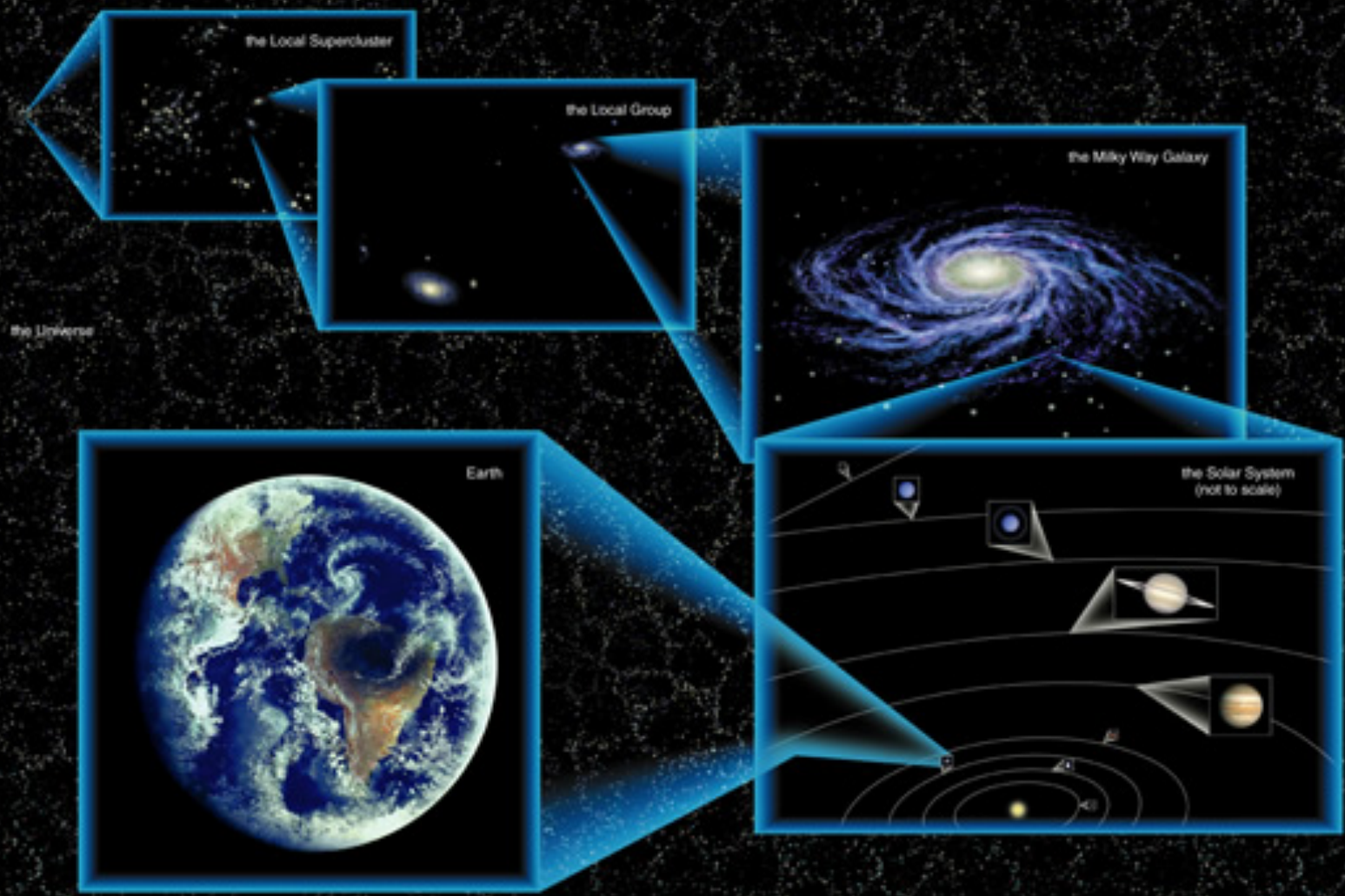


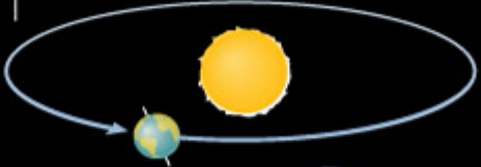
# How are the motions and positions of Earth, the Moon and the Sun connected to what happens on Earth?

- A Day:
- A Month:
- A Year:

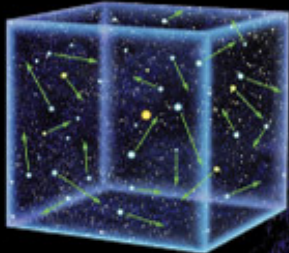




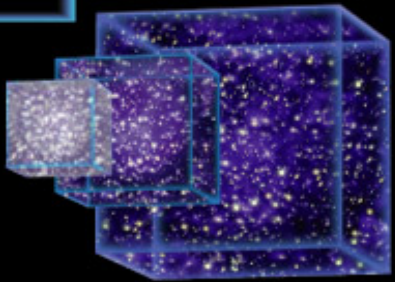
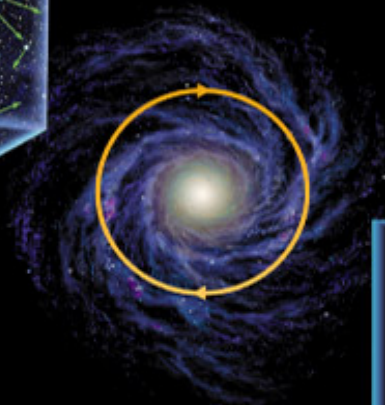
You live on \_\_\_\_\_.



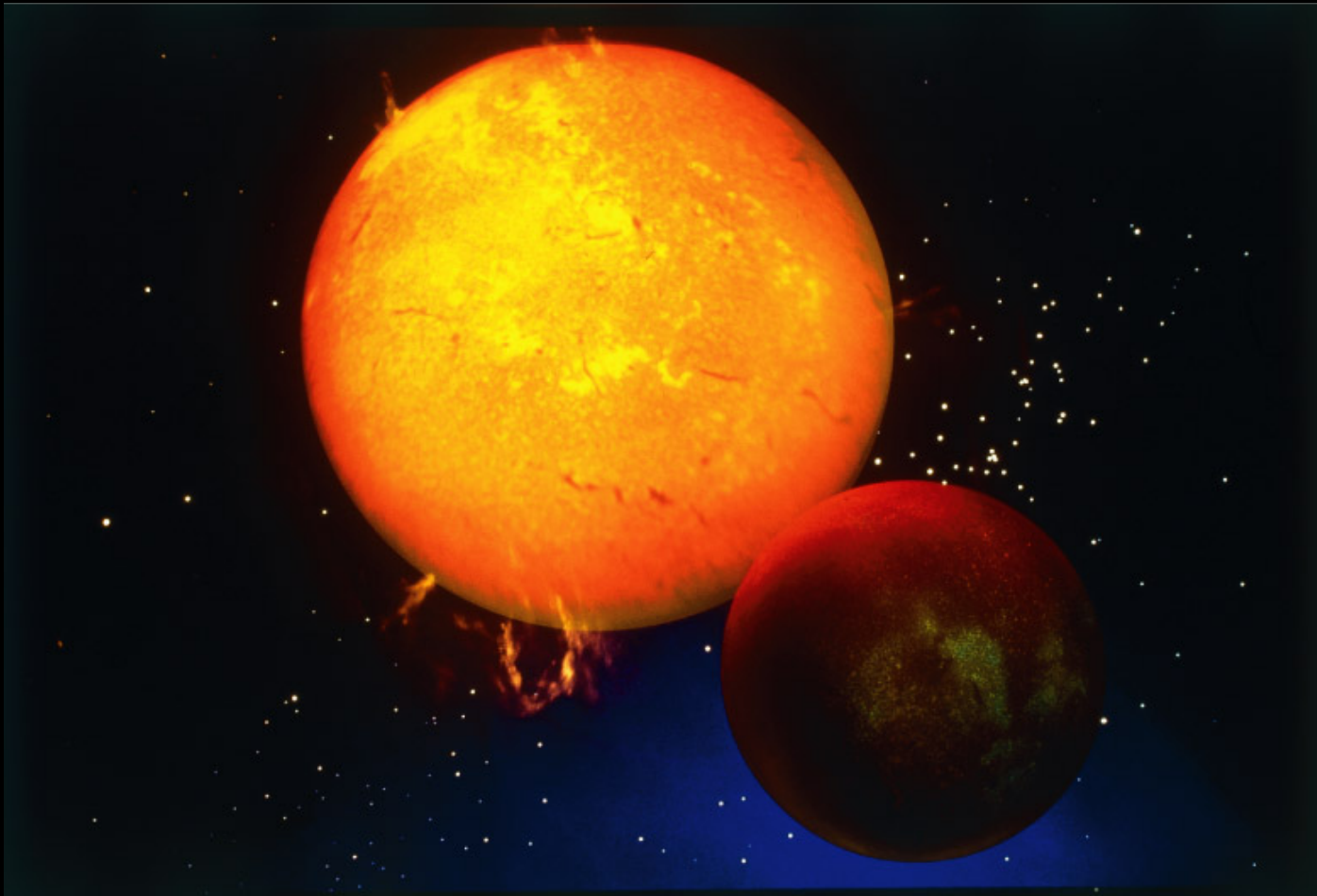
Earth \_\_\_\_\_ the \_\_\_\_\_.

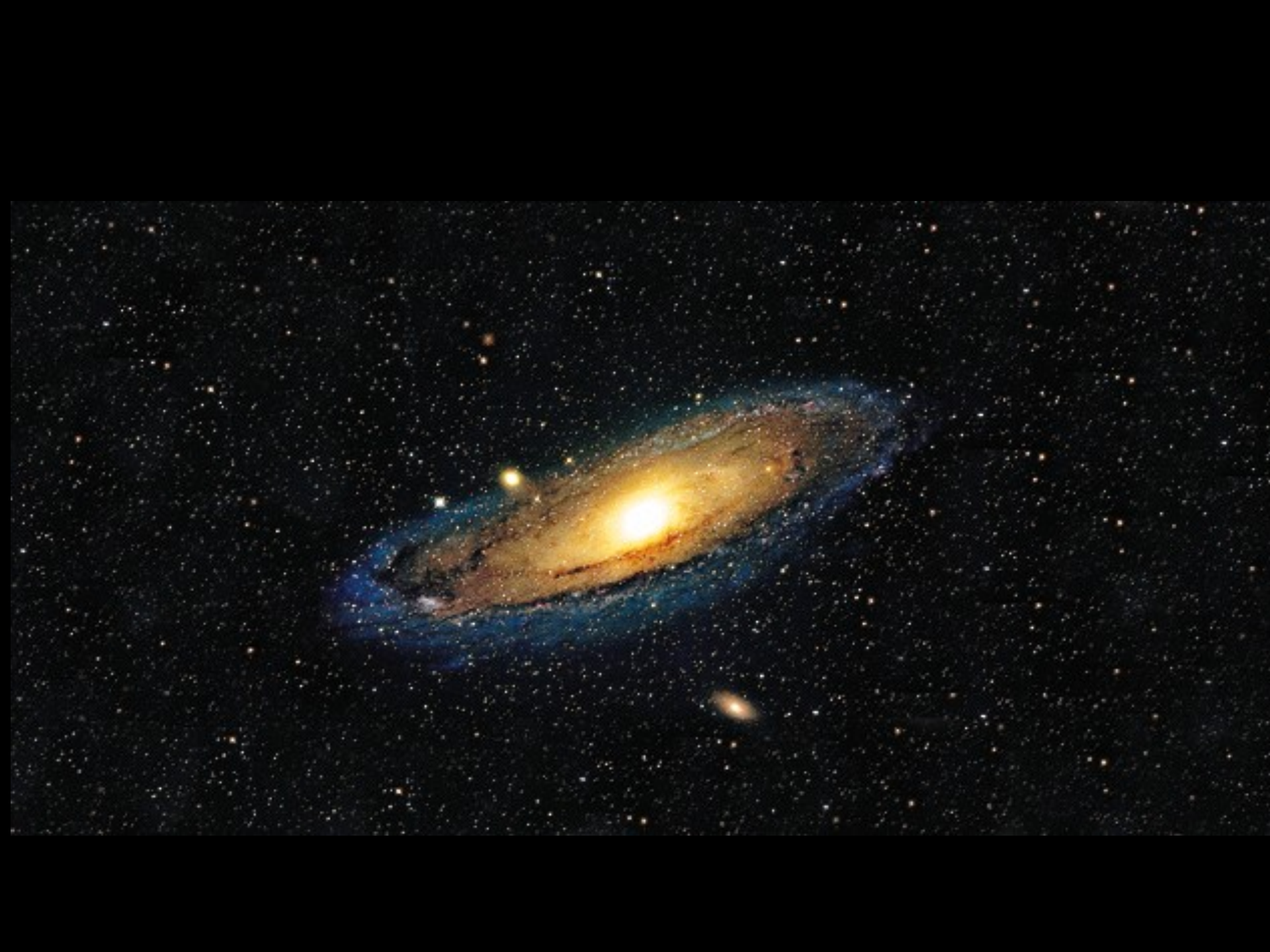


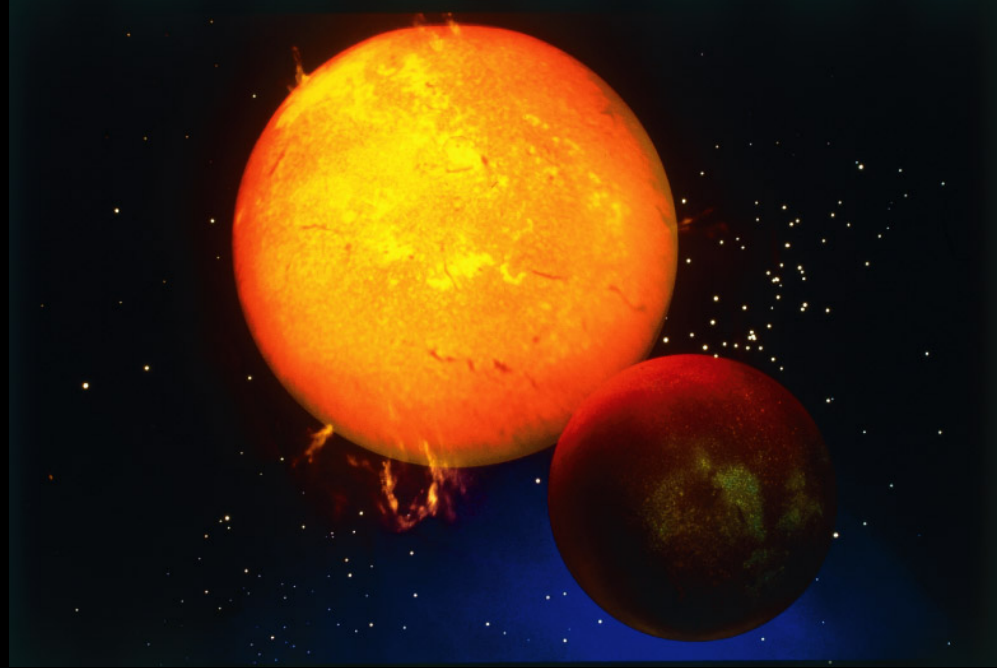
The Sun moves relative to other \_\_\_\_\_, which are all in our \_\_\_\_\_.

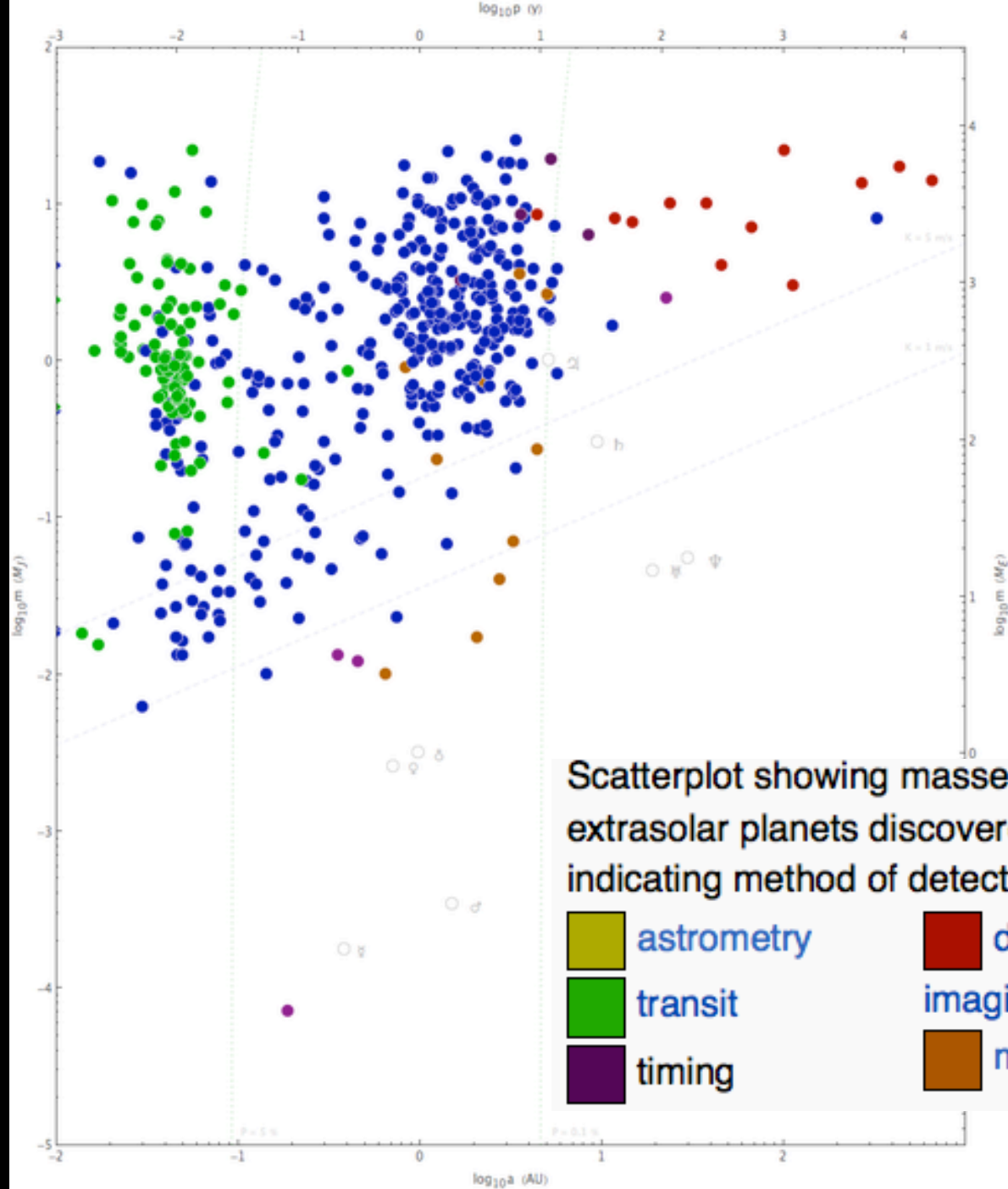










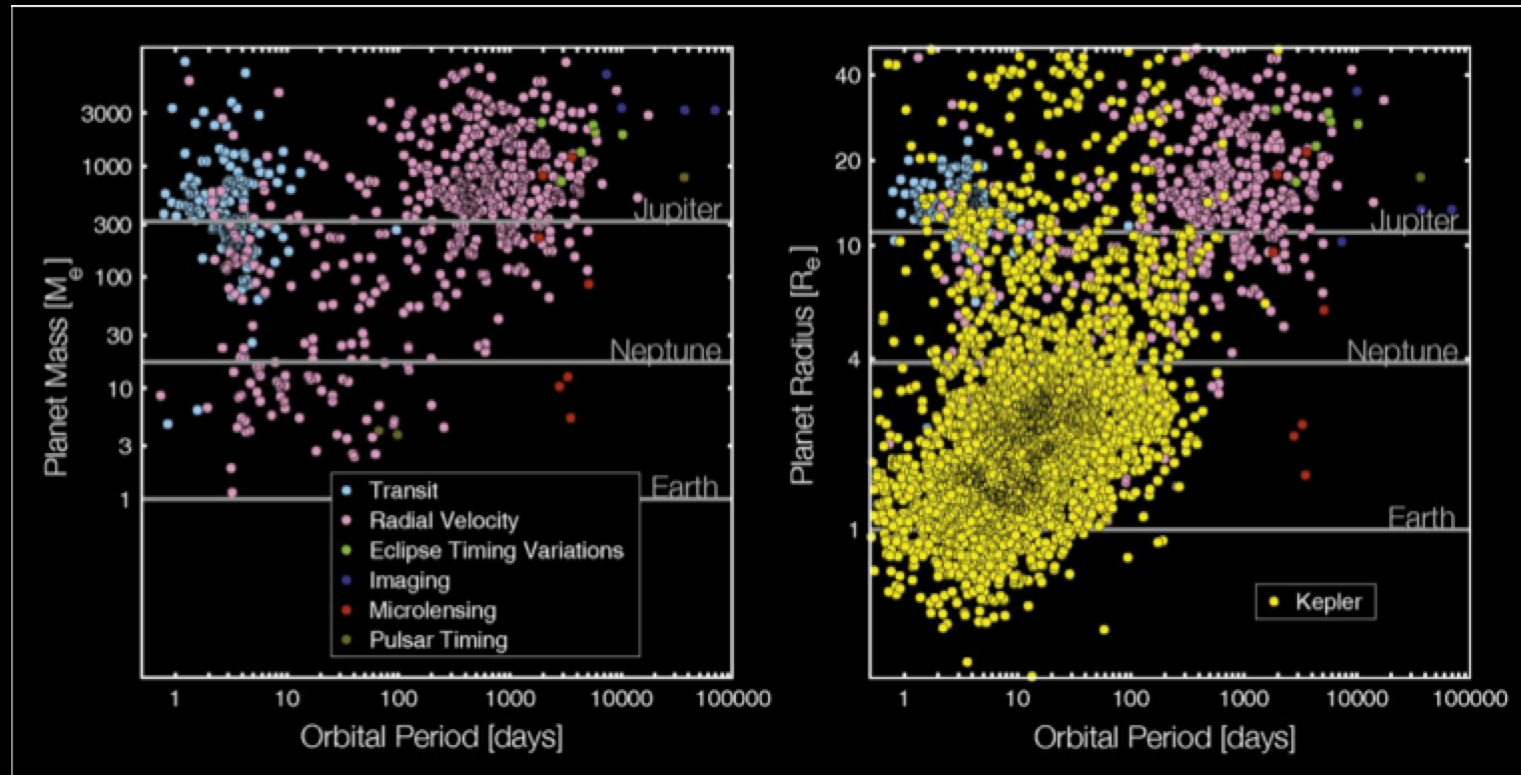


Scatterplot showing masses and orbital periods of all extrasolar planets discovered through 2010-10-03, with colors indicating method of detection:

- astrometry
- direct
- radial velocity
- transit
- imaging
- pulsar timing
- timing
- microlensing

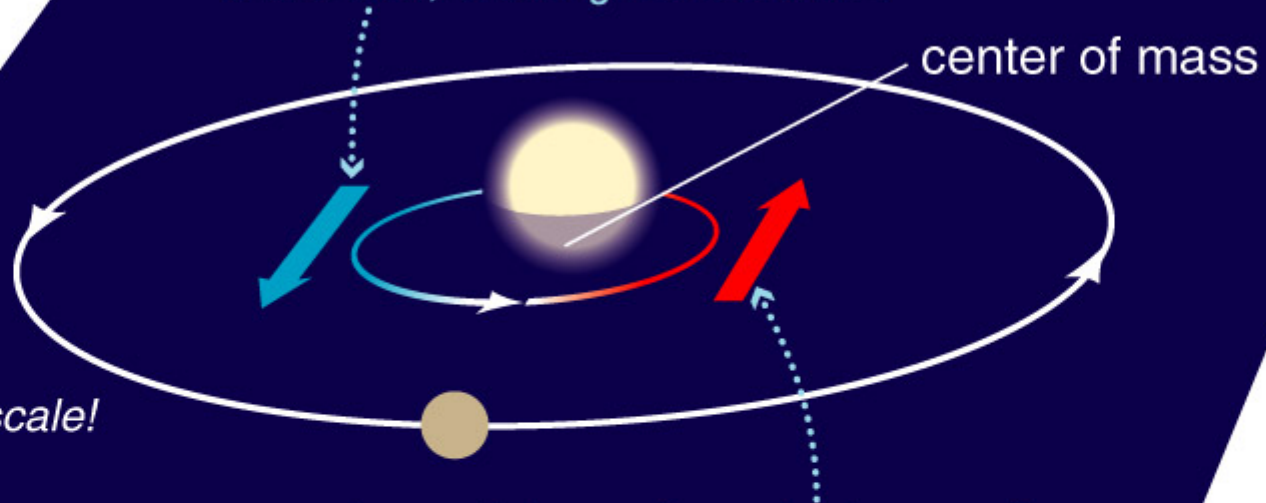


# Detecting Other Planets in our Galaxy – aka Exoplanets





*We view the orbit of this planet and star at an angle, so part of the star's motion is toward us on one side of the orbit, creating a blueshift. . .*



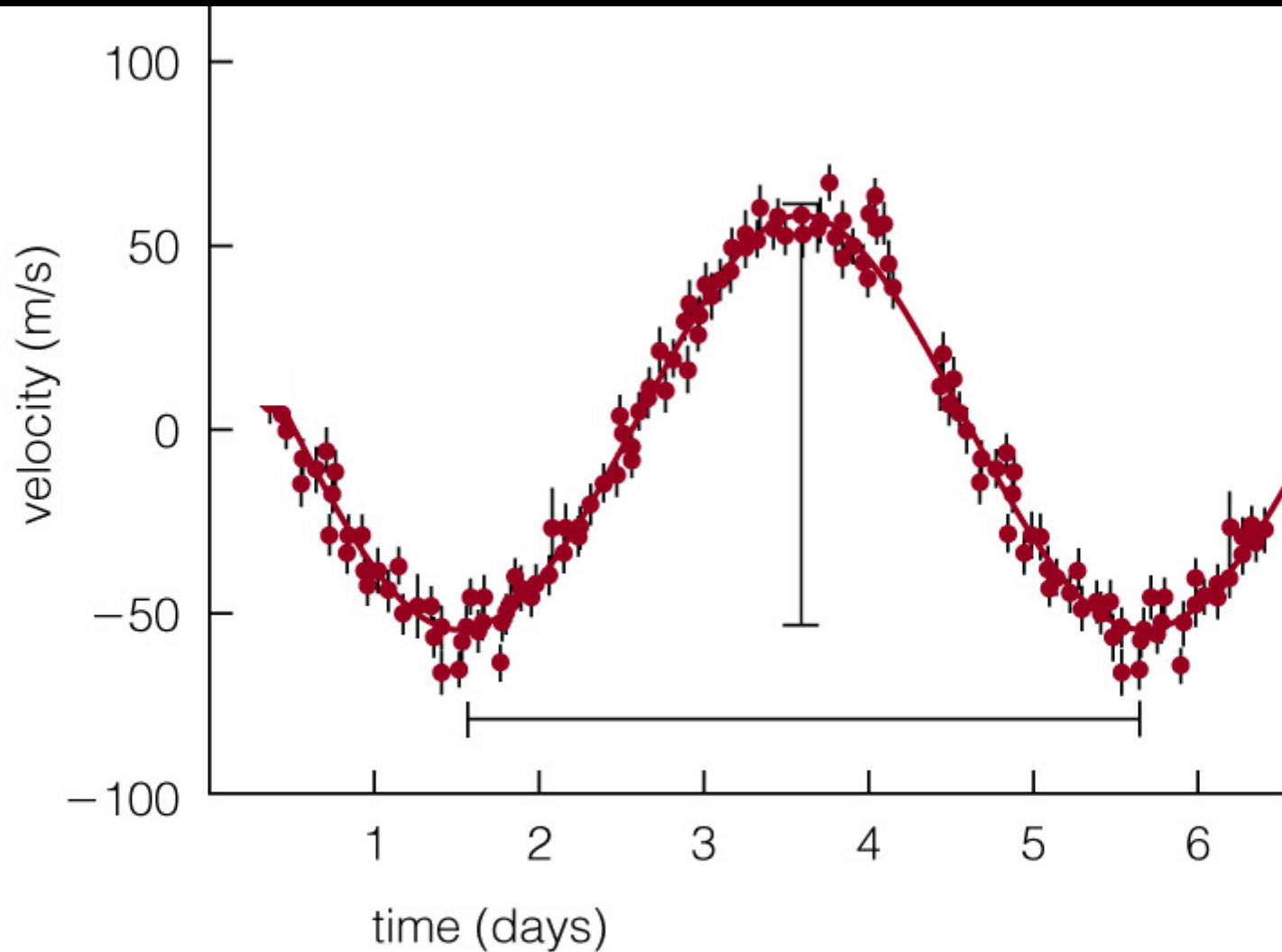
*Not to scale!*

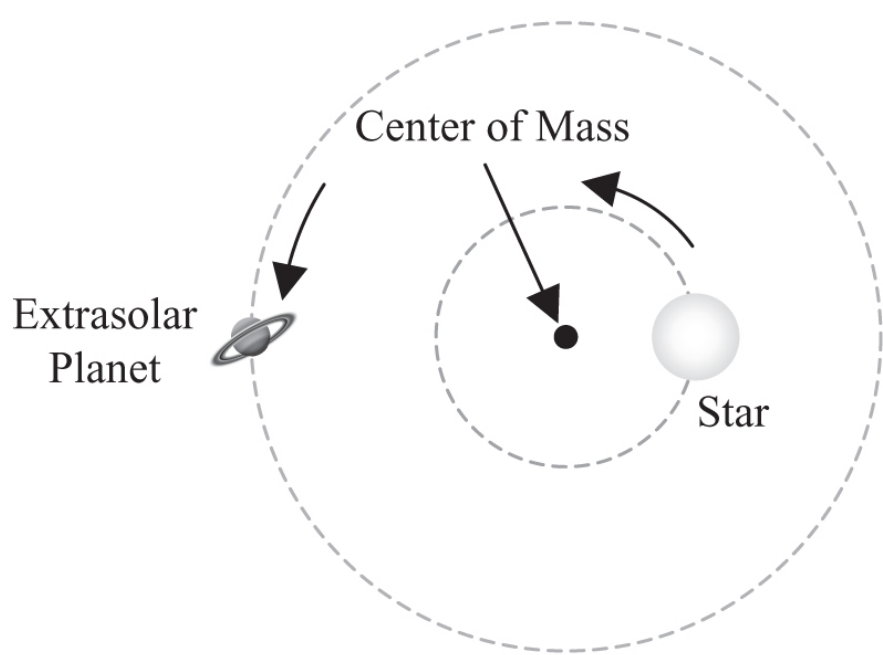
*. . .and part of the star's motion is away from us on the other side, creating a redshift.*

On what day did the star first start moving away from Earth?

What is the time it takes for the planet to make one full orbit?

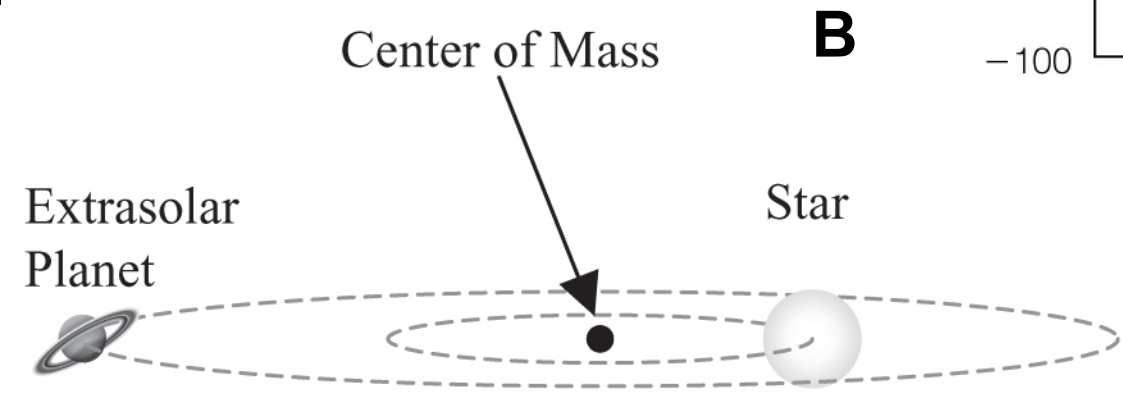
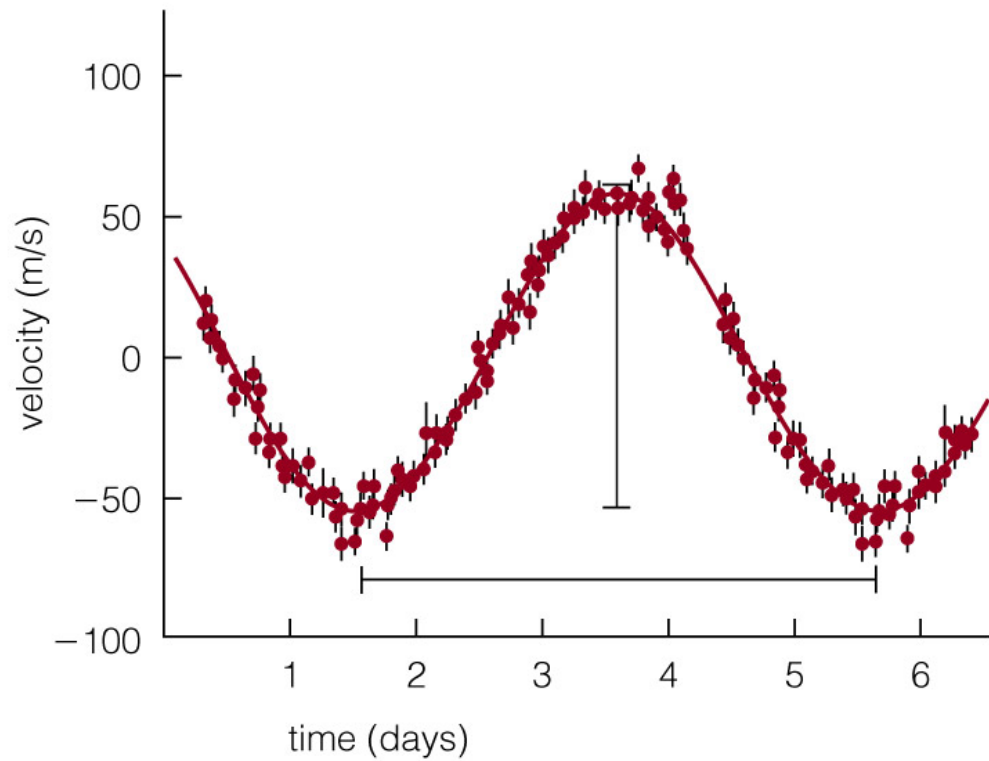
On what day (or days) was the planet moving away from Earth with the greatest speed?





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**A**

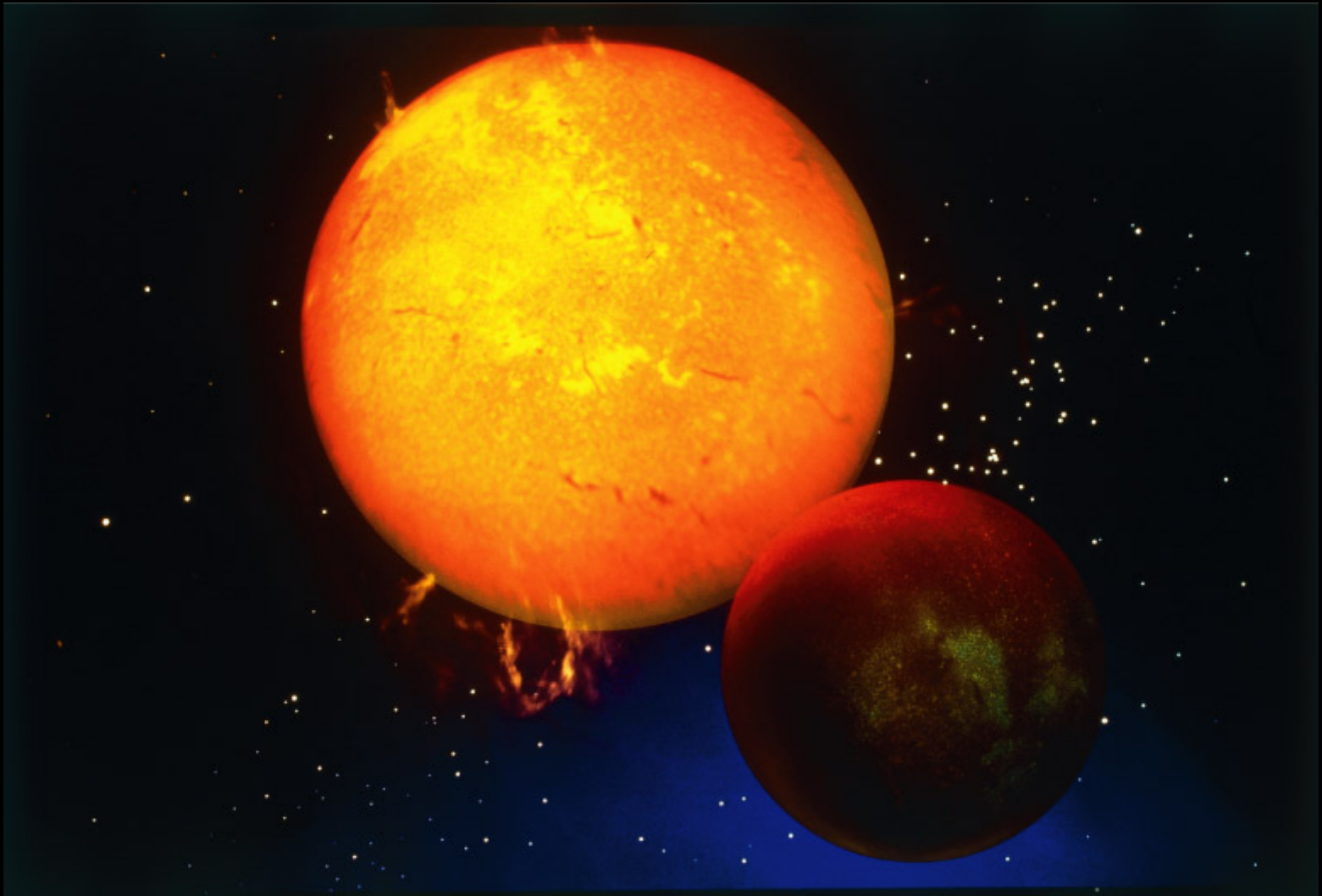


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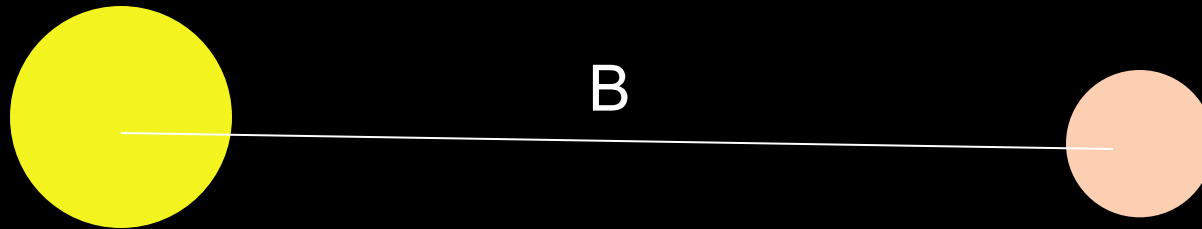
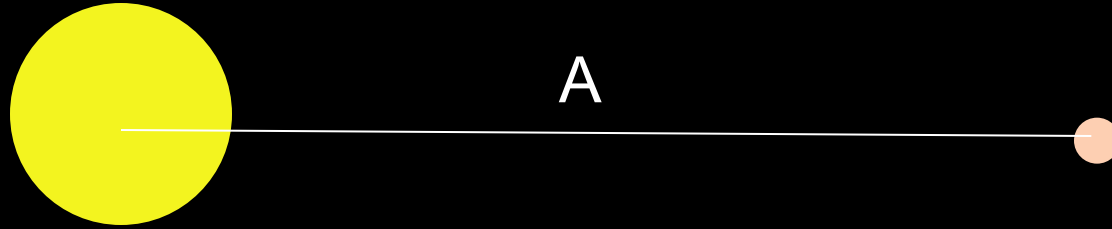
**B**



Amount of Doppler shift in Star's light  $\approx \frac{M_p}{\sqrt{(M_s \times d)}}$



Amount of Doppler shift in Star's light  $\approx \frac{M_p}{\sqrt{(M_s \times d)}}$



In which case would the star's light be Doppler shifted by the greatest amount?

Amount of Doppler shift in Star's light  $\approx \frac{M_p}{\sqrt{(M_s \times d)}}$



In which case would the height of the graph for the star's velocity be tallest?



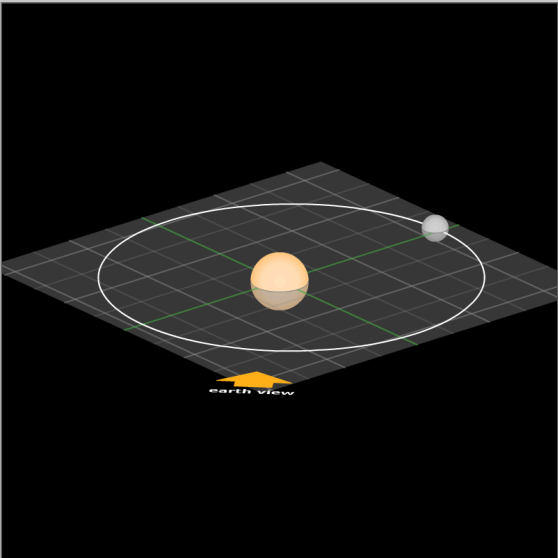
It is easiest to detect a planet in an extrasolar planet system when

- A. a low mass planet is far from a low mass star.
- B. a high mass planet is close to a high mass star.
- C. a low mass planet is far from a high mass star.
- D. a high mass planet is close to a low mass star.
- E. a low mass planet is close to a high mass star.

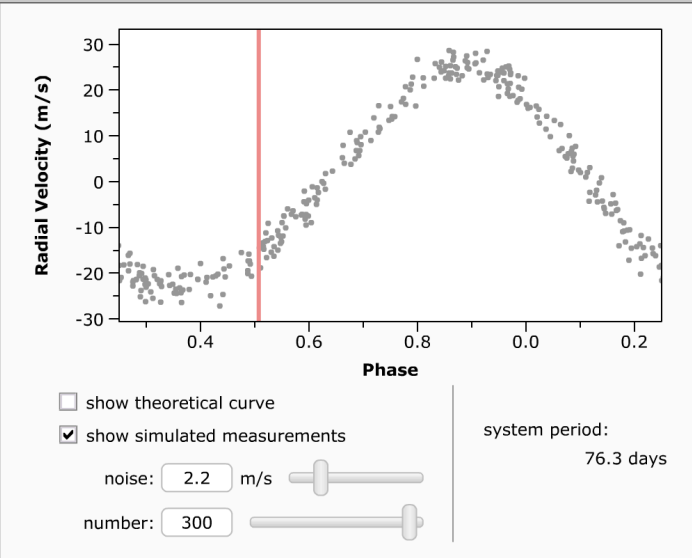
# Amount of Doppler shift in Star's light $\approx \frac{M_p}{\sqrt{(M_s \times d)}}$

Astro.UNL.edu

Exoplanet Radial Velocity Simulator reset help about



earth view



Radial Velocity (m/s)

Phase

show theoretical curve  
 show simulated measurements

noise: 2.2 m/s

number: 300

system period: 76.3 days

Visualization Controls

show multiple views

System Orientation

inclination: 90.0 °

longitude: 45.0 °

Presets

1. Option A

Animation Controls

animation speed:

phase: 0.508

Star Properties

mass: 0.20  $M_{\text{sun}}$

(a main sequence star of this mass would have spectral type M4V, temperature 3230 K, and radius 0.3  $R_{\text{sun}}$ )

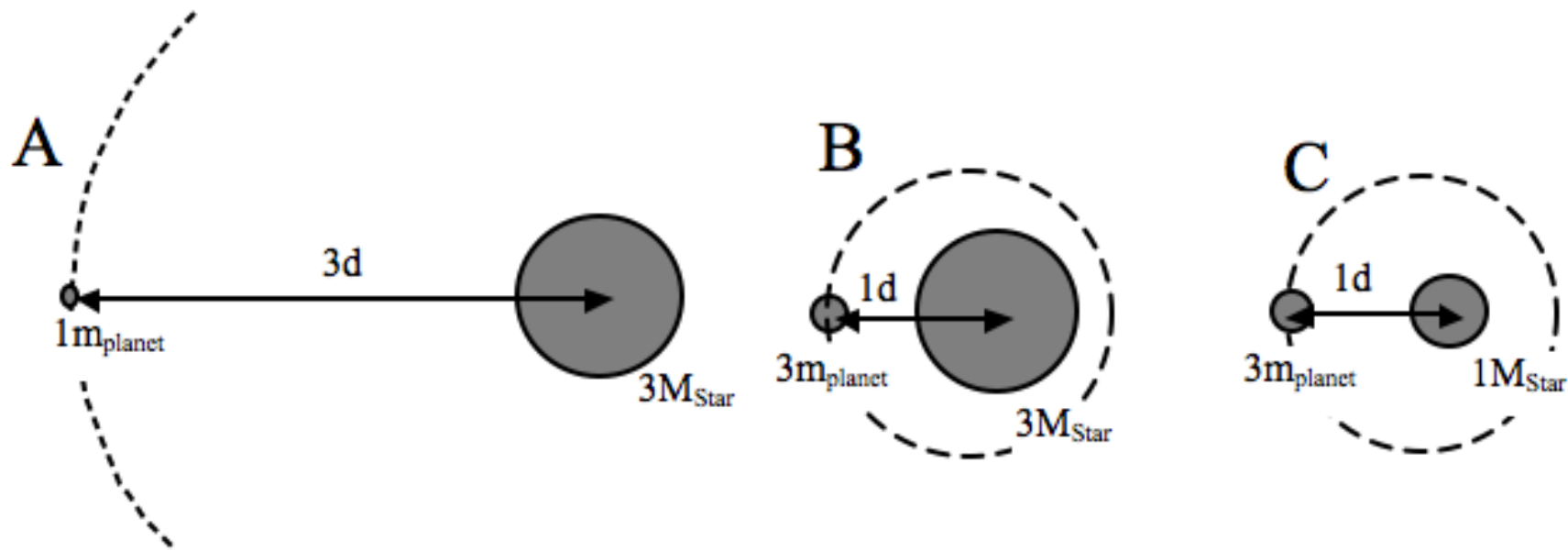
Planet Properties

mass: 0.173  $M_{\text{jup}}$

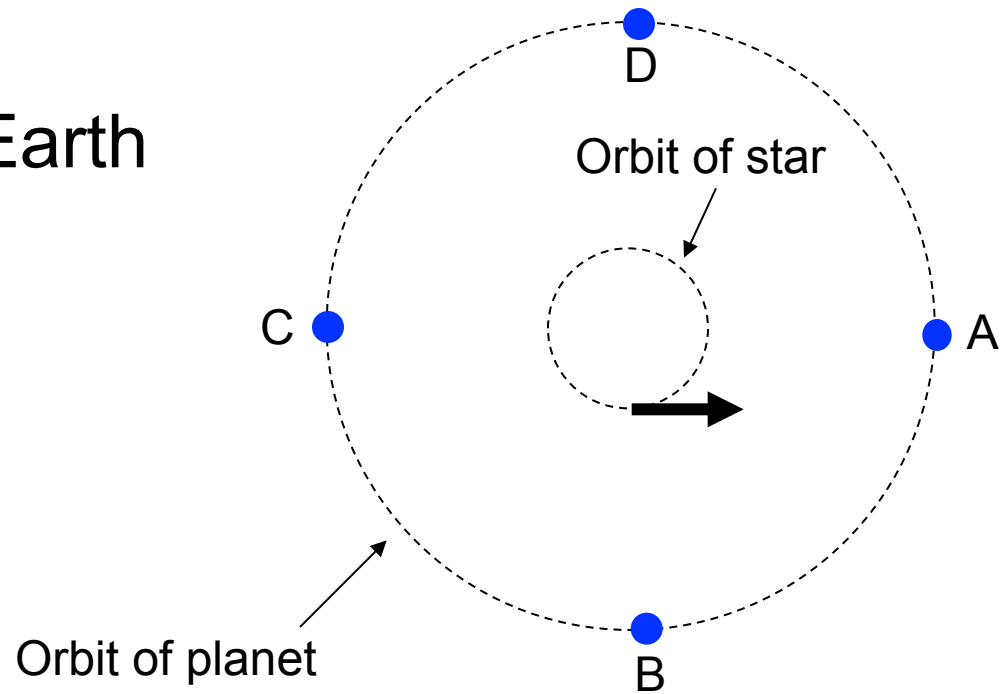
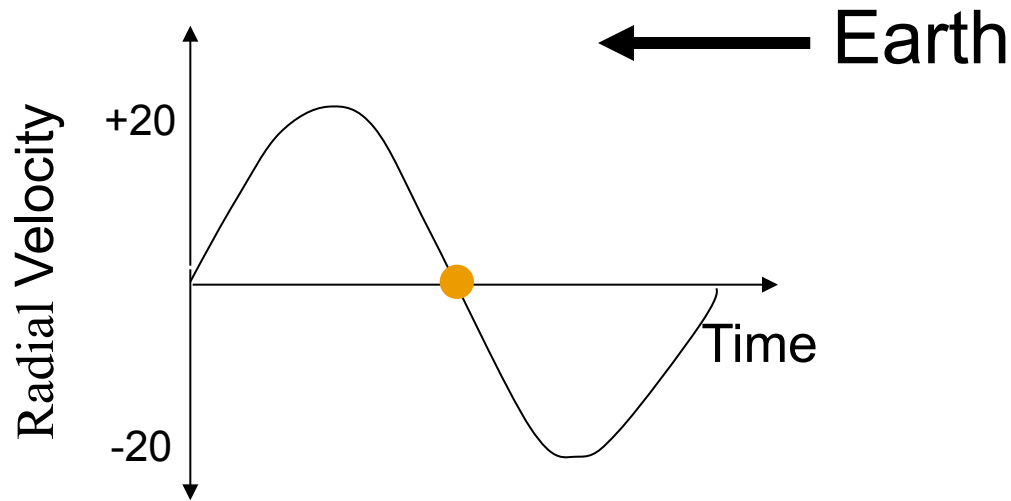
semimajor axis: 0.206 AU

eccentricity: 0.08

In which situation below would the extra-solar planet be easiest to detect?





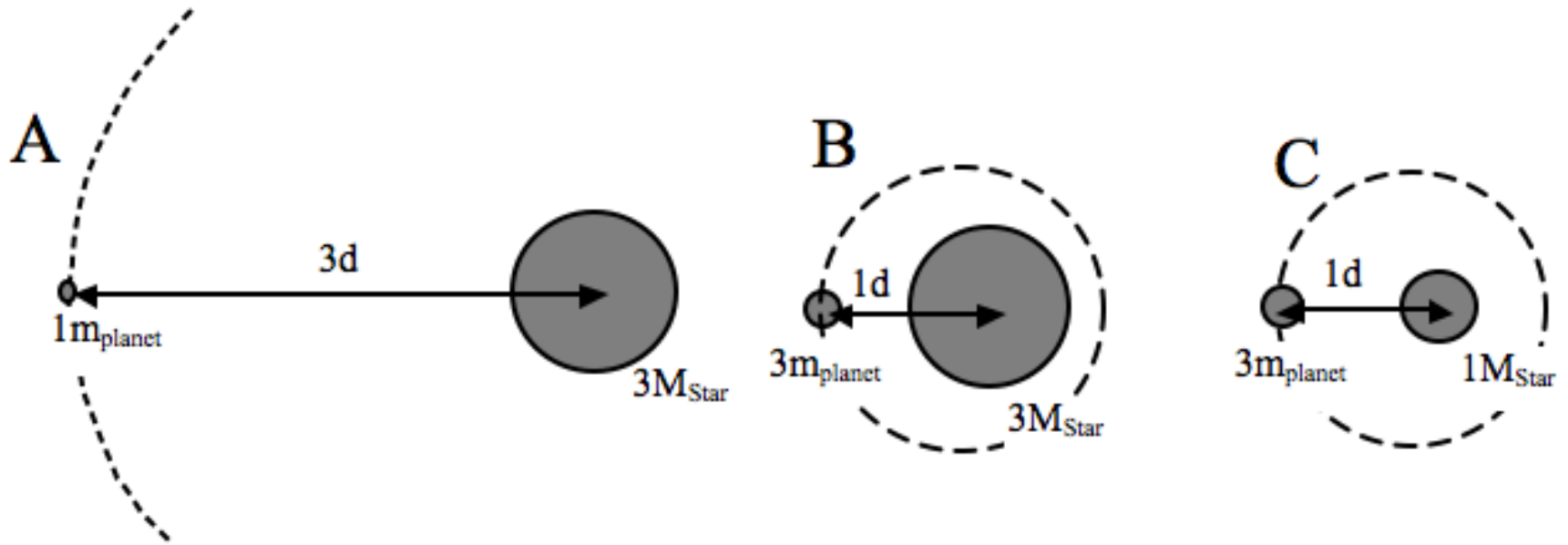


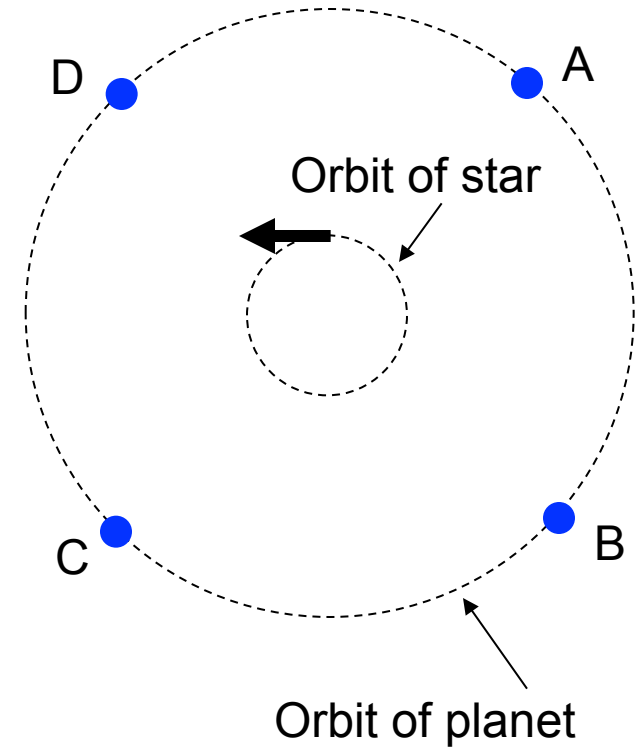
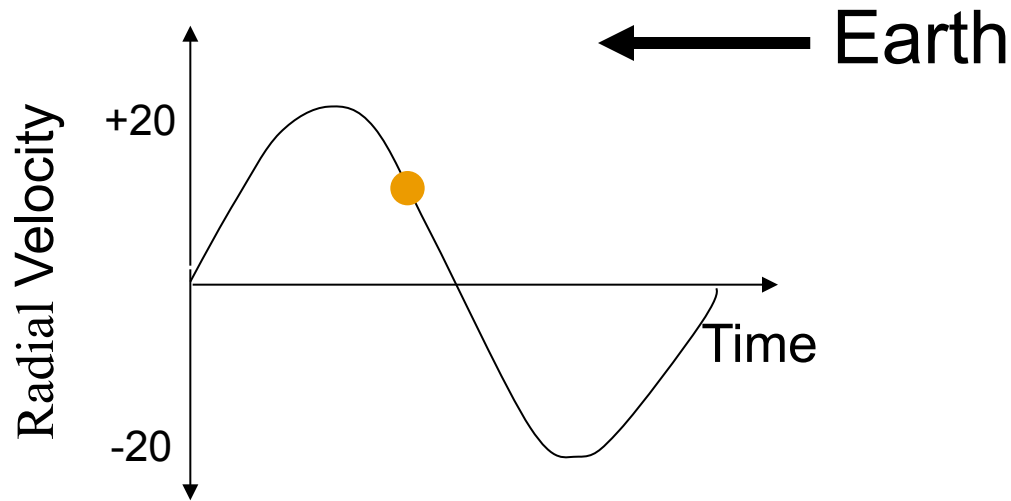
Given the location marked on the star's radial velocity curve, at which location in the planet's orbit would you expect the planet to be?

# Tutorial: Motion of Extrasolar Planets

- Work with a partner!
- Read the instructions and questions carefully.
- Discuss the concepts and your answers with one another. Take time to understand it now!!!!
- Come to a consensus answer you both agree on.
- If you get stuck or are not sure of your answer, ask another group.

Rank the exoplanet systems A-C, from easiest to hardest to detect?





Given the location marked on the star's radial velocity curve, at which location in the planet's orbit would you expect the planet to be?