

ANTARCTICA SEARCH FOR TRANSITING EXTRASOLAR PLANETS

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Abstract. We present “*A STEP*”, a project dedicated to the search for planetary transits from Antarctica. The project consists of a fully automatic 40 cm telescope equipped with an 11-million-pixel CCD installed at Dome C. The site offers crucial assets for a ground-based exoplanet transit search: uninterrupted phase coverage and excellent seeing.

This system would be able to detect hot Jupiters transiting in front of stars as faint as magnitude sixteen and could also detect smaller planets in close-in period around brighter stars. Our estimations, based on results of previous surveys are an average of 6 detections per 60 days survey. Compared to existing surveys, this excellent yield is due to the nearly-continuous phase coverage and excellent seeing. This short term project is meant to be a photometric qualifier for the site and the first stage of a massive detection campaign. A mid-term objective of 1000 detections for 2012 could be achieved either with many small telescopes or with a large Schmidt telescope with a large field of view.

The project is relatively simple and cost-effective, and has the double purpose of qualifying the site and obtaining first-class scientific results. Our team is already familiar with transit detection with an automated telescope (BEST) and cold temperature qualification.

1 Introduction

The field of extrasolar planet research has received considerable attention since the discovery of an extrasolar planet around 51 Peg (Mayor & Queloz 1995). More

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than 100 such extrasolar planets are currently known. However, nearly all planets have been discovered with the radial velocity technique, and more than 20 surveys using this technique are currently active or planned for the near future (Horne 2001). However, this only yields the planets orbital distance and a minimum value of their mass. On the other hand, the transit method is the only method allowing to infer both the radius of the planet and the inclination of its orbit. It is based on the photometric detection of the dimming of a star due to a planetary companion whose orbital plane brings it periodically between its star and the Earth. The recent successes of the OGLE survey have confirmed that Jupiter-sized planets are within reach of ground-based programs.

In spite of its participation to the COROT mission, France is almost absent from ground-based transit search programs (~ 15 currently active, see www.obspm.fr/encycl/encycl.html). A *STEP* is a great opportunity for France and Europe to combine an access to the best site on Earth for transit surveys, with the use of HARPS, one of the best instruments dedicated to radial-velocity observations. The combination of transit detection and radial velocimetry follow-up is the only way to determine the density of exoplanets and hence constrain their internal composition.

2 The Telescope

In A *STEP*, we use a 40 cm Newton telescope. Our simulations have shown that, even if the main constraint to detectivity is linked to photon noise, the number of detections increases linearly with telescope size. Because the price of telescopes increases faster, this size represents a good compromise.

Using a Schmidt telescope would allow a large field of view, a major advantage for a transit search program. However, because of the extreme temperature conditions at Dome C, this has two drawbacks: it requires having the capter heated inside the telescope, because no electronical components associated to CCDs are qualified to temperatures under -50° . Warming a CCD inside the telescope is hazardous as it can create internal turbulence. It is not a problem for Newton telescopes, as the CCD is outside the tube. Succesful tests of CCD heating outside the telescope have already be made on site. The second problem of Schmidt combination is the fact that in order to keep a small pixel size with a large field, you need to use a matrix of ccds, which creates a large central obstruction and datas losses where the CCDs joint each other. Other combinations do not provide really large fields.

The telescope is opened at $f/3$, with a coma corrector to ensure a flat field of 1.43° . We plan to use a SBIG STL11000 CCD. It has 4008×2745 pixels of $1''05$ size on the sky. Command routines for this CCD have been tested; our team has an experience of data pipeline treatment with BEST (Berlin Extrasolar Transit Search).

The tube, built in carbon fiber for weight and insignificant dilatations at cold temperature, will be mounted on a german equatorial Astrophysics 1200 mount. The Astrophysics 900 mount has already been successfully tested on site with

GSEM and we have the experience to “antarctize” this mount. The cost of the telescope would be $\sim 100\,000$ euros, including cold temperature qualification and hardware. This price does *not* consider the installation on site and the logistics at Dome C (*e.g.* it requires that the necessary space be available on a platform).

3 Expected Results and Prospects

From radial velocities measurements, we know that most of known Pegasi planets (hot Jupiters) have periods around 3 days. Most transit events are expected around G and F stars. The mean transit depth for Jupiter-sized planets around these stars is around 1%, but could be smaller if the planets contain a massive central core (*e.g.* Guillot 1999).

Realistic estimates of the number of expected detections from transit surveys based on the OGLE III results are presented by Pont & Bouchy (these proceedings). Their simulations show that an intermitent phase coverage yields a vanishingly small yield if the transit depth is lower than $\sim 1\%$. Observations from Dome C thus present a great advantage over other sites. The nearly continuous phase coverage both increases the number of potentially detectable Jupiter-sized planets, and also allows the detection of planets of smaller radii.

Another advantage of the Dome C is the very low scintillation (Lawrence *et al.* 2004), which is directly linked to photometric accuracy. Our simulations for *A STEP* yield an average of 6 exoplanet detections per 60 days of continuous survey. Considering the low cost of the mission, this is an extremely good result.

Due to the nearly continuous phase coverage during the winter season and the low scintillation, Dome C has qualities that compares it to space observations, at only a fraction of the cost. Of course, it has several disadvantages: the full night lasts 3 months at most, the Sun is never low on the horizon, and the full moon can rise to up to $\sim 40^\circ$. These parameters should be properly taken into account to carefully define observation strategies. They imply that only planets with short orbital periods (less than ~ 10 – 20 days) can be detected.

One advantage of Dome C over space is of course its accessibility, which implies that instruments (filter, etc.) can be changed, and most importantly that data storage is a less severe problem than in space. Specifically, in order to limit the data rate, the COROT observations in the exoplanet fields are summed in masks of ~ 50 pixels. This implies that confusion due to background eclipsing binaries (*e.g.* Brown 2001) could become a severe problem, and require many follow-up observations.

With *A STEP*, we plan to keep all the information in each pixel, and to thus discriminate transit events from most background eclipsing binaries whose signal will be off-centered relative to the target star. *A STEP* could thus be used to confirm or infirm COROT detections without the need for time-consuming radial velocity observations.

Further transit detection programs aiming at detecting many more planets will experience this false alarm problem even more acutely. It is therefore of prime

importance that a mission such as *A STEP* be selected to assess the magnitude of the problem and its possible solutions.

We have described a mission that could both qualify accurately the visible photometry during winter at Dome C, and be an important low-cost scientific mission to detect and characterize extrasolar planets. Its relative simplicity imply that it could begin as soon as in 2007.

References

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