Abstract

The combined observations of a planet's transits and the radial velocity variations of its host star allow the determination of the planet's orbital parameters, and most interestingly of its radius and mass, and hence its mean density. Observed densities provide important constraints to planet structure and evolution models. The uncertainties on the parameters of large exoplanets mainly arise from those on stellar masses and radii. For small exoplanets, the treatment of stellar variability limits the accuracy on the derived parameters. The goal of this PhD thesis was to reduce these sources of uncertainty by developing new techniques for stellar variability filtering and for the determination of stellar temperatures, and by robustly fitting the transits taking into account external constraints on the planet's host star.

To this end, I developed the Iterative Reconstruction Filter (IRF), a new post-detection stellar variability filter. By exploiting the prior knowledge of the planet's orbital period, it simultaneously estimates the transit signal and the stellar variability signal, using a combination of moving average and median filters. The IRF was tested on simulated CoRoT light curves, where it significantly improved the estimate of the transit signal, particulary in the case of light curves with strong stellar variability. It was then applied to the light curves of the first seven planets discovered by CoRoT, a space mission designed to search for planetary transits, to obtain refined estimates of their parameters. As the IRF preserves all signal at the planet's orbital period, t can also be used to search for secondary eclipses and orbital phase variations for the most promising cases. This enabled the detection of the secondary eclipses of CoRoT-1b and CoRoT-2b in the white (300–1000 nm) CoRoT bandpass, as well as a marginal detection of CoRoT-1b's orbital phase variations. The wide optical bandpass of CoRoT limits the distinction between thermal emission and reflected light contributions to the secondary eclipse.

I developed a method to derive precise stellar relative temperatures using equivalent width ratios and applied it to the host stars of the first eight CoRoT planets. For stars with temperature within the calibrated range, the derived temperatures are consistent with the literature, but have smaller formal uncertainties. I then used a Markov Chain Monte Carlo technique to explore the correlations between planet parameters derived from transits, and the impact of external constraints (e.g. the spectroscopically derived stellar temperature, which is linked to the stellar density).

Globally, this PhD thesis highlights, and in part addresses, the complexity of performing detailed characterisation of transit light curves. Many low amplitude effects must be taken into account: residual stellar activity and systematics, stellar limb darkening, and the interplay of all available constraints on transit fitting. Several promising areas for further improvements and applications were identified. Current and future high precision photometry missions will discover increasing numbers of small planets around relatively active stars, and the IRF is expected to be useful in characterising them.