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SuperLupus: A Deep, Long Duration Transit Survey

Daniel D. R. Bayliss[1], Penny D. Sackett[1], and David T. F. Weldrake[2]

[1]Research School of Astronomy and Astrophysics, The Australian National University (ANU), Mount Stromlo Observatory, Cotter Road, Weston Creek, ACT 2611, Australia
email: daniel@mso.anu.edu.au
email: psackett@mso.anu.edu.au
[2]Harvard Smithsonian Center for Astrophysics, 60 Garden Street MS-51, Cambridge, MA 02138, USA
email: dweldrak@cfa.harvard.edu

Abstract. SuperLupus is a deep transit survey monitoring a Galactic Plane field in the Southern hemisphere. The project is building on the successful Lupus Survey, and will double the number of images of the field from 1700 to 3400, making it one of the longest duration deep transit surveys. The immediate motivation for this expansion is to search for longer period transiting planets (5-8 days) and smaller radii planets. It will also provide near complete recovery for the shorter period planets (1-3 days). In March, April, and May 2008 we obtained the new images and work is currently in progress reducing these new data.

1. The Original Lupus Survey

The Lupus Survey was a deep transit survey of a 0.66 square degree patch of sky near the Galactic Plane (b=11°). The survey was conducted using the ANU 40 Inch Telescope at Siding Spring Observatory, Australia in May and June of 2005 and 2006. In total, 1783 good quality images of the field were obtained. The images were 5-minute exposures taken in a wide V+R filter. Time series photometry was performed for 110,372 stars in the field, with 16,134 of those stars having a precision of $\sigma < 0.025$. The transiting planet candidates and results from this survey will be published in Bayliss *et al.* (2008). The discovery of a Hot Jupiter in the field, Lupus-TR-3b, has been published in a separate letter (Weldrake *et al.* 2008), and the radial velocity follow-up confirming the discovery is set out in Figure 1. Additionally, 494 new variables were discovered in the survey field. These variables have been cataloged in Weldrake & Bayliss (2008).

2. SuperLupus: Extending the Survey Duration

The duration of a transit survey is critical to its prospects of success, and underestimating required durations may have contributed to early surveys not discovering transiting planets in the numbers expected (Pont, Zucker, & Queloz 2006).

We modeled the effect of increasing our survey duration by looking at the transit recoverability for Hot Jupiters as a function of planetary period and the duration of the survey. We created 1000 transiting Hot Jupiters in each of 7 period bins, ranging from 2-3 days to 7-8 days. Each transit lightcurve was given a random phase. We then convolved these transits with a window function out to 100 nights based on actual weather logs taken from the Siding Spring Observatory site. A detection was equated with observing the equivalent of three full transits. The results of the simulation are plotted in Figure 2. These results indicate that by 100 nights (the SuperLupus duration) we will

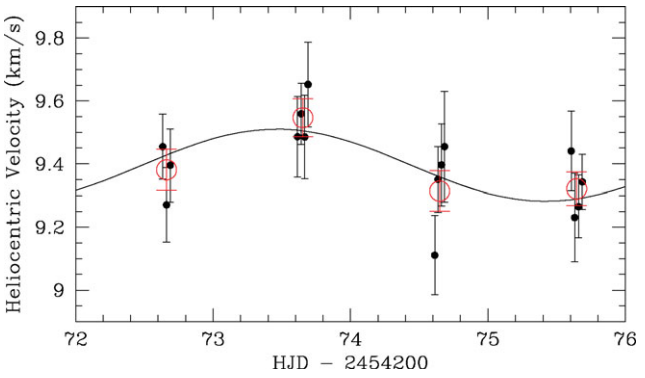

Figure 1. Radial velocity measurements for Lupus-TR-3 from MIKE on Magellan II (Clay) (Weldrake *et al.* 2008). Small solid circles are the individual radial velocity measurements, with the error bars determined from the actual scatter in the orders. Large open circles are uncertainty-weighted nightly averages. The solid line is the best-fit sinusoid with only the period fixed (from the photometry). The fitted phase matched the photometrically-determined phase to within 0.13 days, well within fit uncertainties.

detect nearly all transiting Hot Jupiters in the field with periods from 1 to 3 days. The fraction of longer period Hot Jupiters we can detect will rise significantly from the original Lupus survey, especially planets with 5-8 day periods, to which the original survey was very insensitive. Our new dataset should also allow us to increase our sensitivity to smaller radius planets, as more data-points in the lightcurve will increase our S/N.

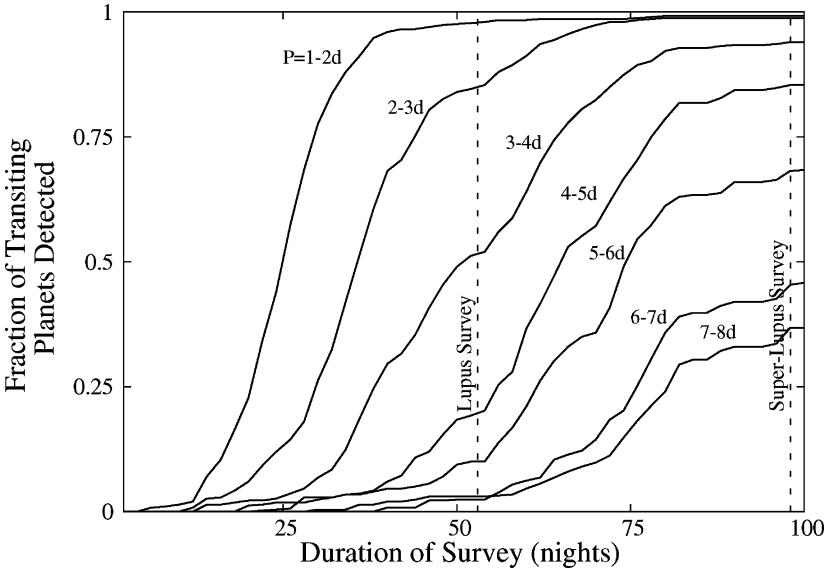

Figure 2. The fraction of planets detected as a function of the duration of the survey for 7 different period bins. These simulations show the benefit of moving from the Lupus Survey (50 nights; left dashed line) to the expanded SuperLupus Survey (100 nights; right dashed line), both in terms of completeness at shorter periods and greatly increased sensitivity at longer periods.

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3. SuperLupus: The New Data

Based on these simulations, we have initiated the SuperLupus project to expand the original Lupus Transit Survey by imaging the field again in 2008. The instrument set-up and observational strategy is identical to that used in the original survey (see Table 1).

Data has now been taken in the months of March, April and May 2008. We have approximately 2500 new images, and expect at least 70% of these will be of sufficient quality to use in the production of high precision time series photometry.

4. Aperture Photometry: Source Extractor

The photometry for the original survey was produced using Difference Imaging Analysis (DIA: Alard & Lupton 1998, Wozniak 2000). This method is well suited to crowded fields. The Lupus field is *moderately* crowded, being only 11° above the Galactic Plane. In order to test how aperture photometry will compare to the DIA photometry in this régime, we used the IRAF package DAOPHOT and the Source Extractor software (Bertin & Arnouts 1996) to produce time series photometry on a small subset of the 2006 images. These tests indicated that Source Extractor, with its more sophisticated background subtraction, gave slightly better results than DAOPHOT for our images, and that it compared well to DIA photometry. Source Extractor is also a very fast algorithm, and this will allow us to perform photometry using multiple apertures and select the one best suited to the star and its environment.

Table 1. Properties of the SuperLupus Transit Survey

Telescope	ANU 40 Inch Telescope (1.0m aperture)
Site	Siding Spring Observatory, Australia
	Lat.: $-31^{\circ}16^{\mathrm{m}}36^{\mathrm{s}}$
	Long.: $-9^{\mathrm{h}}56^{\mathrm{m}}16^{\mathrm{s}}$ W
Field of View	0.66 sq degrees
Cadence	6 minutes
Field Location	Lupus (b=11°)
	RA:$15^{\mathrm{h}}30^{\mathrm{m}}36.3^{\mathrm{s}}$,
	Dec:$-42^{\circ}53'53.0''$ (J2000)
Pixel Size	15 microns, 0.375 pixels/arcsecond
Filter	Custom V+R filter
Stars Monitored	110,372, with 16,134 to $\sigma < 0.025$ mags
Number of Images	1783, expanding to ≈3400 with SuperLupus

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