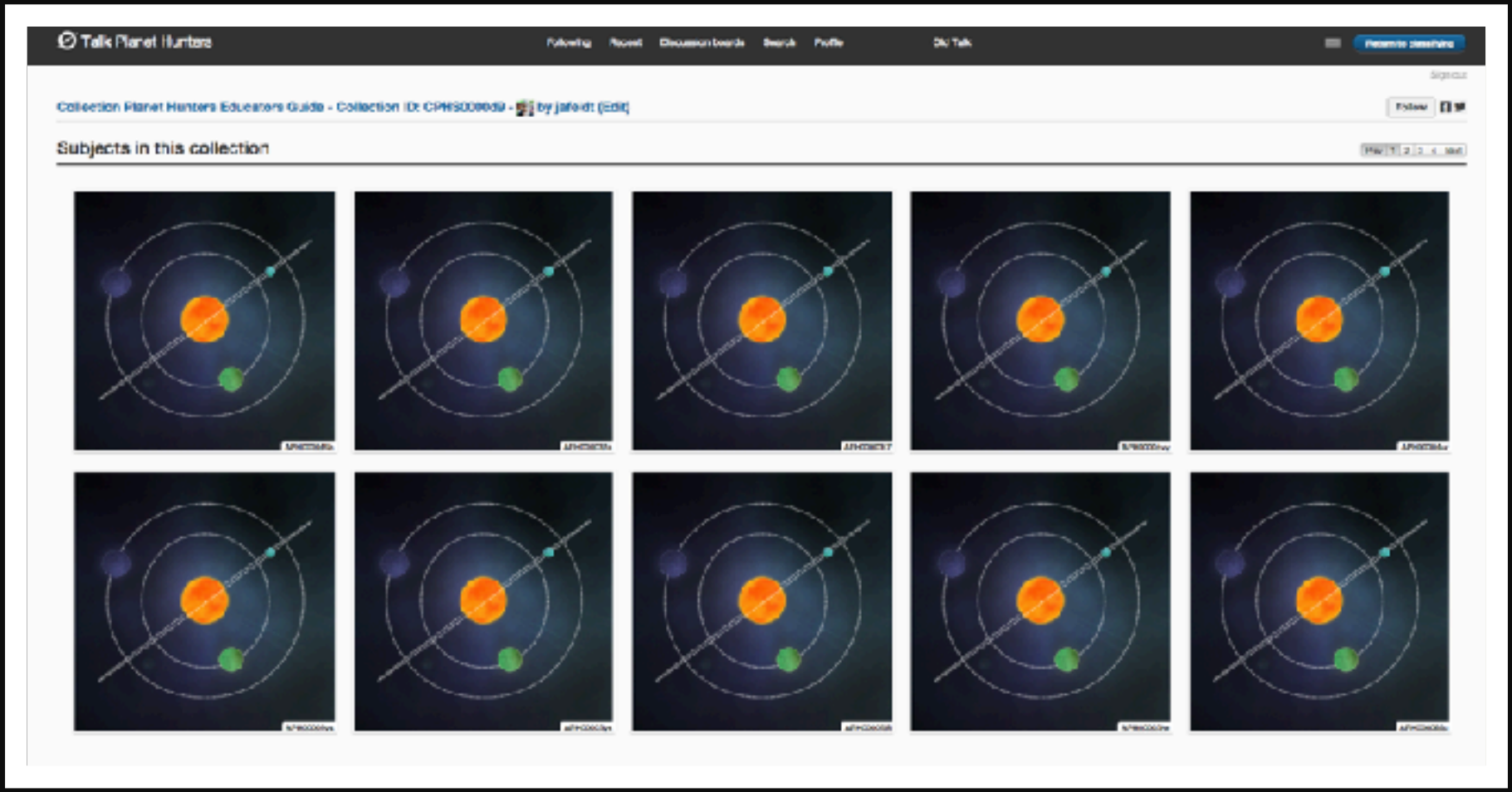
GUIDE FOR NAVIGATING PLANET HUNTERS

CALCULATING EXOPLANET CHARACTERISTICS

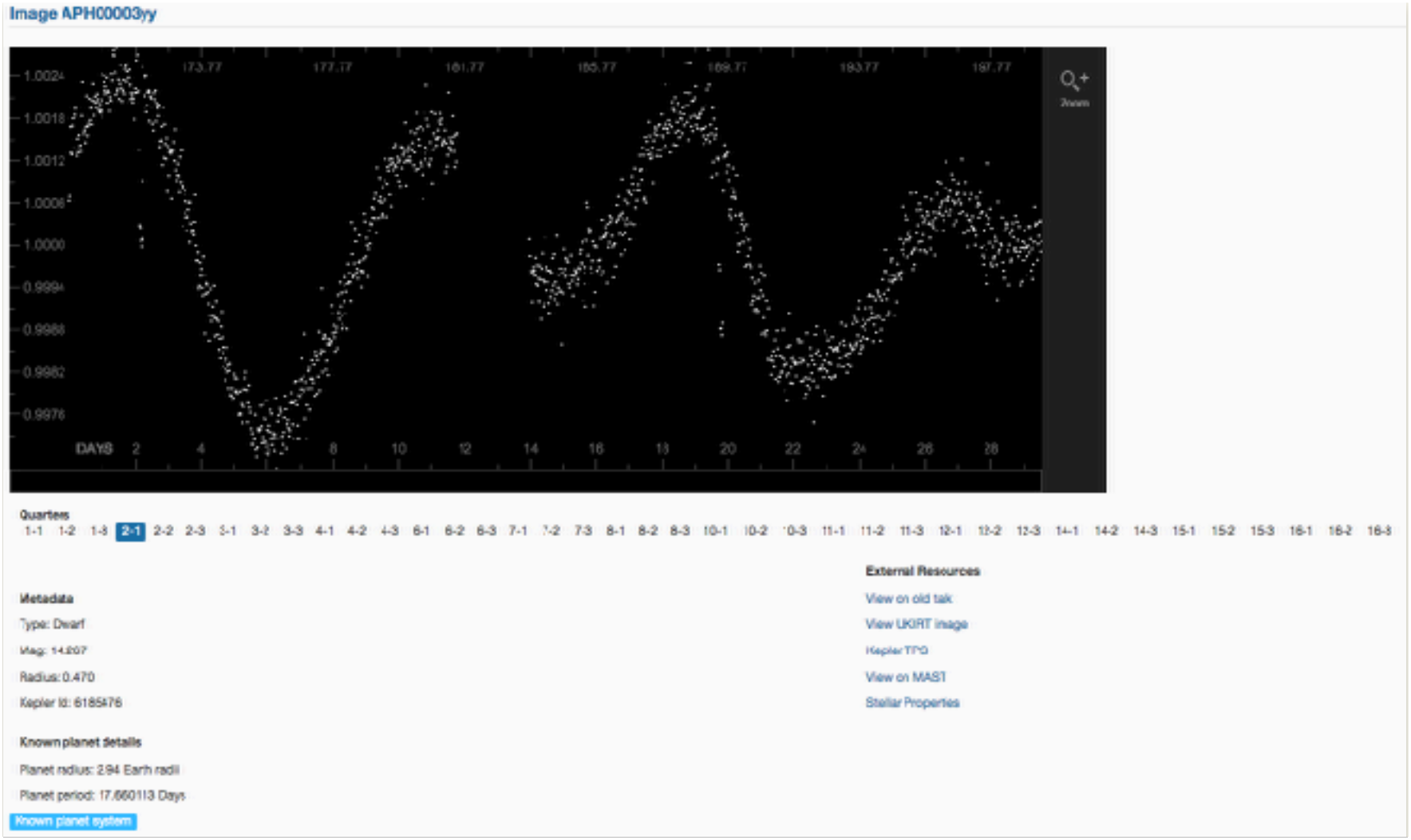
PLANET HUNTERS



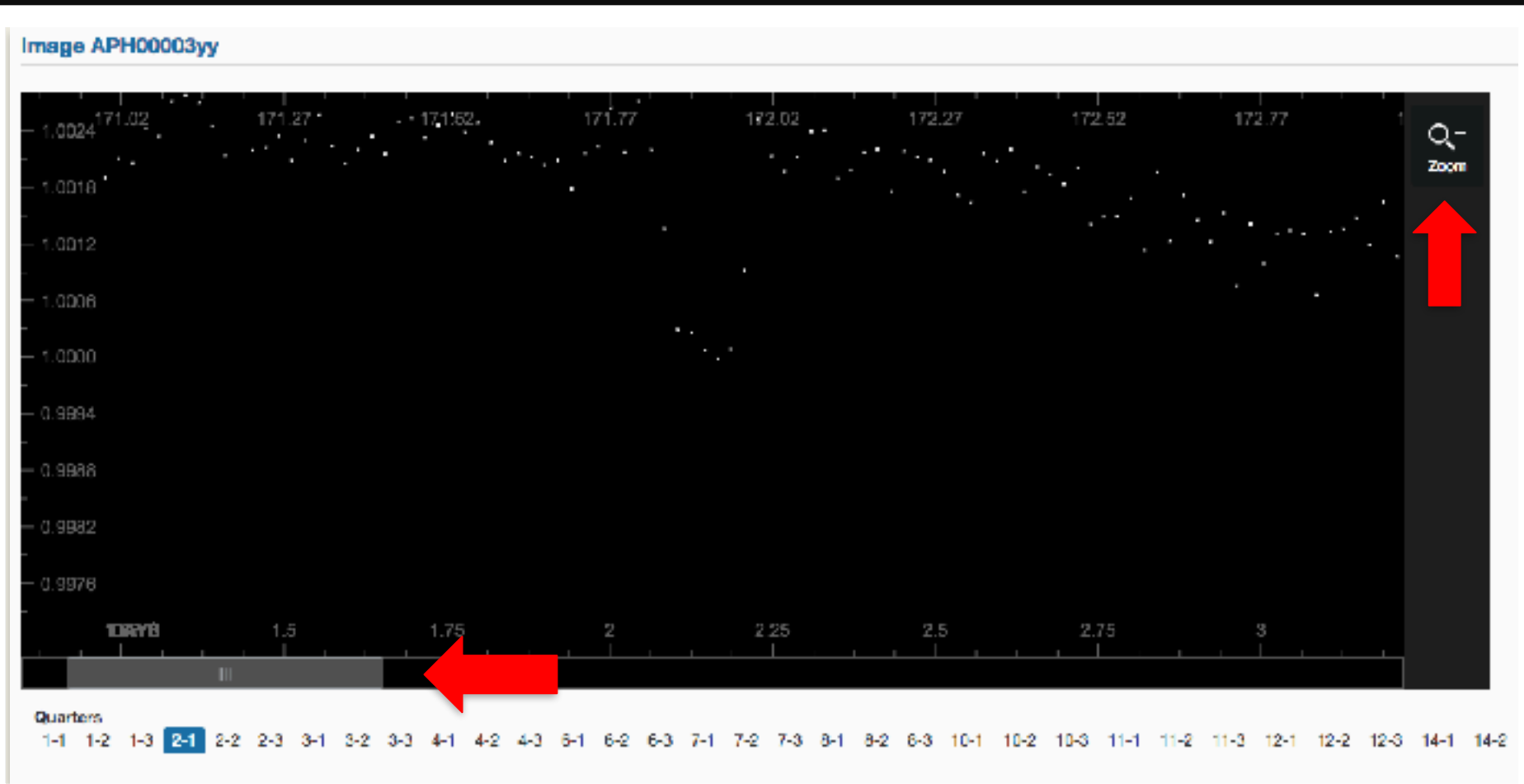
- Go to: www.planethunters.org
- Log in with the provided information



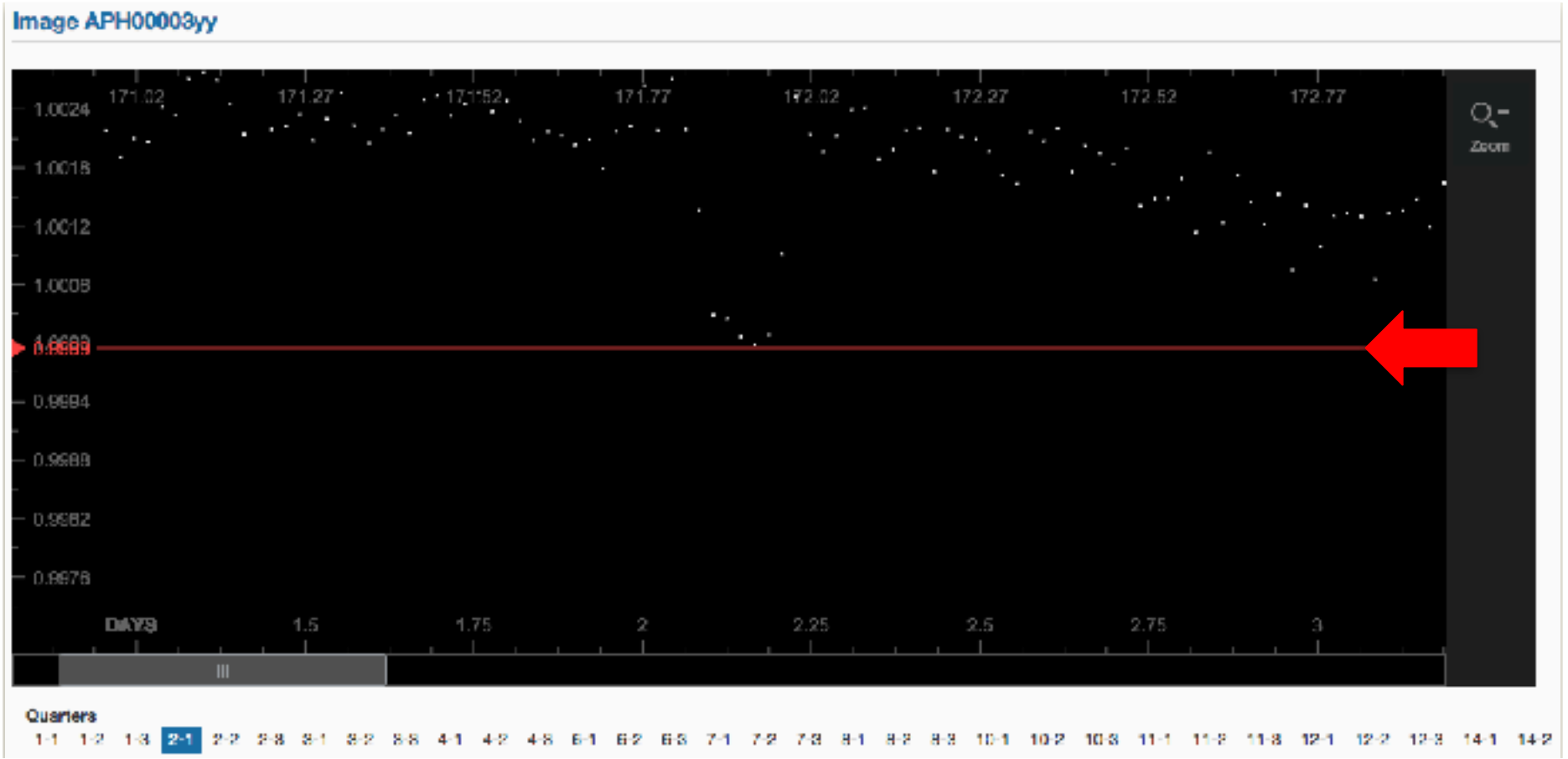
- Go to the Planet Hunter Educators Guide collection: http://talk.planethunters.org/#/collections/CPHS0000d9
- Here you will find stars with known exoplanets around them.
- Select a star to focus on, try to select a different star from your other classmates.



- Once you select a star, you should be able to see the light curves for this star.
- Note: Each star can have multiple light curves taken at different times.
- Select a Quarter to see other time periods.
- Try to identify where the transits are in the curve (there are 2 in the image above)



- Zoom in on the transit to see the transit more closely.
- Use the scroll bar on the x-axis to move to different moments in the transit.



- Run your cursor over the y-axis for a red line to appear.
- Use this to determine the amount of change in brightness.

Equations

Orbital period

$$p_1 = d_2 - d_1$$
$$p_2 = d_3 - d_2$$
$$p = \frac{(p_1 + p_2)}{2}$$

Note: you may see more or fewer than 3 transits. You want to calculate the average of all the periods you find. If you only see one transit, then you cannot find the orbital period.

Radius

$$Drop\ in\ Brightness = \frac{r^2}{R^2}$$

- *r* = radius of the planet (km)
- *R* = radius of the star (km)
- Earth radius ($r_{Earth} = 6378.1\ km$)

Mass

This can be estimated based on the size of the planet and its distance from its star.

- If $r < 6\ r_{Earth}$, then:

$$m = 0.9515r^{3.1}$$

- If $6\ r_{Earth} \leq r < 10\ r_{Earth}$, then:

$$m = 1.7013r^{2.0383}$$

- If $r \geq 10\ r_{Earth}$, then:

$$m = 0.6631r^{2.4191}$$

- *r* = radius of planet (km)
- Earth mass ($m_{Earth} = 5.976{\times}10^{24}\ kg$)

For the planet types discussed in class, the masses would be approximately:

- **Hot Jupiter**: $1.90{\times}10^{27} kg = 317.8\ m_{Earth}$
- **Hot Neptune**: $1.03{\times}10^{26} kg = 17.23\ m_{Earth}$
- **Super-Earth**: $1.90{\times}10^{27} kg = 317.8\ m_{Earth}$
- **Exo Earth**: $5.976{\times}10^{24} kg = 1\ m_{Earth}$

Semi-major axis (the distance of the planet from the star)

Listen to your instructor as to which way they would like you to calculate this.

- *Kepler's Third Law graphs* from *Lesson 7: Creating and Interpreting Light Curves*
  - Using the orbital period, find the corresponding semi-major axis value on the line.
- Kepler's Third Law:

$$P^2 = \frac{4\pi^2}{G(m + M)} a^3$$

  - *P* = orbital period
  - *G* = gravitational constant ($6.67384{\times}10^{-11} m^3 kg^{-1} s^{-1}$)
  - *m* = mass of the planet
  - *M* = mass of the star
  - *a* = semi-major axis
  - For this equation, the units need to match up with those of the gravitational constant and would need to estimate the mass of the planet and star first.
- Approximation of Kepler's Third Law:

$$P^2 = a^3$$

- P = orbital period (yrs)
- a = semi-major axis (AU)
- 1 AU is equal to the distance between Earth and the Sun $(149597871\ km)$.

Density

$$V = \frac{4}{3}\pi r^3$$
$$d = \frac{m}{V}$$

The units should be in kilograms per meter cubed, $(\frac{kg}{m^3})$.

Surface temperature

$$T_P = \left(\frac{L(1-A)}{16\pi\sigma a^2}\right)^{\frac{1}{4}} = \left(\frac{R^2 T_S^4 (1-A)}{4a^2}\right)^{\frac{1}{4}}$$

- T_P = surface temperature of the planet
- L = luminosity of the star $(L = 4\pi R^2 \sigma T^4)$
- a = semi-major axis
- T_S = temperature of the star
- σ = Stefan-Boltzmann constant $(5.670\times10^{-8} W m^{-2} K^{-4})$
- A = albedo of the planet

For the types of planets discussed in class the albedo would be:

- **Hot Jupiter**: $A = 0.52$
- **Hot Neptune**: $A = 0.35$
- **Super-Earth**: $A = 0.39$
- **Exo Earth**: $A = 0.39$

Planetary Information Sheet

IMPORTANT SOLAR SYSTEM PLANETARY INFORMATION

	Mass ($x10^{24}$ kg)	**Radius** (km)	**Density** (kg/m3)	**Period** (days)	**Distance from Sun** ($x10^{6}$km)	**Mean Temp.** (°C)
Mercury	.330	2440	5427	88	57.9	167
Venus	4.87	6052	5243	244.7	108.7	464
Earth	5.97	6378	5515	365.2	49.6	15
Mars	0.642	3396	3933	687.0	227.9	-65
Jupiter	1899	71492	1326	4331	778.6	-110
Saturn	568	60268	687	10747	1433.5	-140
Uranus	86.8	25559	1270	30589	2872.5	-195
Neptune	102	24764	1638	59800	4495.1	-200

TYPES OF EXOPLANETS

Hot Jupiter – A gaseous planet that has a mass similar to Jupiter, but is much closer to its star, creating very hot surface temperatures.

Hot Neptune – A gaseous planet that has a mass and characteristics similar to Neptune, but is much closer to its star, creating high surface temperatures.

Super-Earth – A gaseous planet that has a mass greater than Earth's but less than Neptune.

Exo Earth – A rocky planet with characteristics similar to Earth.

Exoplanet Data Sheet

NAME _____

DATE _____

Part 1

Transit 1

Star I.D.				
Total Brightness				
Transit Brightness				
Transit Day				

Transit 2

Star I.D.				
Total Brightness				
Transit Brightness				
Transit Day				

Transit 3

Star I.D.				
Total Brightness				
Transit Brightness				
Transit Day				

Part 2

Star I.D.				
Orbital Period				
Radius				
Mass				
Semi-Major Axis				
Density				
Surface Temperature				