Astrometric search for extrasolar planets in stellar multiple systems

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Abstract

Using ground based large telescopes like the ESO/VLT in Chile (VLT), we observe nearby stellar multiple systems and monitor their separation and position angle over the time very precisely by relative astrometry. Our goal is to detect extrasolar planets in binaries and triple systems in order to improve our understanding of observational biases and selection effects in the sample of extrasolar planets known today. Observing our targets with AO assisted infrared imagers, we are able to study binaries over a wide range of apparent semi-major axes from about five AU up to thousand AU. This allows us to search for exoplanets in `hidden' binary systems, where the AO-assisted binarity of the system can only be revealed by orbital period and position angle time series (e.g. with the ESO/VLT). In order to improve our understanding of observational biases and selection effects in the sample of extrasolar planets known today, we observe the semi-major axes range from several to thousand AU and by including also suitable systems with no known exoplanets as well as with known exoplanets in order to confirm them by an additional check of their astrometric stability.

As a first result, we detected the astrometric signal of a further higher mass object in the HD19994 exoplanet host binary. Our astrometric detection is confirmed by speckle-interferometry as well as spectroscopic follow-up observations. Thus, HD19994 is a triple system where an exoplanet orbiting one of its stars.

1. Astrometric search of extrasolar planets

Currently, about 450 exoplanets are detected, most of them by radial velocity or transit measurements. Today, it is generally known that each search method has its own observational bias and selection effect. For example, using our own solar system as a archetype, most of the exoplanet searches programs today concentrate on single sun-like stars. As one can clearly see in Fig. 1, every observation method covers a specific area in the parameter-space. Transiting exoplanets are mainly found for jovian planets with a mass of\( M_\text{Jov} \leq 10 M_{\oplus} \) and for stars with a mass of\( M_\ast < 1 M_{\odot} \).

2. Astrometric observations of stellar multiple systems

Our targets are nearby (\( \leq 100 \) pc) stellar multiple systems, mainly binaries and triple systems. We choose suitable systems with no known exoplanets as well as with known exoplanets in order to confirm them by an astrometric signal. Covering the semi-major axis range from several to thousand AU and by including also systems with late-type stars, we are able to systematically analyze exoplanet properties with respect to the stellar system properties, like host star mass and separation.

3. First result: The exoplanet host binary HD19994 - now a triple system

At the end of 2009, we observed one of our targets, the exoplanet host-system HD19994, for the fourth time. Due to the stellar binary orbit itself, which also affects the binary separation and position angle and which we handle as a second order polynomial, we need at least four measurements before we are able to check our data for an astrometric signal. HD19994 is a stellar binary with an FVW as primary (\( \theta_1 \leq 111.6^\circ \)) and its secondary (\( \theta_1 \leq 111.6^\circ \)) with a separation of about 2.6 arcsecs. Our goal was to detect the astrometric signal of HD19994 A (\( \theta_1 \leq 111.6^\circ \)) and HD19994 B (\( \theta_1 \leq 111.6^\circ \)), which turned out to be a second order polynomial as a stellar binary influence. Deviations and a model for a further astrometric companion around HD19994 B is plotted in the middle panel. At the bottom the residuals to the astrometric companion is shown. In 2004 no astrometric calibration was observed, which results in larger error bars.