

What is an extrasolar planet?

Written by Administrator

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extrasolar planet, also called exoplanet, any planetary body that is outside the solar system and that usually orbits a star other than the Sun. The first extrasolar planets were discovered in 1992. More than 700 are known, and more than 2,300 await further confirmation.

Detection of extrasolar planets

Because planets are much fainter than the stars they orbit, extrasolar planets are extremely difficult to detect directly. By far the most successful technique for finding and studying extrasolar planets has been the radial velocity method, which measures the motion of host stars in response to gravitational tugs by their planets. The first planet discovered with this technique was 51 Pegasi b in 1995. Radial velocity measurements determine the sizes and shapes of the orbits of extrasolar planets as well as the lower limits of the masses of these planets. (They provide only lower limits on planetary mass because they measure just the portion of the star's motion toward and away from Earth.)

A complementary technique is transit photometry, which measures drops in starlight caused by those planets whose orbits are oriented in space such that they periodically pass between their stars and the telescope; transit observations reveal the sizes of planets as well as their orbital periods. Radial velocity data can be combined with transit measurements to yield precise planetary masses as well as densities of transiting planets and thereby limit the possible materials of which the planets are composed. Spectroscopic studies that rely on variations in the depth of the transit with wavelength have been used to identify gases such as hydrogen, sodium, and methane in the upper atmospheres of some close-in giant planets. The first

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detected transiting planet was HD 209458 b in 1999. Both radial velocity and transit techniques are most sensitive to large planets orbiting close to their stars. Three other techniques that have detected extrasolar planets are pulsation timing, microlensing, and direct imaging. Pulsation timing measures the change in distance between the signal source and the telescope by using the arrival times of signals that are emitted periodically by the source. When the source is a pulsar (a rotating, magnetized neutron star), current technology can detect motions in response to a planet whose mass is as small as that of Earth's Moon, whereas only giant planets can be detected around pulsating normal stars. The first extrasolar planets were discovered in 1992 around the pulsar PSR 1257+12 by using this method. Microlensing relies upon measurements of the gravitational bending of light (predicted by Albert Einstein's general theory of relativity) from a more distant source by an intervening star and its planets. This technique is most sensitive to massive planets orbiting hundreds of millions of kilometres from their star and has also been used to discover a population of free-floating giant planets that do not orbit any star. Direct imaging can be done by using starlight reflected off the planet or thermal infrared radiation emitted by the planet. Imaging works best for planets orbiting those stars that are nearest to the Sun, with infrared imaging being especially sensitive to young massive planets that orbit far from their star.

Physical properties

Between 5 and 10 percent of stars surveyed have planets at least 100 times as massive as Earth with orbital periods of a few Earth years or less. Almost 1 percent of stars have such giant planets in very close orbits, with orbital periods of less than one week. Some of these planets seem to be distended in size as a result of heating by their stars. More than 20 percent of stars have somewhat smaller nearby planets, with sizes of several to a few tens of Earth masses and with orbital periods of less than three months.

The most massive planets that transit their stars are made primarily of the two lightest elements, hydrogen and helium, as are the Sun and its two largest planets, Jupiter and Saturn. The term Jupiters is often used to describe these worlds, and the term hot Jupiters is applied to those massive planets orbiting very near their stars. Similarly, the terms Neptunes and hot Neptunes refer to planets less than about 10 percent of Jupiter's mass, and the term super-Earths refers to those planets that may well be rocky bodies only a few times as massive as Earth. The divisions between these various classes are not well defined, and these terms may well overemphasize the similarities with particular objects in the solar system. However, the lowest-mass transiting planets contain larger fractions of heavier elements than do transiting giant planets. An analogous relationship between planetary mass and composition exists within the solar system.

Nevertheless, many of the mentioned properties of extrasolar planets are in sharp contrast to those in the solar system. Jupiter, which takes nearly 12 years to travel around the Sun, has the shortest orbital period of any large planet (more massive than Earth) in the solar system. Even the closest planet to the Sun, Mercury, requires 88 days to complete an orbit. Within the solar system, the planets, especially the larger ones, travel on nearly circular paths about the Sun.

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Most extrasolar giant planets with orbital periods longer than two weeks have elongated orbits. Models of planetary formation suggest that giant extrasolar planets detected very near their stars formed at greater distances and migrated inward as a result of gravitational interactions with remnants of the circumstellar disks from which they accumulated. The free-floating giant planets had a different history in that they were probably formed in circumstellar disks but were ejected from their solar systems through gravitational interactions.

Stars that contain a larger fraction of heavy elements (i.e., any element aside from hydrogen and helium) are more likely to possess detectable gas giant planets. More massive stars are more likely to host planets more massive than Saturn, but this correlation may not exist for smaller planets. Many extrasolar planets orbit stars that are members of binary star systems, and it is common for stars with one detectable planet to have others. The planets detected so far around stars other than the Sun have masses from nearly twice to thousands of times that of Earth. All appear to be too massive to support life like that of Earth, but this too is the result of detection biases and does not indicate that planets like Earth are uncommon.

Directions for future research

Research in the field of extrasolar planets is advancing rapidly as new technologies enable the detection of smaller and more distant planets as well as the characterization of previously detected planets. Almost all the extrasolar planetary systems known appear very different from the solar system, but planets like those within the solar system would with current technology be very difficult to find around other stars. Thus, as most of those stars surveyed do not have detectable planets, it is still not known whether the solar system is normal or unusual.

The U.S. National Aeronautics and Space Administration's Kepler mission, launched on March 6, 2009, uses transit photometry from space to achieve unprecedented sensitivity for small planets with orbital periods of up to two years and should discover whether planets analogous to Earth are common or rare. In 2010 the Kepler team announced its first discoveries: four gas giant planets somewhat larger than Jupiter and one planet slightly larger than Neptune that is more enriched in heavy elements; all five orbit very close to their stars. In 2011 the Kepler team announced that they had discovered a planet, Kepler-22b, that was the first to be found in the habitable zone of a star like the Sun. They also discovered the first Earth-sized extrasolar planets, Kepler-20e and Kepler-20f (with radii 0.87 and 1.03 times the radius of Earth, respectively), and announced the discovery of 2,326 candidate planets. Many of those are smaller than Neptune—the smallest of the solar system's gas giants, with a radius 3.8 times that of Earth. Forty-eight of those candidate planets were found within the habitable zones of their stars, and 10 of those candidate planets are smaller than two Earth radii. More than one-third of the candidate planets were found in systems with other candidates.