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EXOPLANET CHARACTERIZATION WITH LONG SLIT SPECTROSCOPY IN HIGH CONTRAST IMAGING

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Abstract. Extrasolar planets observation and characterization with high contrast imaging instruments will be a very important subject for observational astronomy in the coming decade. Dedicated new instruments are being developed in order to achieve this goal with very high performance. In particular, full spectroscopic characterization of low temperature planetary companions is an extremely important milestone. We present a new data analysis method for long slit spectroscopy (LSS) with coronagraphy which allows characterization of planetary companions with low effective temperature. In a speckle-limited regime, the method allows an accurate estimation and subtraction of the scattered starlight, in order to extract a clean spectrum of the planetary companion. This method was developed in the context of SPHERE (Dohlen et al. 2006), a second generation instrument for the VLT, that will offer several observing modes for detection and characterization of exoplanets in the near-infrared. Using this method we are able to achieve a contrast reduction of 0.5 to 2.0 magnitudes compared to the coronagraphic observations on simulated images, leading to the possible characterization of planetary companions with effective temperatures of 600 K and 900 K orbiting respectively around M0 and G0 stars at 10 pc, and for angular separations of 1.0″.

1 Data analysis

The main limitation in high-contrast coronagraphic images are the speckles induced by atmospheric phase residuals and instrumental aberrations. To remove the scattered starlight and retrieve a clean planetary spectrum we have developed a data analysis method for long slit spectroscopy which uses the fact that the speckle pattern size and position is wavelength dependant (Sparks & Ford 2002), whereas the planet position remains fixed with wavelength (Fig. 1). A detailed description of the method is available in Vigan et al. (2008).

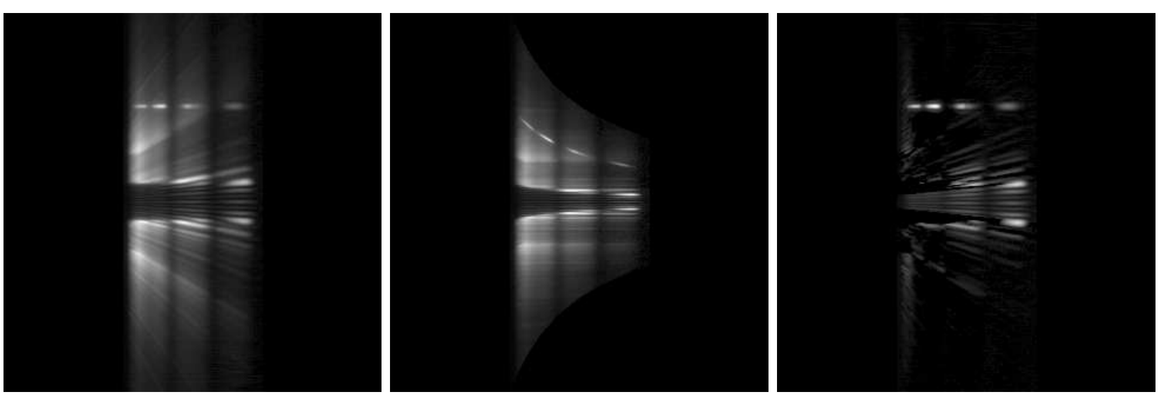

Fig. 1. Illustration of our data analysis method. **Left:** the coronagraphic star spectrum with one companions at 1″. **Middle:** same spectrum after spatially rescaling each column according to its corresponding wavelength. **Right:** final spectrum after removing the star contribution and rescaling the columns back to their original size.

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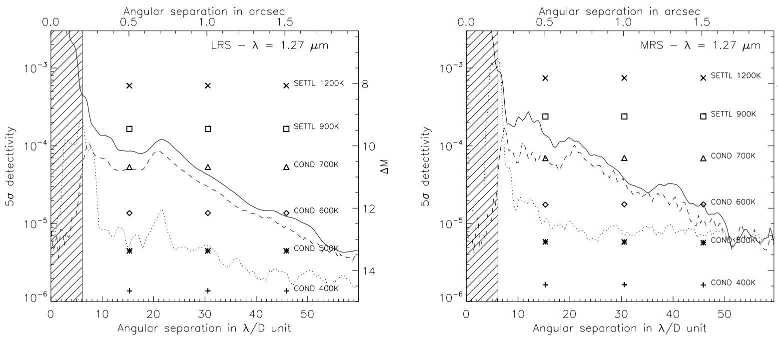

Fig. 2. Detection limit as a function of angular separation for an M0 star at 10 pc in low (left) and medium (right) resolution at $\lambda = 1.27$ μm, and for an exposure time of 1 hour. *Plain line*: non-coronagraphic PSF. *Dashed line*: coronagraphic PSF. *Dotted line*: detection limit after data analysis. *Hatched area*: coronagraph mask.

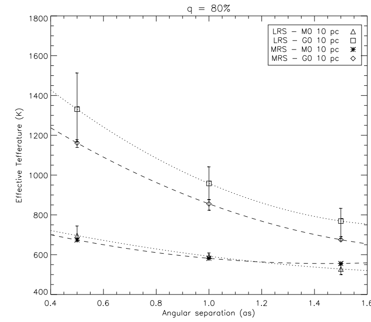

Fig. 3. Effective temperature at which a value of $q = 80\%$ is reached for M0 and G0 stars at 10 pc, as a function of angular separation, in low and medium resolution.

2 Performances

The performance of the data analysis method is evaluated in two ways: the contrast reduction and the quality of the spectrum extraction.

2.1 Contrast reduction

Our data analysis method offers an improvement of the detection limit by 1.0 to 2.5 magnitudes (Fig. 2) in J and H band. In K band the results are slightly decreased because the contrast is already very favorable. Considering COND-2003 models (Allard et al. 2003), our method would allow proper characterization a 600 K companion orbiting at $1.0''$ around an M0 star at 10 pc, in both low ($R = 35$) and medium ($R = 400$) resolution. This performance is equivalent to the detection mode of SPHERE (Boccaletti et al. 2008).

2.2 Extraction quality

We defined a quality factor, q, which measures the correlation and discrepancy between input and output spectra of the companion. Analysis with COND-2003 atmosphere models shows that error on T_{eff} determination of the companion is less than 100 K for $q > 80\%$. Figure 3 shows the effective temperature at which a value of $q = 80\%$ is reached in different cases. We see that the performance is comparable in low and medium resolution for both M0 and G0 stars at 10 pc. The performance depends on angular separation, especially for bright stars.

References

Dohlen, K. 2006, SPIE Proc., 6269

Sparks, W. B. & Ford, H. C. 2002, ApJ, 578, 543

Vigan, A. 2008, ArXive e-prints, 808, arXiv:0808.3817

Allard, F. 2003, IAU Symposium, 211, Brown Dwarfs

Boccaletti, A. 2008, ArXiv e-prints, 807, arXiv:0807.0697