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The role of IR-observations for removing false-positives in transit, and radial-velocity surveys

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Abstract

Although there are already well-developed methods for removing most of the false-positives of planet search programs, future missions to study specific planets require target lists that are absolutely free from false-positives. It is thus necessary to develop methods for removing false-positives even further. In here I discuss what role IR-observations could play in this respect.

1. Introduction

Given that radial-velocity surveys have undoubtedly detected more than 500 extrasolar planets, and transit search programs more 100, one might think that the issue of false-positives is solved. However, we are now entering a phase in which large amounts of observing time and resources are invested in order to study a few, well selected targets. Such programs require input catalogues that are absolutely free of false-positives. Because it is planed to study the atmospheres of planets discovered with the radial-velocity (e.g. EPICS [1]), as well as with the transit method (e.g. JWST [2]), we have to develop methods to remove false-positives for both. In here I discuss how IR observation can help to detect false-positives for both methods.

2. False-positives in radial-velocity programs

False positives of radial-velocity search programs are caused by surface features on the star, and by blends due to other stars in the entrance-fibre (or slit).

If there are two stars in the fibre of the spectrograph, a mixture of the spectra of the two stars is observed. If the two stars have the same brightness, we observe an SB2-system. If one star is much fainter than the primary, we may not see it but it may still cause radial-velocity variations .

Methods like TODCOR [3] have successfully been used in order to detect the signature of a faint star in the spectrum of a bright one. Alternatively we can use the line-bisector method. However, in extreme cases both methods may not be sensitive enough.

In this case IR-observations help. The most obvious idea is to observe the targets with an AO-system in order to find out whether there is a faint star close to the target. However, this method does not work, if the separation is too small.

An object with a small separation would most likely be a physical companion. A physical companion that is faint would have spectral type that is later than the primary. Thus, the brightness difference between the two stars would be smaller in the IR than in the optical [4]. It would thus be quite easy to detect a faint companion in an IR-spectrum (Figure 2). If we use additionally TODOCR, we are able to exclude even the most extreme cases of false-positives [3].

Because spots are cooler than the photosphere, almost the same method works also for false-positives caused by spots. Such false-positives can easily be removed by obtaining radial-velocity measurements in the optical and in the IR [5]. Thus, IR-spectroscopy allows to remove very efficiently false-positives that cannot be detected easily by other means.

3. False-positives in transit-search programs

In the cause of CoRoT and Kepler-mission efficient methods have been developed to remove false-positives. After these tests have been made, the most difficult case to exclude is a triple star containing a bright primary and two faint companions. Figure 1 shows an example for such a system [6].

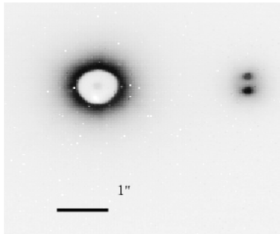

Figure 1. Example for a triple system consisting of a bright primary and two faint stars. (Image taken with NaCo [6]).

If the two faint companions are an eclipsing binary and all three stars are within the photometric aperture, we would observe a shallow transit like a transiting planet.

Such cases are not rare. About 8% of the solar-type stars are in systems containing three or more stars [7]. Dynamically stable triple systems are hierarchical with $P_L/P_S>5$ [8]. Because a faint companion has to have a later spectral type than the primary, the brightness difference between primary and secondary is smaller in the IR than in the optical. An IR spectrum thus allows to rule out this source of false-positives again. Figure 2 shows a binary consisting of primary with a spectral type G5V and a secondary of spectral type M3V. Although it would be difficult to detect the companion in the optical regime, the lines from the secondary (marked) are easily visible in the K-band spectrum [4].

Another method to exclude a triple-system is to observe the transit in the optical and in the infrared. If the transit were on a faint, red star instead of the primary, the transit would be deeper in the IR than in the optical.

4. Conclusions

Infrared spectroscopy is a very power-full tool in order to detect false-positives, which are not easily, detect with other methods. Thus by taking a few IR spectra of the most interesting targets, the number of false-positives can be significantly reduced.

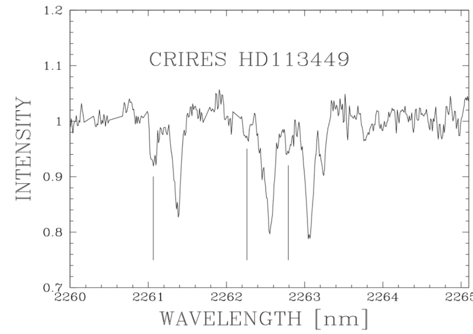

Figure 2.: IR spectrum of a binary consisting of a G5V primary and an M3V secondary (marked) [4].

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