Notes – Methods for finding Exoplanets

Radial Velocity-also known as the spectroscopic or Doppler method, looks for tiny shifts in the light spectrum of a star that indicate that it is moving ever so slightly. When it is moving more towards Earth the star's spectrum shifts slightly towards the blue, and when it is moving more away from us it shifts towards the red. If the spectrum shifts occur at fixed regular intervals it indicates that the star is rocking back and forth at a fixed rate. This can mean that the star is moving to the tug of an invisible planet that pulls it back and forth as it orbits. The majority of exoplanets discovered to date were found by this method.

Disadvantages: cannot find the mass of the planet. Often we are seeing the star and planets at an angle and so the full wobble is not seen making an estimate of the mass impossible. Sometimes we are seeing a wobble due to a small mass star and not a planet. Also this method is best at finding large mass planets close to their star.

Transit Photometry- looks for a slight temporary dimming of a star that repeats itself over and over again. If the dimming occurs at regular intervals and lasts a fixed length of time it often means that a planet is "transiting" the star, passing between it and the Earth every time it completes an orbit, blocking out part of the star's light. Because it depends on extremely precise measurements of light, transit photometry is very susceptible to atmospheric interference, and the true potential of the method will only be realized from space, with missions such as COROT and Kepler.

Advantages: can find smaller planets, can find atomosphere, mass, temperature, density and orbital period of planets.

Disadvantages: in order to be measured earth must be a the right location for a transit to occur. Transit times may be very small compared the orbit of the planet around the star.

Microlensing: relies on a remarkable effect predicted by Einstein's general theory of relativity. When a star is positioned precisely behind another star when viewed from Earth, the closer star "lenses" the light from the distant star, causing it to appear as much as 1000 times brighter than normal. This effect usually lasts for a few weeks until the two stars move out of alignment, the lensing ceases, and the stars appear as dim as they normally would. But if the lensing star is orbited by a planet then it too adds its mass to the lensing effect, causing a unique second spike of brightness lasting several hours or days. When a second spike of brightness is observed and measured in a microlensing event, it is a very strong indication that a planet is orbiting the lensing star.

Advantages: Microlensing is capable of finding the furthest and the smallest planets of any currently available method for detecting extrasolar planets. In January of 2006 scientists announced [the discovery through microlensing of a planet](http://www.planetary.org/news/2006/0126_Discovery_of_Small_Distant_Planet.html) of only five Earth masses, orbiting a star near the center of our galaxy, 22,000 light-years away! It was the lowest mass planet detected up to that time, and also the furthest from the Earth.

Disadvantages: Unlike planets detected by other methods, which are associated with particular stars and can be observed repeatedly, planets detected by microlensing will never be observed again. This is because microlensing events are unique and do not repeat themselves. Another problem with microlensing is that the distance of the detected planet from the Earth is known only by rough approximation. When dealing with planets tens of thousands of light-years away, this could mean errors of thousands of light-years!

Astrometry: relies on extremely accurate measurements of a star's position in the sky to determine whether it is moving to the tug of an orbiting planet. Unlike the radial velocity and transit photometry approaches that work best when the plane of the planetary system is "edge on" when viewed from Earth, astrometry works best when the system is "face on" to an observer from Earth. In that configuration the full extent of a star's motion in the sky can be measured from Earth. Astrometry's future potential is enormous, and astronomers predict that it will be able to detect Earth-sized planets in Earth-like orbits around their stars

Advantages: Astrometry is one of the most sensitive methods for detection of extrasolar planets.

Disadvantages: First of all, discovering extrasolar planets through astrometry is extremely hard to do. It requires a degree of precision that has seldom been achieved even with the largest and most advanced telescopesastronomers believe that astrometry will be very useful for detecting planets in the Solar neighborhood, the method will be far less effective when applied to more distant objects. The new astrometric measurements could be so sensitive that they might be affected by star spots - there is an inherent difficulty in observing planets with long periods, the very planets that astrometry should excel in

Direct Imaging-There are, however, exceptional circumstances in which it is possible to observe an exoplanet with a telescope, and several such planets have been directly imaged to date.

Advantages: provides scientists with valuable information about the planet. Works best for planets a large distance from their stars.

Disadvantages: only possible on rare occasions.

Pulsar Timing: is the method used in 1992 to detect the first confirmed exoplanets, orbiting pulsar PSR B1257+12. Since then a handful of additional pulsar planets have been found by this method. Pulsars are rapidly rotating neutron stars -- the small but enormously dense remnants of massive stars that had exploded in a supernova. As they rotate pulsars emit a powerful beam of electromagnetic radiation that is detected on Earth as a regular and precisely timed pulse. Known pulsars have a rate that ranges from a few miliseconds to several seconds, depending on the speed of the star's rotation. Slight regular variations in the timing of the pulses indicate that the pulsar is moving back and forth, rocking to the tug of an orbiting planet. By precisely measuring the irregularities in the timing of the pulsars astronomers can deduce the orbit as well as the mass of the planet. The method is so sensitive that it can detect planets as small as one tenth the mass of Earth. However, the method applies only to pulsars, which are relatively rare celestial objects. Furthermore planets orbiting these dead stars with their high radiation are very unlikely to be hosts for life.