# Life on Other Planets?

Four hundred years ago an advocate of the idea that planets orbited stars other than our Sun was burned at the stake. Giordano Bruno, a rebellious, independent Dominican monk (until he was kicked out of the order) further infuriated religious leaders by asserting in the late 16th century that beings like humans inhabited these other worlds. Let us now begin our study of extrasolar planets.

A Planet Around 51 Pegasus

Consider the data below which shows the oscillations in the speed of the star 51 Pegasus implying the existence of an unseen, orbiting companion. What is the period of the oscillation? How is this period related to the distance from 51 Pegasus to the unseen companion? What do these result imply about the maximum mass of the unseen companion? Asume the mass of 51 Pegasus is $m_s = 2 \times 10^{30}\ kg$ from its spectral type.
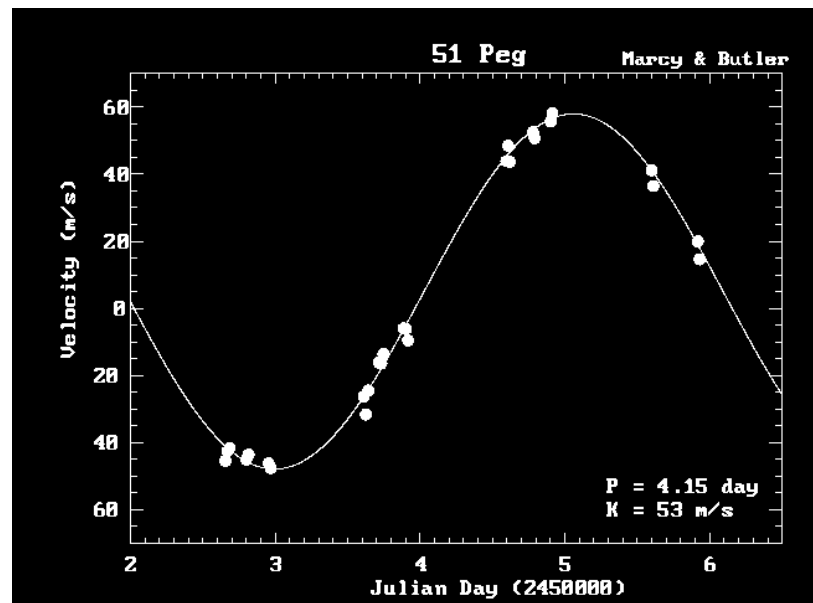
'Wobbling' Stars

Consider a solar system that consists only of the Sun and Jupiter orbiting each other about the center of mass. What is the size of the Sun's 'wobble' as it orbits the center of mass? What is the size of the angular displacement when viewed from a distance of 42 ly (the distance to 51 Pegasus). Compare the wobble with the radius of the Sun.

Jupiter's mass	$1.90 \times 10^{27} \ kg$
Sun's mass	$1.99 \times 10^{30} \ kg$
Sun-Jupiter distance	$7.8 \times 10^{11} \ m$
Sun's radius	$6.96 \times 10^{8} \ m$
1 light-year	$9.46 \times 10^{15} \ m$

The Doppler Effect
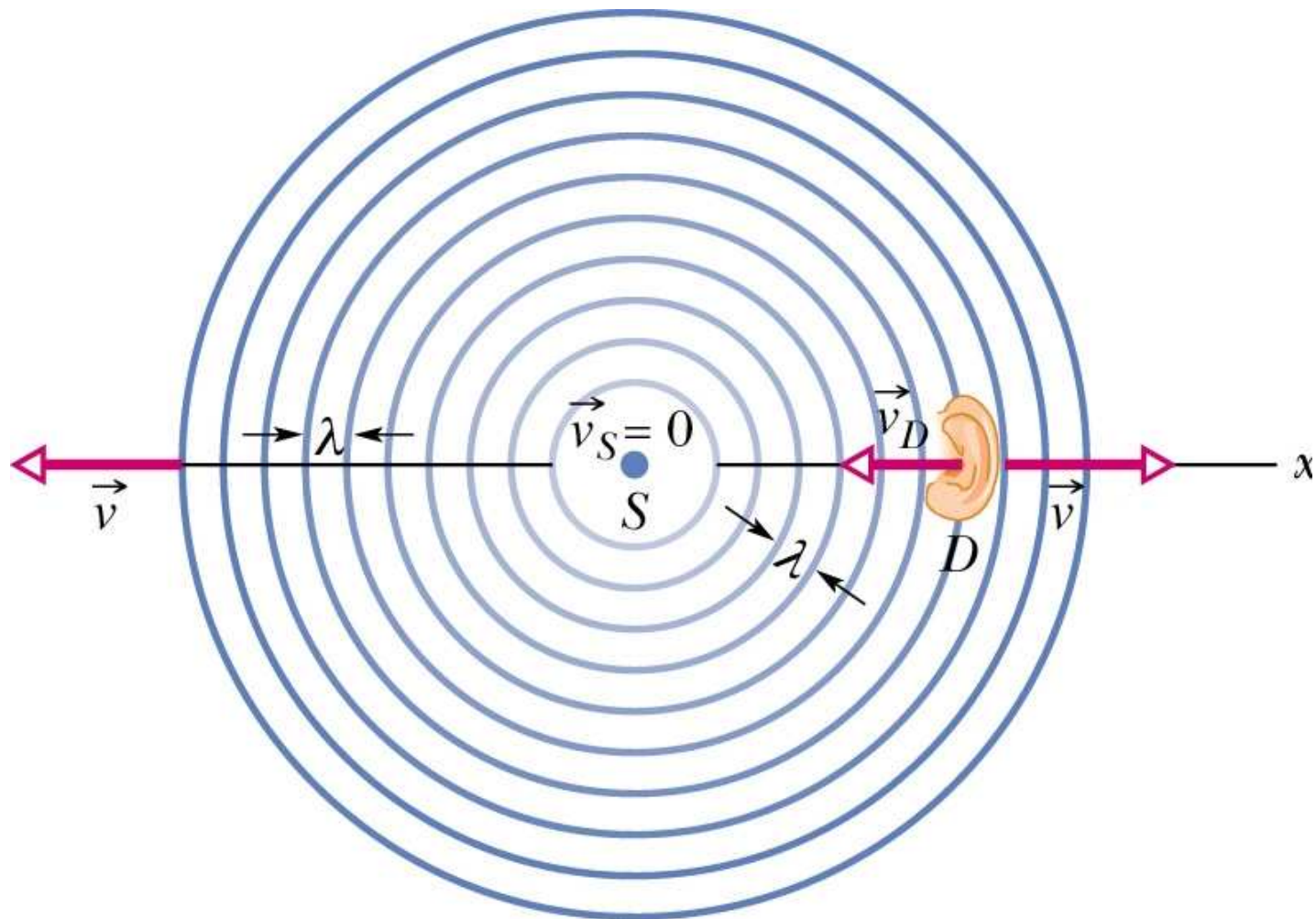
The Doppler Effect

Wobbling Stars

Doppler Shift due to Stellar Wobble

Unseen planet

51 Pegasus

The Great Square
of Pegasus

51 Peg
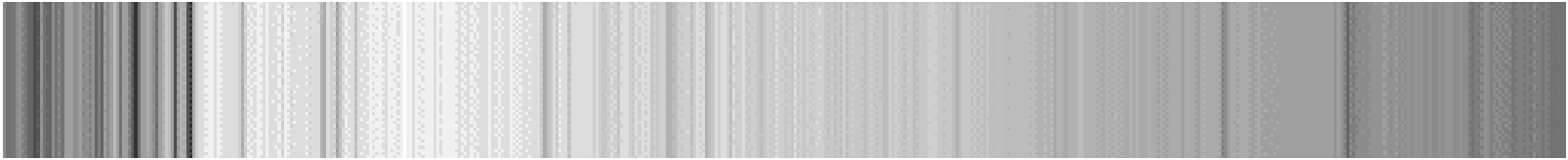
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Photo: Jim Seevers
Adler Planetarium & Astronomy Museum
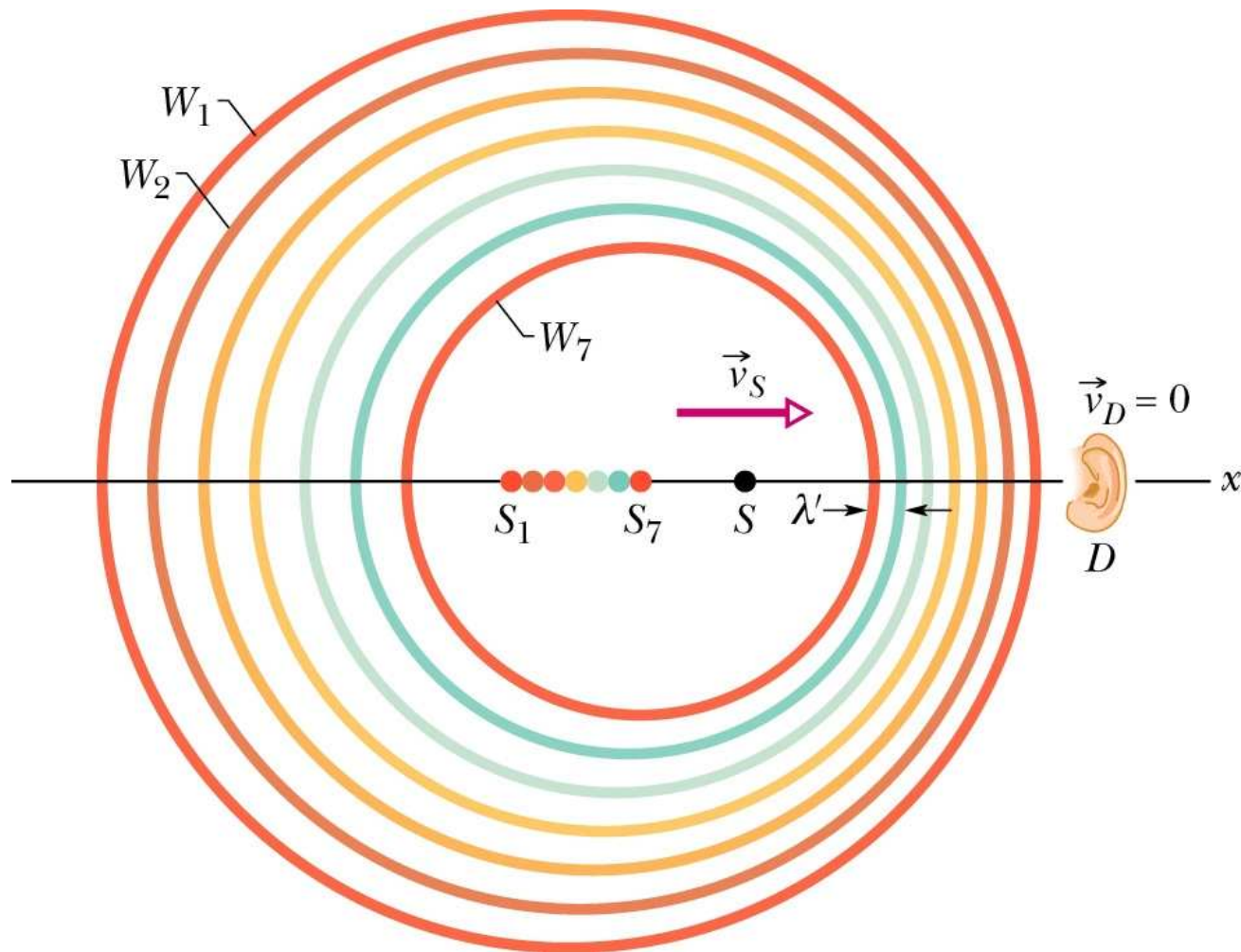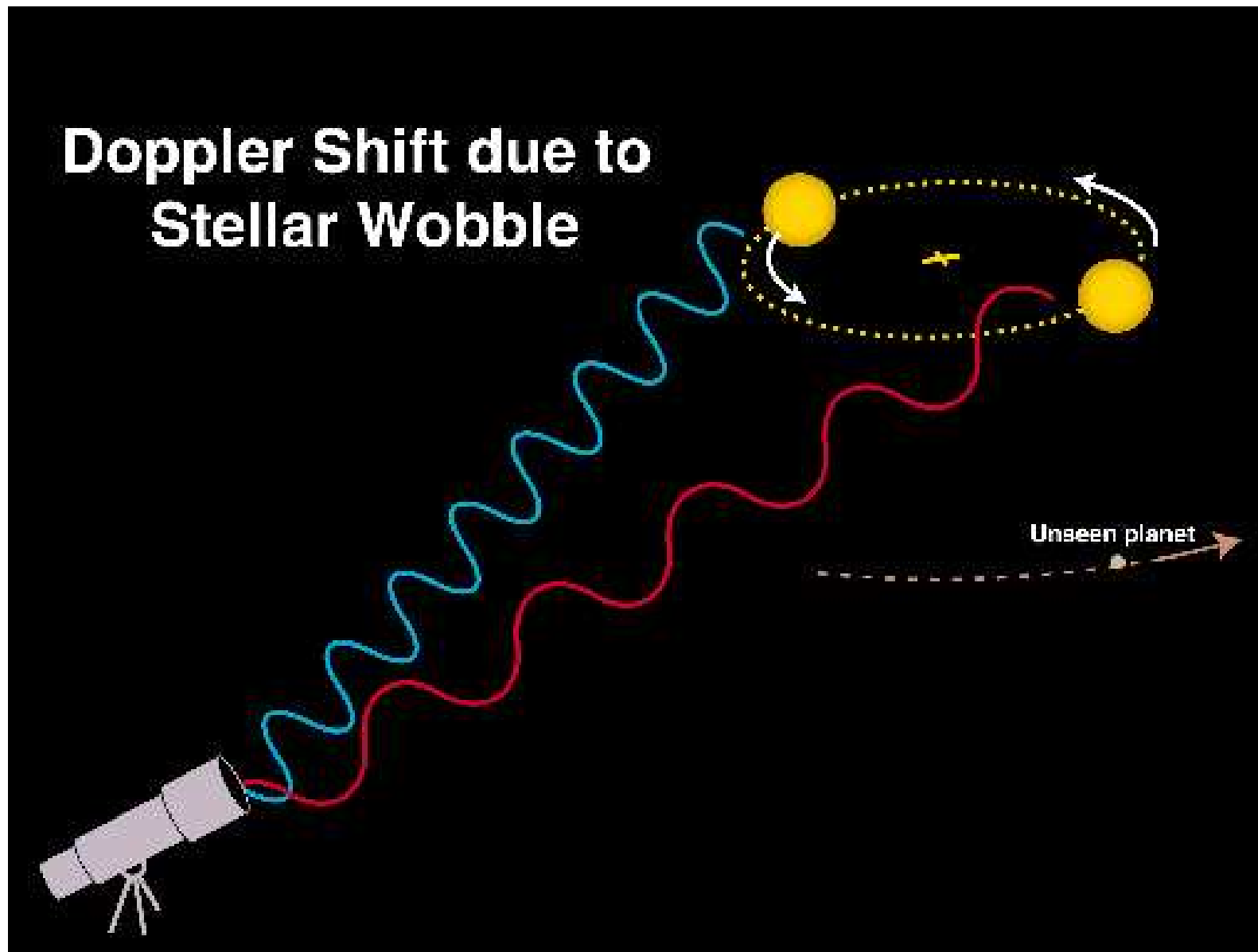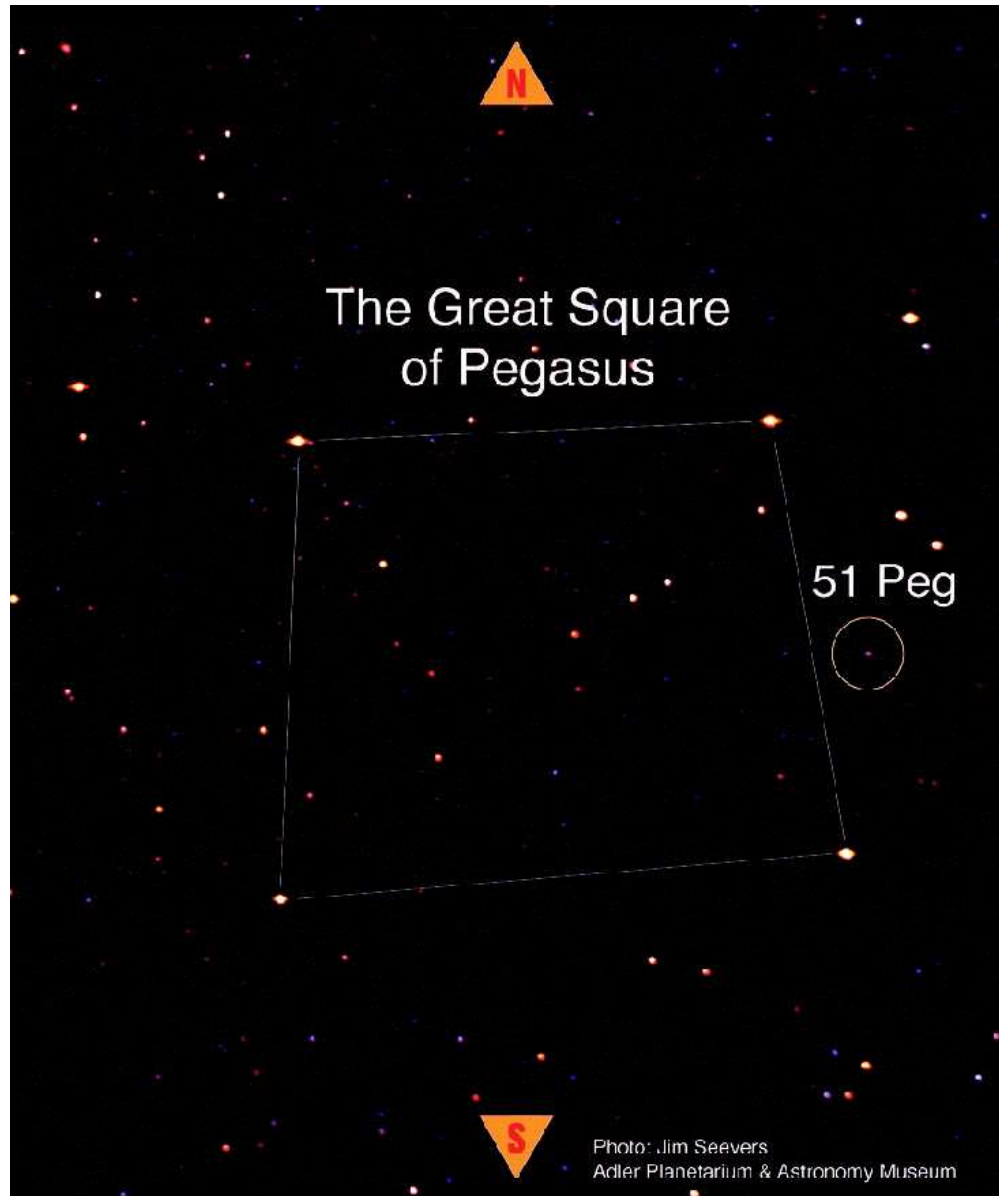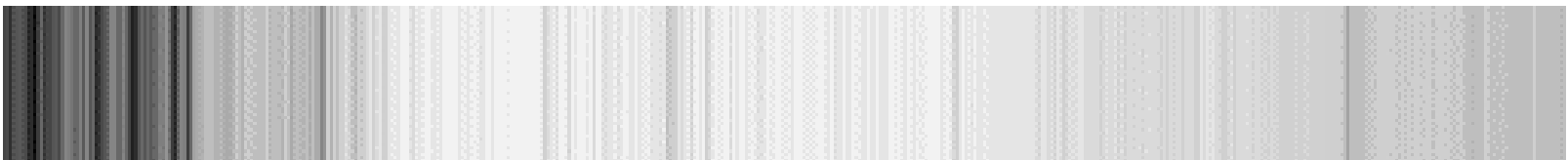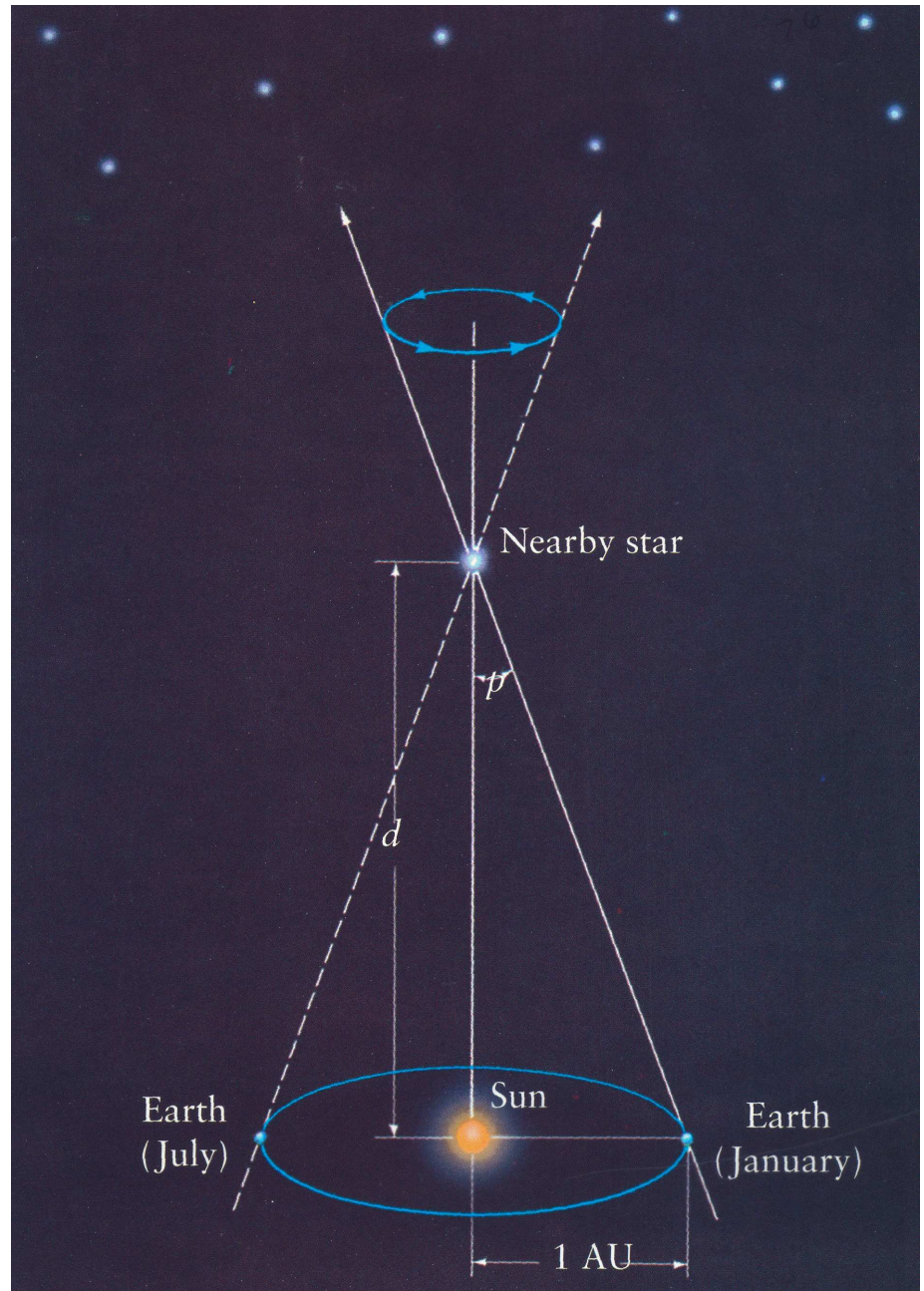
Stellar Spectra


G-type

A-type

K-type

The Method of Trigonometric Parallaxes

Nearby stars appear to move with respect to more distant background stars due to the motion of the Earth around the Sun. This apparent motion (it is not "true" motion) is called Stellar Parallax.
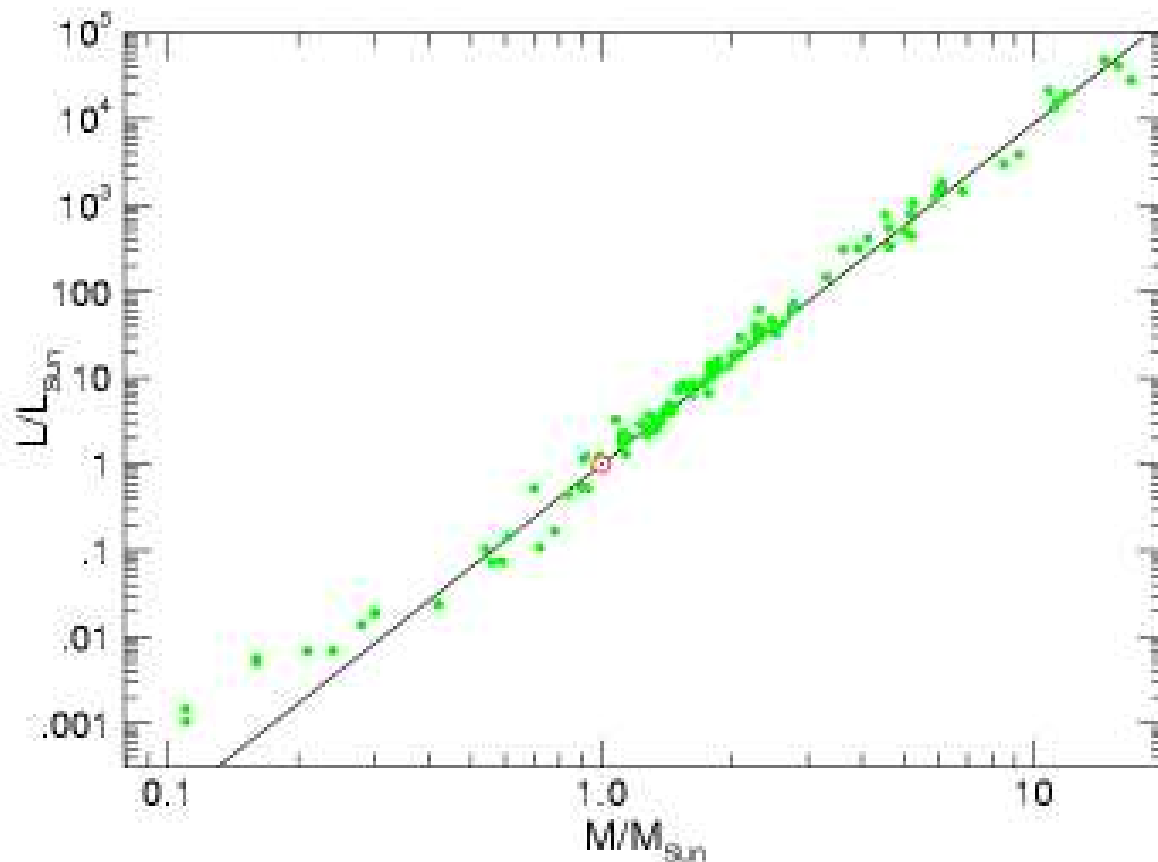
The Main Sequence

The main sequence of the Hertzsprung-Russell diagram is the curve where the majority of stars are located in this diagram. This line is so pronounced because both the spectral type and the luminosity depend on a star's mass only to zeroth order as long as it is fusing hydrogen.
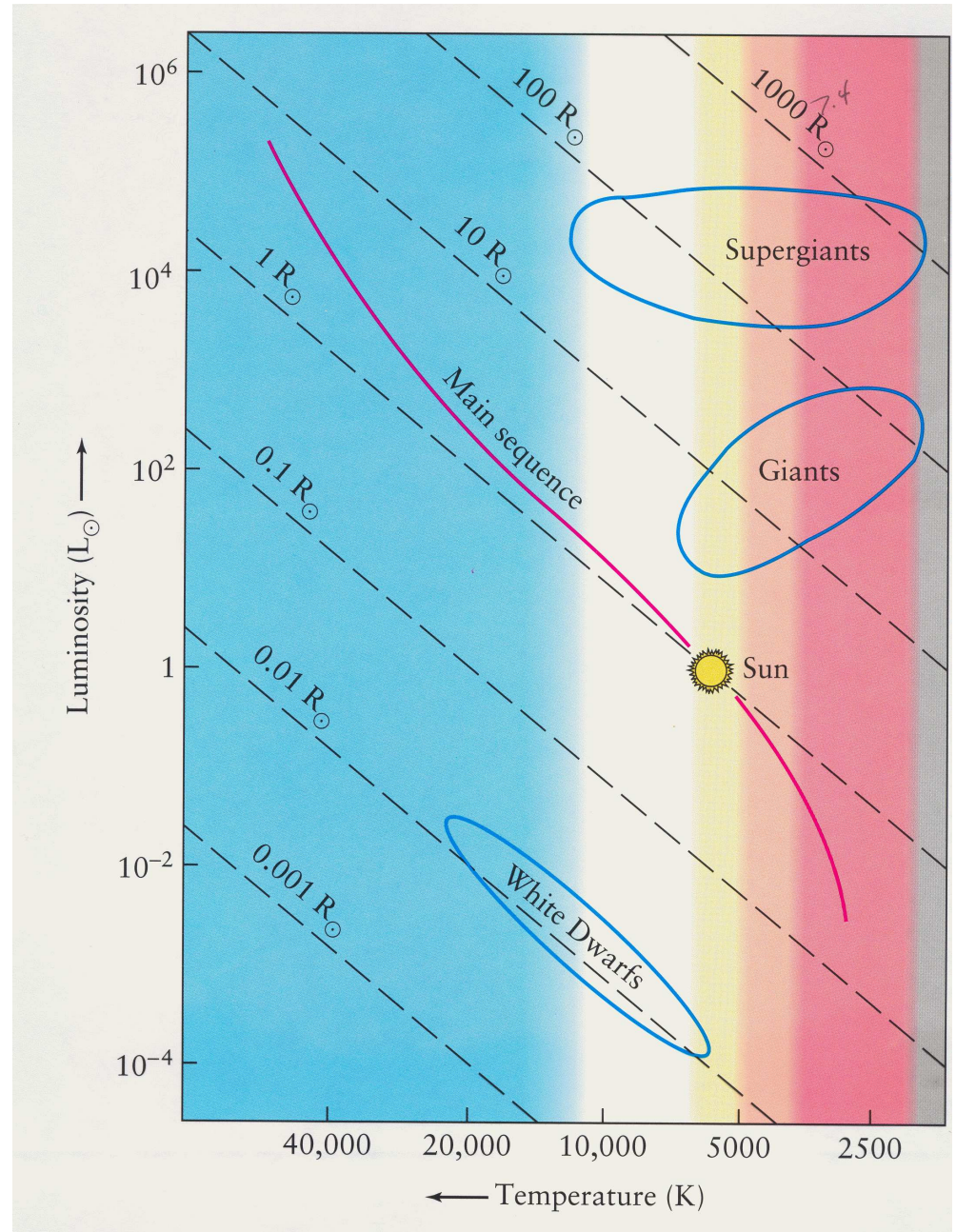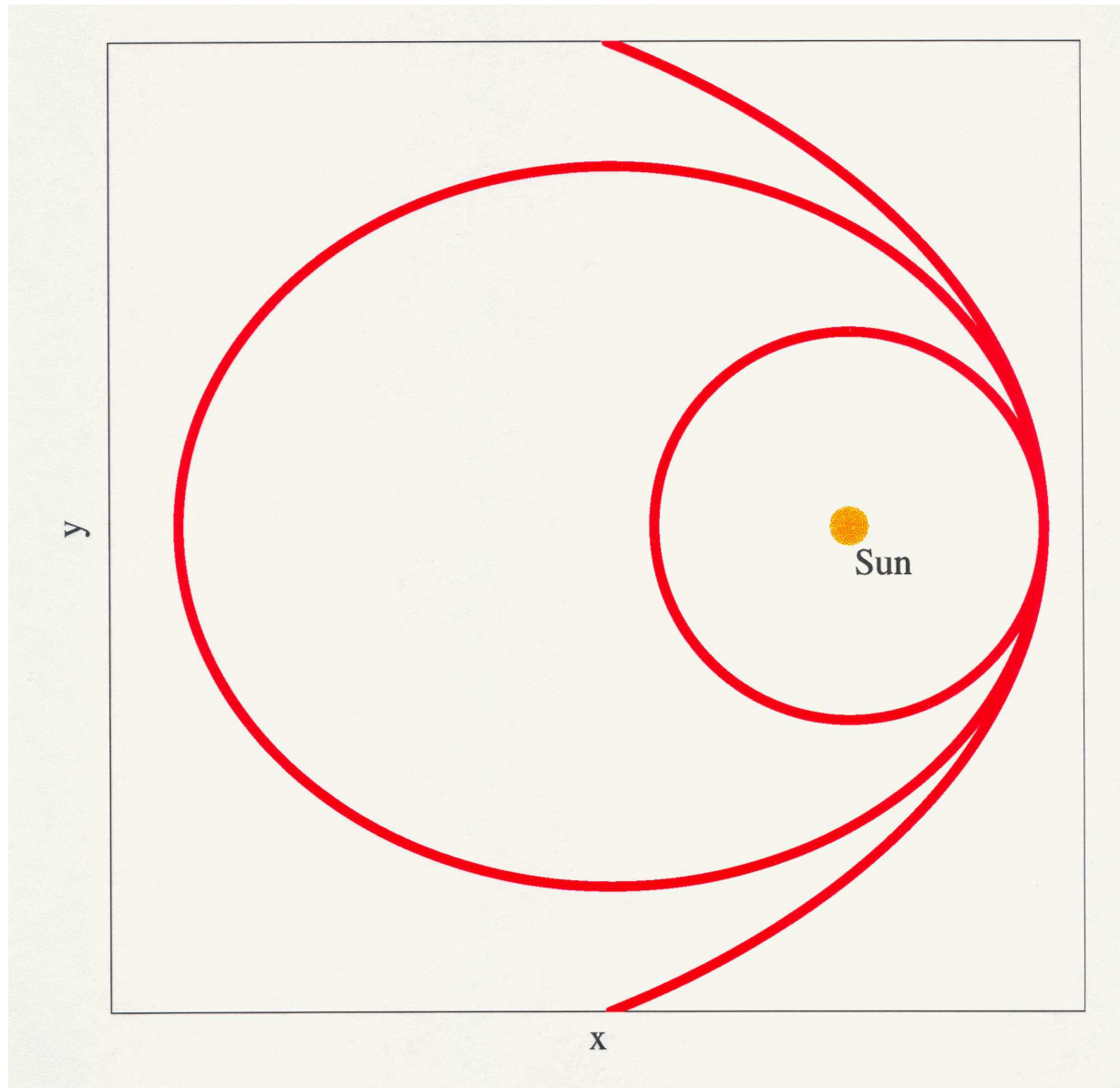
Getting the Mass of the Star

The luminosity of main sequence stars is proportional to their mass as shown in the plot below. Thus identifying the spectral type places the star on the main sequence and then measurments of its luminosity can be directly related to its mass.
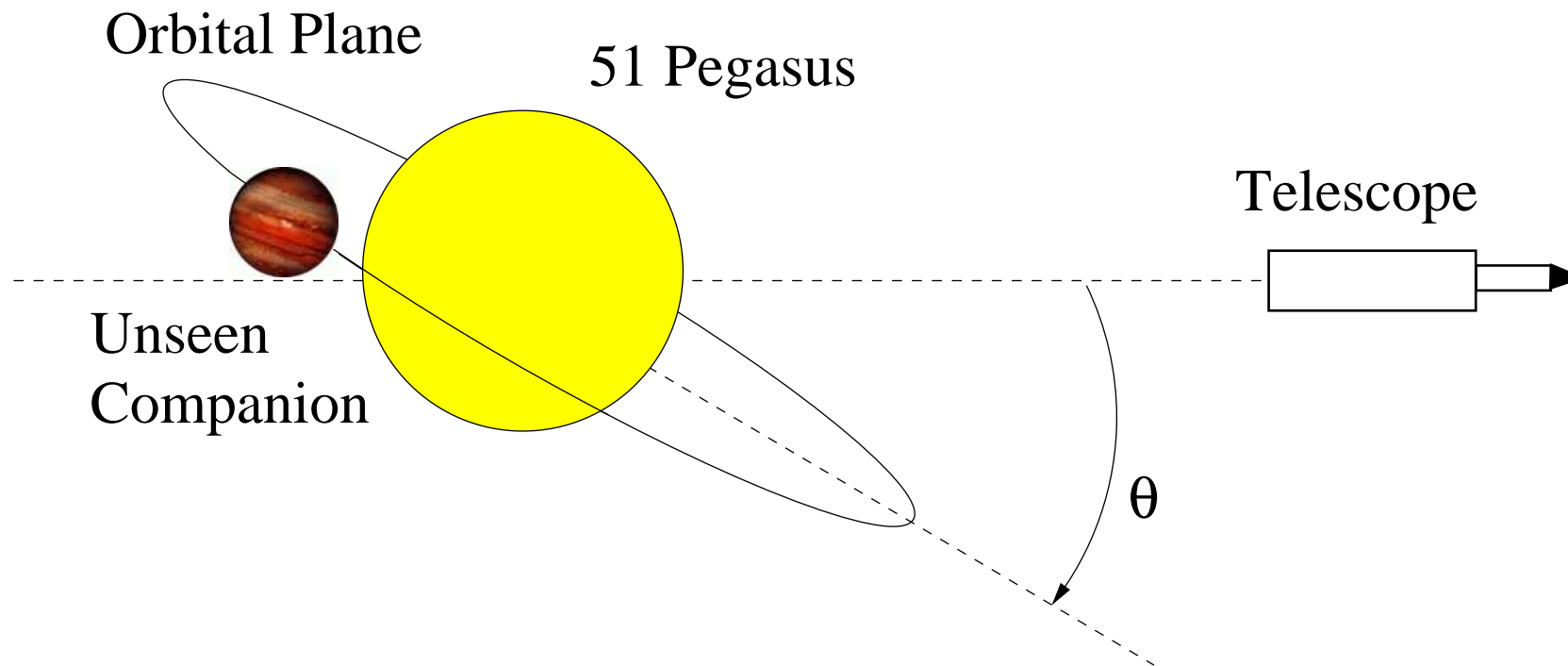
Bound Orbits

Orbital Plane Tilt

Orbital Plane

51 Pegasus

Telescope

Unseen
Companion

θ

A Comparison of the 51 Pegasus Planet with the Solar System

Mass in Units of Earth Mass

350
300
250
200
150
100
50

$M_{Sun} = 392,000 \cdot M_{Earth}$

51 Peg Planet

Jupiter

Mercury
Venus
Earth
Mars

0 1 2 3 4 5

Distance From the Sun in A.U.