

Radial Velocity Method Article

*This is an excerpt of an original article you can find here at this link in case you want to read the whole thing (but that's **optional**)*

<https://www.planetary.org/articles/color-shifting-stars-the-radial-velocity-method>

Color-Shifting Stars: The Radial-Velocity Method

The radial-velocity method for detecting exoplanets relies on the fact that a star does not remain completely stationary when it is orbited by a planet. The star moves, ever so slightly, in a small circle or ellipse, responding to the gravitational tug of its smaller companion. When viewed from a distance, these slight movements affect the star's normal light spectrum, or color signature. The spectrum of a star that is moving towards the observer appears slightly shifted toward bluer (shorter) wavelengths. If the star is moving away, then its spectrum will be shifted toward redder (longer) wavelengths.

HOW DO WE DETECT **EXOPLANETS**?



THE RADIAL-VELOCITY METHOD

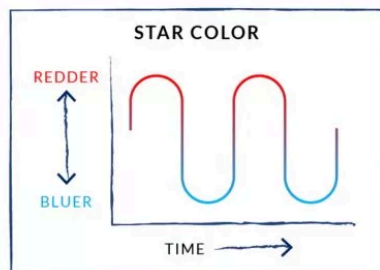
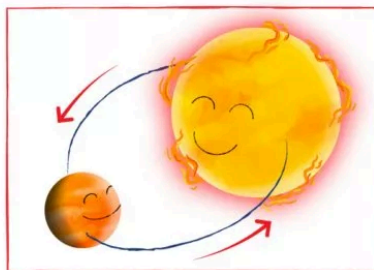
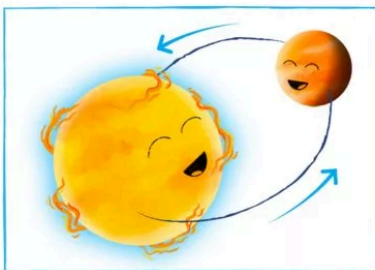
Gravity pulls on everything. Stars pull planets, and planets pull stars. We can sometimes see this pull when a planet is tugging on a star either toward us or away from us, making the star appear bluer or redder. This is due to the Doppler effect, which shifts the wavelength of the star's light. It's the same reason an ambulance siren changes pitch as it passes you!

Best for: ✓

- Finding **big** exoplanets in **close orbits**
- Measuring exoplanet **mass**
- **Ground-based telescopes**

Not great for: ✗

- Finding exoplanets in **distant orbits**
- Measuring exoplanet **diameters**
- Finding **small** exoplanets



How We Detect Exoplanets: The Radial-Velocity Method Exoplanets and their stars pull on each other. We can't see the exoplanet, but we can see the star move. The star's motion makes its light bluer and redder as seen from Earth.*Image: The Planetary Society*

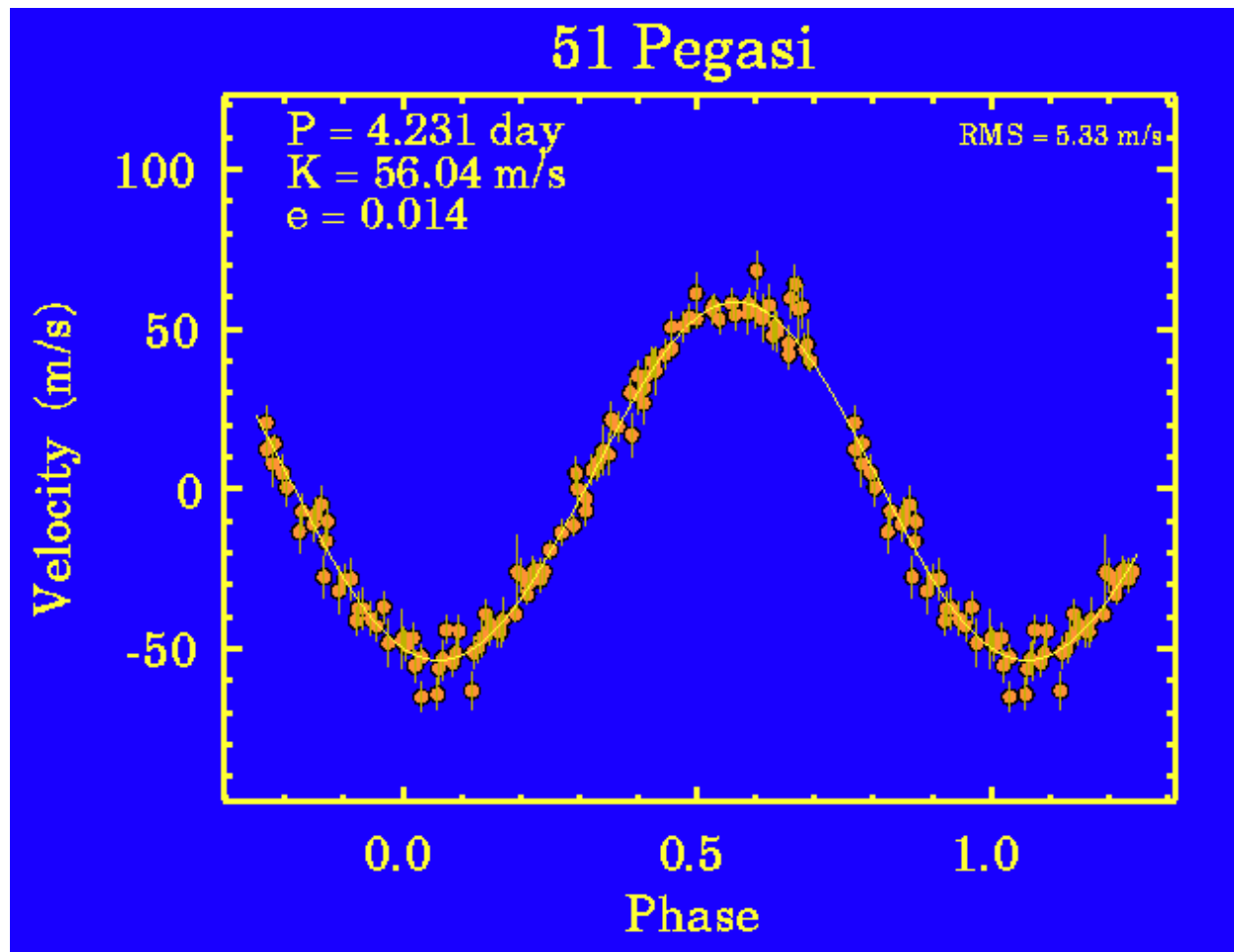
Using highly sensitive spectrographs attached to ground-based telescopes, planet hunters can track a star's spectrum, searching for periodic shifts spectral wobbles. The spectrum appears first slightly blue-shifted, and then slightly red-shifted. If the shifts are regular, repeating themselves at fixed intervals of days, months, or even years, it is almost certainly caused by a body orbiting the star, tugging it back and forth over the course of its orbit. If the body has a mass lower than about 10 times that of Jupiter (about 3,000 times the mass of Earth), then it is probably a planet. (Larger-mass objects are probably stars.)



The 3.6 meter telescope dome in La Silla, Chile This telescope was used to measure the radial velocity of numerous exoplanets discovered to date.*Image: S. Brunier/ESO*

Advantages

It's hard to argue with success. Radial velocity was the first successful method for the detection of exoplanets, and is responsible for identifying hundreds of faraway worlds. It is ideal for ground-based telescopes because (unlike for transit photometry) stars do not need to be monitored continuously. It doesn't require space-based telescopes or even the largest professional telescopes; the Isaac Newton telescope has a 2.5-meter primary mirror.



The radial velocity graph of 51 Pegasi 51 Pegasi was the first exoplanet detected and confirmed. The points on the graph indicate actual measurements taken. The sinusoid is the characteristic shape of the radial velocity graph of a star rocking to the tug of an orbiting planet. Image: exoplanets.org

Drawbacks

It is a fundamental feature of the radial-velocity method that it cannot accurately determine the mass of a distant planet, but only provide an estimate of its minimum mass. This is a serious problem for planet hunters, because mass is the leading criterion for distinguishing between planets and small stars. Some astronomers believe that at least some of the "planets" detected by the

radial-velocity method are not planets at all but very low-mass stars.

The source of this trouble with radial velocity is that the method can only detect the movement of a star towards or away from the Earth. This is not a problem if the orbital plane of the distant planetary system appears edge-on when observed from the Earth. In that case, the entire movement of the star will be towards or away from Earth, and can be detected with a sensitive spectrograph. The mass of the planet, derived from this movement, will in this case be fully accurate.

Another drawback of the radial-velocity method is that it is most likely to find the types of planets that are the least likely to be hosts to life. Early on, most of the planets detected by spectroscopy were of a type known among scientists as hot Jupiters. These are giant planets composed mostly of gas, similar to our neighbor, Jupiter, but orbiting at dizzying speeds at a very short distance from their star. Their size, short periods, and close proximity to their star ensures that they produce the quick and relatively large stellar wobbles that are most easily detected by spectroscopy. Cooler planets orbiting further away produce more moderate wobbles in their home star, and take years to complete each orbit, factors which make them much harder to detect with spectroscopy.

But while hot Jupiters are relatively easy to find by the radial-velocity method, they are unlikely homes to any form of life as we know it.

Even worse, their presence at the center of a planetary system makes it less likely that more Earthlike planets had survived in their neighborhood. In other words, while the discoveries made with spectroscopy established the presence and prevalence of planets outside our Solar System, most of the systems detected with this method are very unlikely abodes for life.