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# EXTRASOLAR PLANETS IMAGING EXPLOITING THE LBT AO SYSTEM + PISCES CAMERA

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**Abstract.** In the next future new instruments for the imaging of extrasolar planets (like e.g. SPHERE at VLT or GPI at Gemini) will be available. At the moment however, one of the best opportunity to image extrasolar planets consists in exploiting the very effective AO system at LBT. Our observations (during the commissioning period at the end of 2011) of the HR8799 planetary system with LBT + the Pisces camera demonstrated our capability to perfectly image all the four planets around that star exploiting the Angular Differential Imaging method. Following these encouraging results, we began a program for the observation of stars with known IR excess. Results for two stars (HIP101800 and HIP85157) were obtained in June 2012. No obvious candidate was found and very strict constraints were put to the mass of possible companions around these targets.

## 1. Introduction

More than 900 extrasolar planets have been found until now but just ~30 of them have been discovered through direct imaging methods. This is mainly due to the great luminosity contrast (of the order of $10^{-6}$ for young giant planets) and to the small separation (few tenths of arcsec for planets at separations of 10 AU for target at distances of some tens of pc). In the next future some important instrument devoted to the imaging of extrasolar planets are scheduled to be installed to the telescope. The most important of them are SPHERE [1] at VLT and the Gemini Planet Imager (GPI) [2] at Gemini South Telescope. However, until the commissioning of these instrument, one the best oppurtunity available to make imaging of extrasolar planets is to exploit the Adaptive Optic (AO) system at the Large Binocular Telescope (LBT).
In this paper we describe the results of the observations made using the AO system + the PISCES camera at LBT of three different targets. The first of these target was the well known multiplanetary system HR8799 composed by four different planets. The first three of them were found by [3] while the fourth and inner one was discovered by [4]. We observed the planets both in the H and in the Ks band and we were able to find them in both the bands. These observations are described in more detail in Section 2. Following the good results of these observations, we were then able to observe, some months later, two more targets with the system in the same configuration as for the previous observations even if this time they were made just in the H band. These observations are described in more detail in Section 4 and 5 respectively. Our conclusions are then given in Section 6.

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## 2. Observations of HR8799

The data used in this case have been taken during the AO+PISCES Science Verification Time (SVT) on October 16, 2011 for the H band and during the Science Demonstration Time (SDT) on November 9, 2011 for the Ks band. For a more detailed description of the observations we refer to [5]. The observations were performed with the image rotator stopped to allow the implementation of the Angular Differential Imaging (ADI) technique [6]. The final images obtained from the data in the H and in the Ks band are displayed in Figure Figure 1 and in Figure Figure 2 respectively.

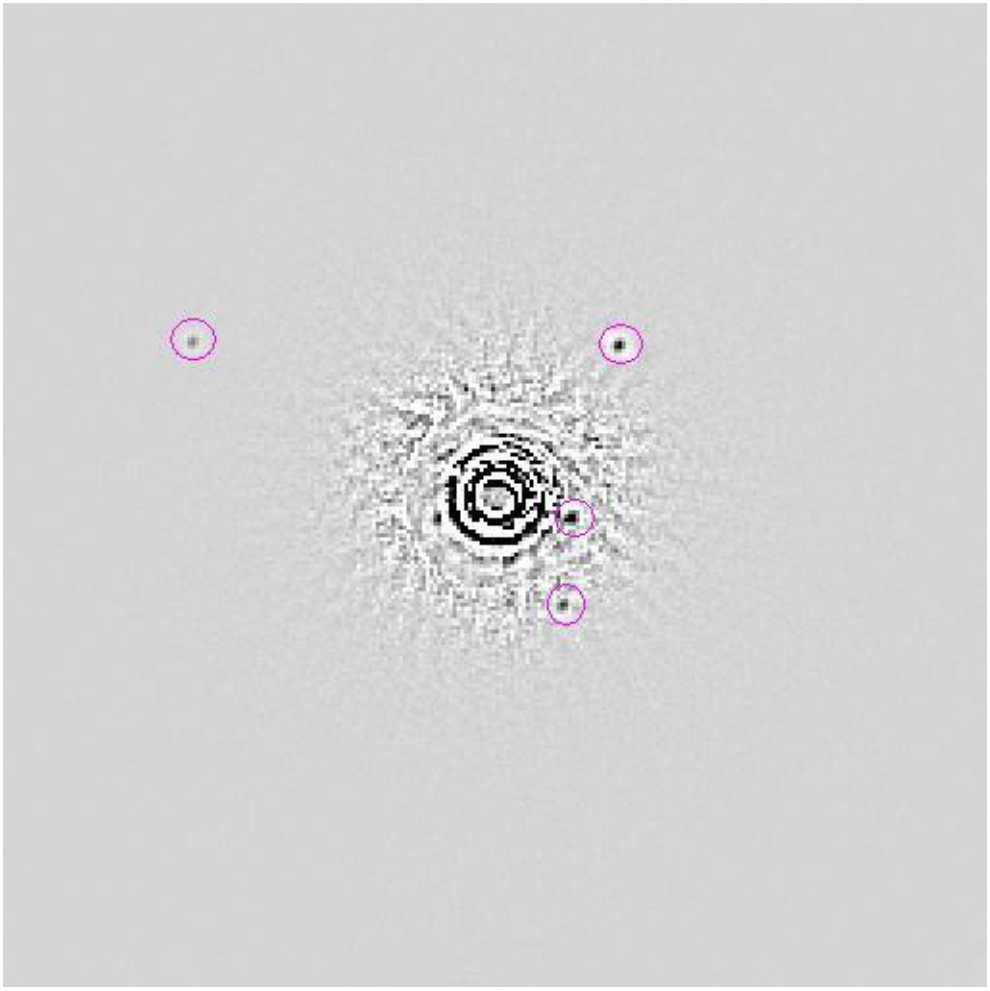

Figure 1 – HR8799 final image obtained from the H band data

In both these images the four planets are clearly visible with a S/N well above 5σ. We have to stress that this is the first time that HR8799e is imaged in the H band. In Figure 3 and in Figure 4 we displayed the contrast plot (in Δmag vs separation expressed in arcsec) both for the H and the Ks band. We superposed to these plots the positions of the planets obtained exploiting our photometry measures. They are indicated with the red triangles. As a acomparison, we displayed the positions of the planets as obtained from the photometry of the original Marois paper. The correspondance between our results and the Marois ones is in general very good.

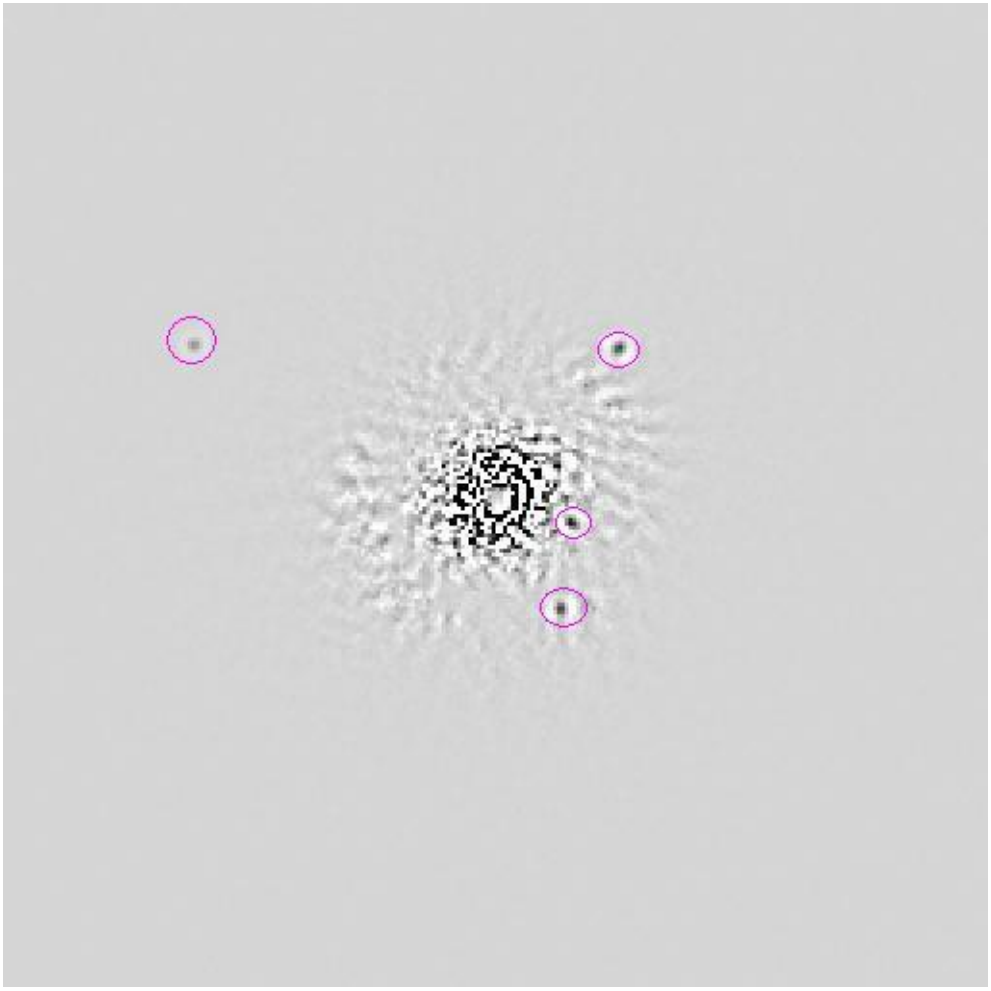

Figure 2 – HR8799 final image obtained from the H band data

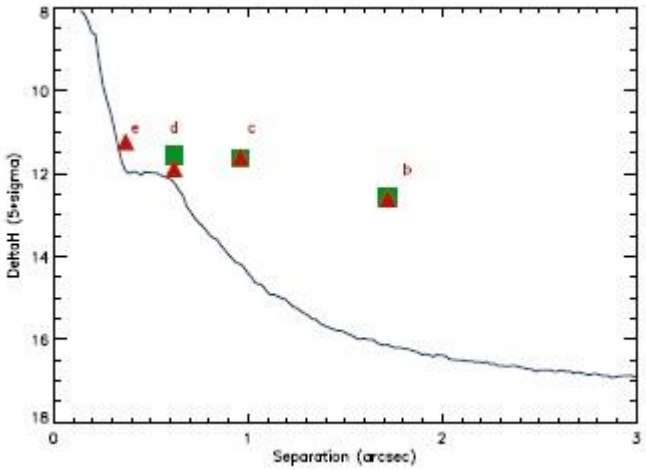


Figure 3 – Contrast plot obtained for the H band.

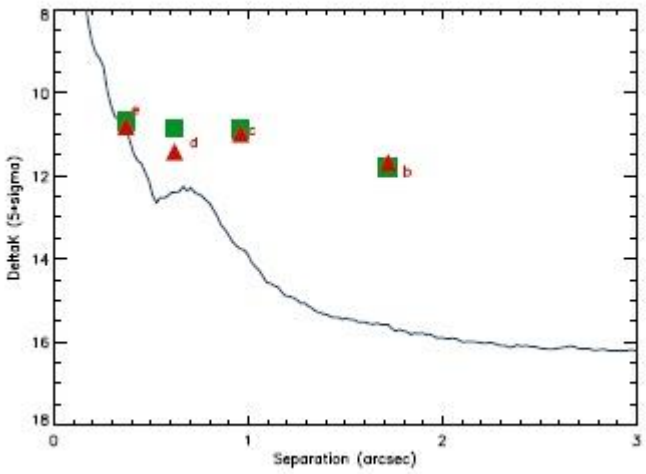


Figure 4 – Contrast plot obtained for the Ks band.

## 3. New observations with LBT+PISCES

Following the good results of the observations described in the previuos paragraph, we decided to test our method on new targets that were selected from a sample of star with known IR excess and that were transiting at the meridian during the observing period at our disposal (that is in the mid of June 2012). At the end we remained with four interesting targets to be observed but it was possible to actually observe just two of them: HIP101800 and HIP85157. Moreover, for the latter the weather condition were not ideal. In the following paragraphs we describe the results obtained for these two targets.

## 4. Observations of HIP101800

This target was observed on June 21, 2012 in the H band with a DIT of 3.5 s in such a way to saturate the central part of the target PSF. The total exposure time was of the order of 1800 s. In the final image obtained from this data two objects are visible at separations larger than 4 arcsec. They are however background objects as demonstrated by images of the same target taken with different instruments. The final image obtained from the analysis of these data is showed in Figure 5. A possible source is visible very near to the star (~0.3 arcsec) with a S/N of the order of 7.5 but it is probably a not well subtracted speckle. The contrast plot that we have obtained from this image is then showed in Figure 6. While the final contrast is not good as the one obtained for HR8799, the final results is however of comparable magnitude. In Figure 7 we display the contrast plot for this target expressed in terms of Jupiter masses calculated exploiting the models by Baraffe [7] assuming for the star an age of 30 Myr as defined by [8]. The vertical line in the plot represents the extimated position of the flux maximum of the disk around the star according to [8].

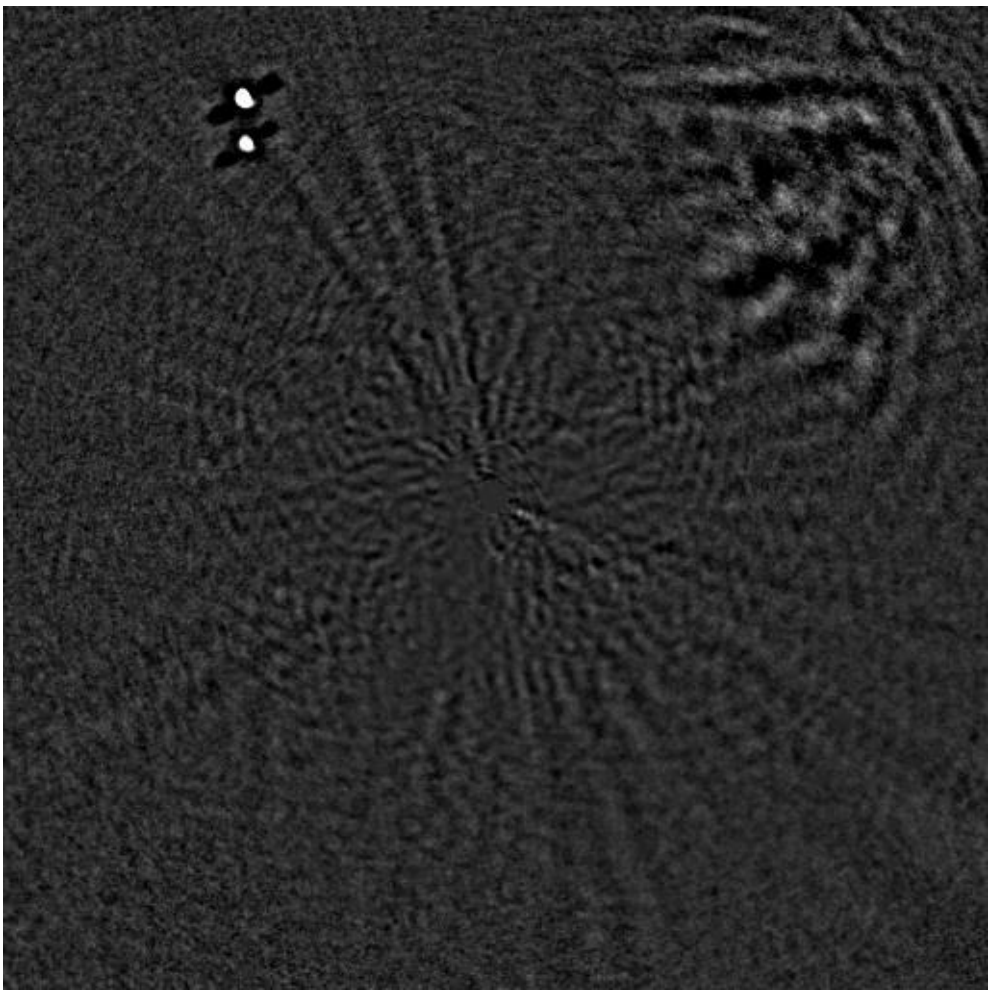

Figure 5 – HIP101800 final image.

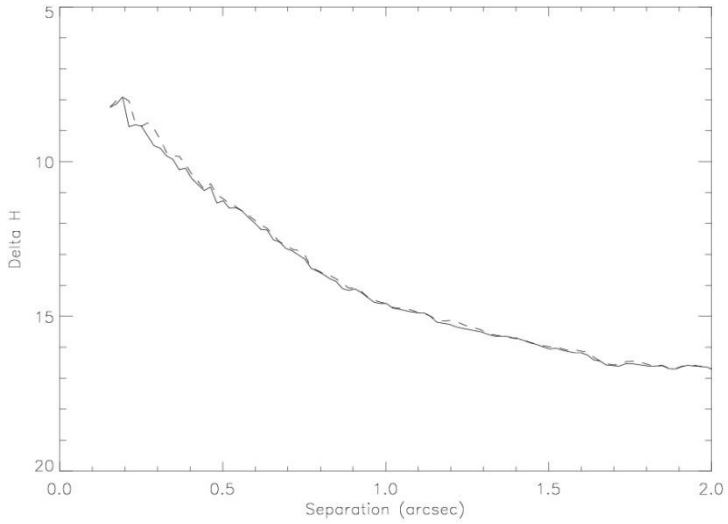


Figure 6 – Contrast plot obtained for HIP10800

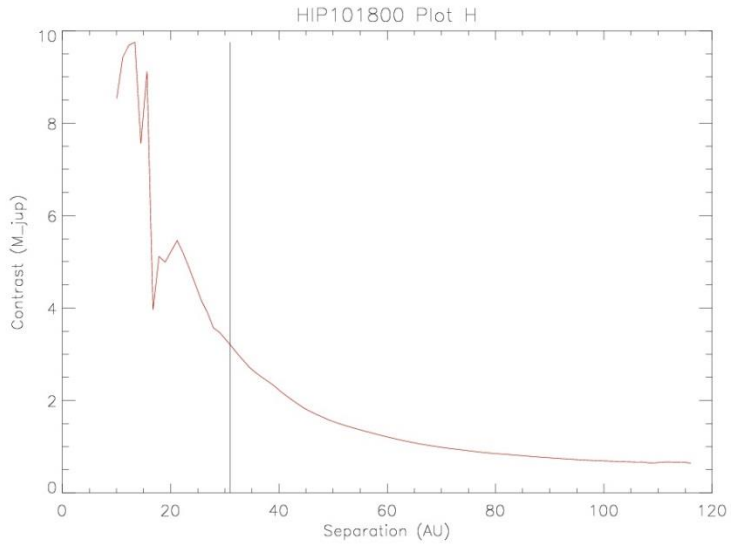


Figure 7 – Contrast plot expressed in Jupiter masses for HIP101800. The vertical line represents the maximum flux of the disk around the star according to [8].

## 5. Observations of HIP85157

HIP85157 was observed on June 19, 2012 in poorer weather conditions than HIP101800. The DIT for this observations was 1 s for a total exposure time of 1800 s. No obvious source was visible in the FOV. For this reason we do not show the final image that we obtained from these data. We were however able to obtain a contrast plot for this target too. It is showed in Figure 8 while in Figure 9 we display as for HIP101800 in terms of Jupiter masses calculated in the same way defined for HIP101800 and assuming a stellar age of 100 Myr [8].

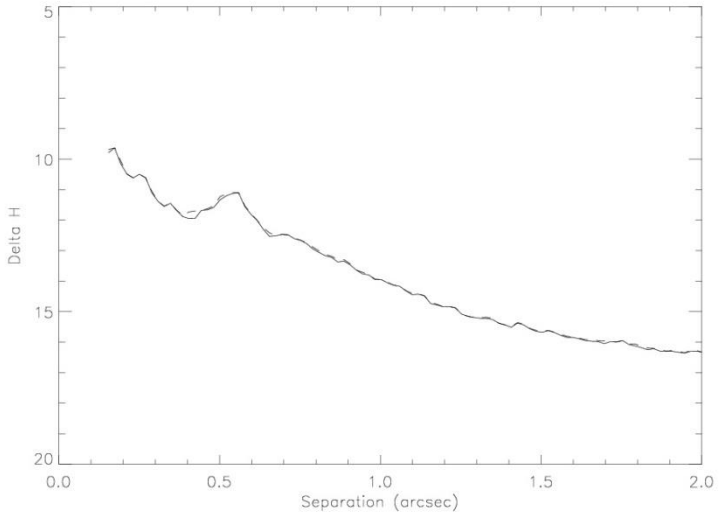


Figure 8 – Contrast plot obtained for HIP85157

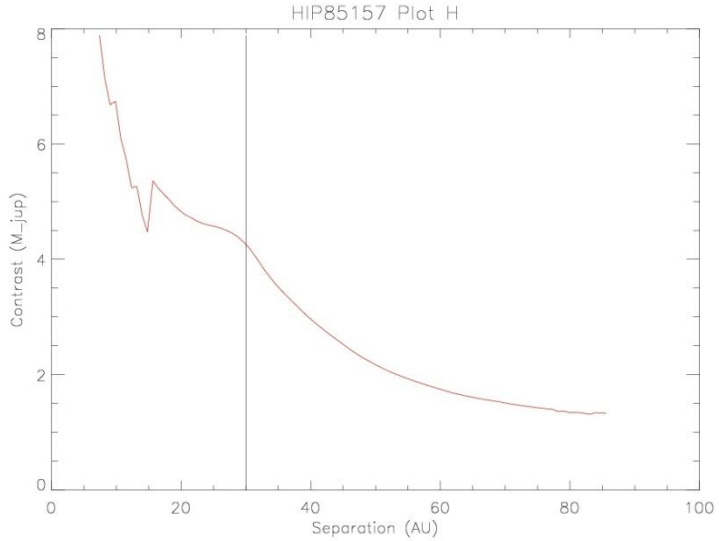


Figure 9 – Contrast plot expressed in Jupiter masses for HIP85157. The vertical line represents the maximum flux of the disk around the star according to [8].

## 6. Conclusions

We have presented our observations aimed to the high contrast imaging of extrasolar planets exploiting the AO system at LBT + the PISCES camera and the ADI data reduction method. A first run of observations were performed during October-November 2011 on the well known planetary system HR8799. In that case, we were able to find all the four known planets around this target and we were able to image HR8799e for the first time in the H band. Our photometric measures were in good agreement with the original ones by Marois [3] and [4].

The observations of new targets selected according to their IR excess performed in June 2012 did not allow us to find any new companion objects for the two targets observed but we werw however able to put strict constraints on the contrast that can be obtained (and then on the companion mass limit around those stars).

In conclusion, the AO system of LBT resulted to be very suitable to perform high contrast imaging aimed to the imaging of low mass companion for young star in the near-IR spectral band. New and more extended observations could take to the discovery of new objects or however put clear limits to their frequency.

## 7. References

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