EPSC Abstracts
Vol. 8, EPSC2013-1020, 2013
European Planetary Science Congress 2013
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SPOTS: Search for Planets Orbiting Two Stars
A Direct Imaging Survey for Circumbinary Planets

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Abstract

Over the last decade, a vast amount of effort has been poured into gaining a better understanding of the frequency and diversity of extrasolar planets. Yet, most of these studies focus on single stars, leaving the population of planets in multiple systems poorly explored. This investigational gap persists despite the fact that both theoretical and observational evidence suggest that such systems represent a significant fraction of the overall planet population. With SPOTS, the Search for Planets Orbiting Two Stars, we are now carrying out the first direct imaging campaign dedicated to *circumbinary planets*. Our long-term goals are to survey 66 spectroscopic binaries in H-band with VLT NaCo and VLT SPHERE over the course of 4–5 years. This will establish first constraints on the wide-orbit circumbinary planet population, and may yield the spectacular first image of a bona fide circumbinary planet. Here we report on the results of the first two years of the SPOTS survey, as well as on our ongoing observation program.

1 Introduction

Most direct (imaging) and indirect (transit, radial velocity) exoplanet surveys to date have actively excluded close binaries from their target lists. This reflects the technological difficulties inherent in the radial velocity and transit methods when faced with a close binary target. Nevertheless, more than a dozen circumbinary planets and brown dwarfs have been discovered over the past years [1, 2]. For binaries with high contrast ratios or unresolved separations, angular differential imaging (ADI) [4] suffers no ill effects from the target's binarity, and thus offers an ideal method to search for circumbinary companions on wide orbits.

Compact binary systems may be particularly favorable targets for planet imaging. The mass of a protoplanetary disk and consequently the number of massive planets formed therein are thought to scale with the mass of the parent star [3]. Thus, a binary system commands the same planet-forming resources as a single star of the same mass while offering more favorable star/planet brightness contrasts. Furthermore, a binary host may relocate planets formed at short separations into wide orbits by scattering [5] or disk-mediated migration [6], where there are more accessible to imaging searches.

Analyses of the number and nature of planets detected around single stars and individual components of wide binaries have suggested that the presence of a distance secondary star leaves an imprint on the planet demographic [7]. Such results contribute valuable input towards understanding the processes of planet formation. For the case of circumbinary planets, the current body of data is not sufficient for such analyses. The SPOTS survey presented herein is designed explore this parameter space.

2. Survey Design and Status

SPOTS aims to observe 66 young nearby spectroscopic binary systems over the course of 4–5 years. Each target is observed in H-band pupil-tracking mode for 1 hour. The data are subjected to ADI high-contrast image processing with the LOCI algorithm [8]. Targets with promising companion candidates are followed up typically 1 year after the first epoch for the purpose of common proper motion testing.

In ESO period P88, we were granted 16 h of VLT NaCo time for a pilot survey covering 16 targets, of

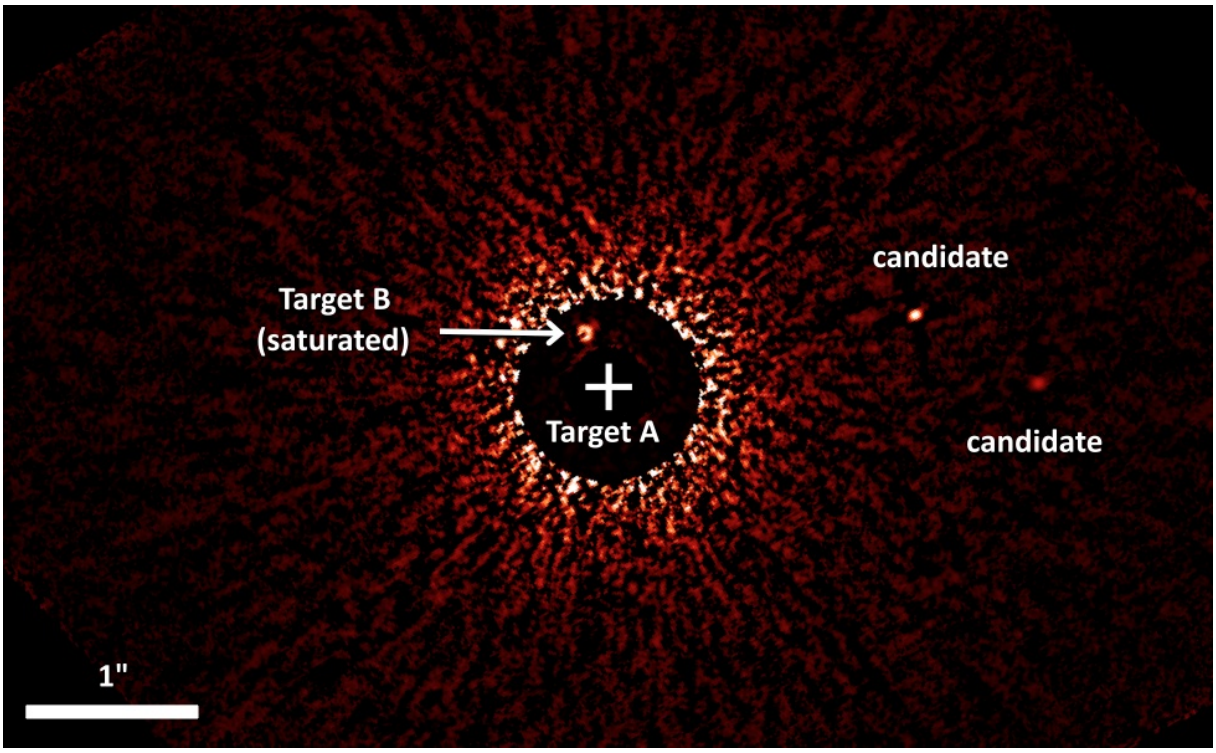

Figure 1: High-contrast image of a nearby young binary star system taken with VLT NaCo as part of the SPOTS survey. The location of the A-type primary star is marked with a plus sign. Software attentuation has been applied to the inner region of the image in order to show the saturated image of the system's G-type secondary star. Two substellar companion candidates are detected at larger separations within a halo of well-behaved residual stellar speckle noise. This image demonstrates how a binary target system with a sufficiently low brightness ratio poses no obstacle to ADI data reduction. Follow-up observations for this target are currently underway.

which 13 were executed. Having delivered a successful proof of concept for our observing strategy, we were granted time for another 16 exploratory observations as well as 5 follow-up observations in P90, of which 9 and 2 have been executed at the time of writing, respectively. The program has been given rollover status and is scheduled to be completed within the year. Finally, we requested 7 hours of follow-up time for P92, which would allow us to conclude the first half of the SPOTS survey.

After the planned decommissioning of VLT NaCo in P93, we plan to resume exploratory observations for the second half of the SPOTS target list using VLT SPHERE.

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