OBLIQUITIES OF KEPLER STARS: CLUES TO PLANET MIGRATION

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In the Solar system, the Sun's spin axis and the planets' orbital axes are nearly aligned. Although exoplanetary systems were also expected to be well-aligned, recent observations have uncovered systems with strongly misaligned orbits, and even retrograde orbits. These discoveries have stimulated progress on the most enduring problem of exoplanetary science: the existence of close-in planets. The results have been marshaled as evidence against the standard scenario of disk migration, and in favor of orbit-shrinking mechanisms involving few-body dynamics and tidal dissipation. However, all the previous work pertains to "hot Jupiters," leaving many questions unanswered. Do smaller planets also show a diversity of orbital orientations? What about planets with longer periods, which do not experience strong tides? And, in systems with multiple planets, are the orbits aligned with one another and with the central star? Kepler provides the first opportunity to answer these questions and study spin-orbit alignment for small planets, long-period planets, and multiple-planet systems. The PI proposes to study the obliquities of Kepler planet-hosting stars, using three complementary techniques: (1) Observations of the Rossiter-McLaughlin effect, a spectroscopic anomaly that reveals the sky-projected stellar obliquity for individual systems. The methodology is also useful for planet validation: making sure a transit-like signal is caused by a planet and not by a conspiracy of eclipsing stars. (2) Rotation rate statistics, which permit an assessment of spin-orbit alignment in an ensemble of stars with transiting planets. The distribution of projected stellar rotation rates is compared to that of a control sample of stars without transits. (3) Starspot anomalies, a new method by which a stars obliquity is revealed by timing the occultations of starspots by a transiting planet.