

Planets Around Sun-Like Stars

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Precise Doppler measurements of 500 main sequence stars have revealed 20 companions that have roughly the mass of Jupiter. The mass distribution rises from about 5 Jupiter-masses toward lower masses, with the detection threshold currently set at 0.5 Jupiter masses. This rising mass distribution suggests that the detected companions represent the high-mass planets. The 5 planets which orbit closer than 0.1 AU all reside in circular orbits, plausibly induced by tidal interactions with the host star. In contrast, all 9 planet candidates that orbit farther than 0.2 AU (out to 2.5 AU) reside in eccentric orbits with ellipticities, $e > 0.1$, more elliptical than the orbits of Jupiter ($e = 0.048$) and Earth ($e = 0.03$). From theoretical models, these elliptical orbits may result from planets that were originally in circular orbits, but subsequently perturbed gravitationally by other orbiting planets, companion stars, passing stars, or by the protoplanetary disk. Our Solar System architecture appears, in retrospect, to represent a low entropy state, with its nine planetary orbits precariously stable in co-planar, circular orbits that have aligned angular momentum vectors. High-entropy planetary systems may represent the norm, leading to dynamical survivors that are preferentially the most massive planets.

The planet-bearing stars are systematically rich in heavy elements (as is the Sun) compared to stars in the Solar neighborhood. This enrichment indicates that planet formation depends sensitively on the abundance of heavy elements in the protoplanetary disk. Future planet searches will involve searches for planets that transit in front of their host star, as seen by the dimming of starlight. Such transits yield the radius of the planets, not yet measured. Ground- and space-based astrometry should detect Saturn- and Neptune-mass planets. Gravitational lensing can reveal Earth-mass planets, and future space-borne interferometry is planned to obtain direct images and spectra.