EUROPEAN SOUTHERN OBSERVATORY

Organisation Européenne pour des Recherches Astronomiques dans l'Hémisphère Austral

Europäische Organisation für astronomische Forschung in der südlichen Hemisphäre

LA SILLA OBSERVATORY

Science Operations

–

Defocused photometry with the NTT+EFOSC Report

Doc. No. LSO-XXX-ESO-NNNNN-NNNN

Issue 1.0

Date 10/08/2009

Prepared for Review - INTERNAL USE ONLY

	Name	Date	Signature
Prepared	C. Snodgrass	10/08/2009	
Approved		dd/mm/yyyy	
Released		dd/mm/yyyy	

Change Record

Issue/Rev.	Date	Section/Parag. affected	Reason/Initiation/Documents/Remarks
1.0	10/08/2009	All	Creation

1 Introduction

1.1 Purpose

This document describes the performance of EFOSC2 on the NTT in a high accuracy relative photometry mode, achieved by extreme defocusing of the telescope.

1.2 Scope

This document is intended for users interested in using this mode.

1.3 Applicable documents

[1] LSO-MAN-ESO-36100-0004 EFOSC2 Users' Manual

1.4 Reference documents

1.5 Abbreviations and acronyms

The following abbreviations and acronyms are used in this document:

AO	Adaptive Optics
ESO	European Southern Observatory
EFOSC2	ESO Faint Object Spectrograph & Camera 2
LSO	La Silla Observatory
NTT	New Technology Telescope
TIO	Telescope & Instrument Operator
VLT	Very Large Telescope

2 Overview

Defocusing the telescope to improve photometry appears at first glance to be counter intuitive – we normally spend a significant amount of effort trying to improve the telescope focus. However, the technique of defocusing by an extreme amount (star images are donuts covering 100s of pixels) can improve relative photometry, as has been demonstrated by a number of authors using a variety of telescopes. We tested the concept with the NTT and EFOSC2, and report here the results. While this will remain a non-standard observation mode and may have only limited use at the NTT; however it is possible to obtain sub mmag accuracy on individual photometric measurements by this technique and the following should serve as advice for any user wishing to attempt this.

3 Defocused Photometry

The advantage of defocusing the telescope is that long exposures can be taken on bright stars, reducing scintillation noise due to the increased time and giving a very low Poisson noise due to the large number of total photons collected. This technique has been used by a number of groups to measure very high precision relative light-curves of bright stars: This is of great use when trying to measure transiting extra-Solar planets. For example, Gillon et al (2009) used this technique with the VLT and FORS and Southworth et al (2009a,b) used DFOSC at the 1.54m Danish telescope. The Danish telescope observations achieved a scatter between points of around 0.5 mmag; the VLT observations also achieved a high accuracy, but suffered from systematic effects attributed to the changing mirror shape in the bad-AO mode.

4 NTT test

We tested the principle at the NTT with observations of the transit of the extrasolar planet WASP-5b on the 5th of July 2009. The observations were performed with EFOSC2 in the R-band with the telescope defocused by 1.2mm, and exposure times of 100s. The star WASP-5 has a V magnitude of ~ 12.3. The target was near to the full moon at the time, but this did not have a very large effect. Figure 1 shows a frame from this experiment.

The star light was spread over a donut with an outer diameter of 65 pixels, and contained ~ 3200 pixels. The peak flux in the donut was around 25k counts/pixel, and the total flux $\sim 6 \times 10^7$ counts.

A precision of 0.75 mmag per point was achieved over 3 hours. The light-curve is shown in figure 2.

For comparison, a typical in focus image of a star of V=12.3 in very good conditions (clear, 0.6" seeing) gives peak counts 40-50k in a 1 second exposure. In this case we measured a photometric precision on the single star of 2 mmag.

5 Conclusions

Defocused photometry appears to be a viable technique for high precision relative photometry with EFOSC2 and the NTT. However, the obvious limitation is the relatively small field of view of EFOSC2 ($4.1' \times 4.1'$), making it difficult to identify suitable comparison stars in the field. The fact that there was only one available comparison star, and that it was ~ 1.5 mag fainter than the target star, was the primary limiting factor in the achieved precision for the observations of WASP-5. Given a suitable field with multiple comparison stars of similar brightness to the target, it is expected that a precision of around 0.5 mmag will be achievable, however such fields will be rare. Another difficulty

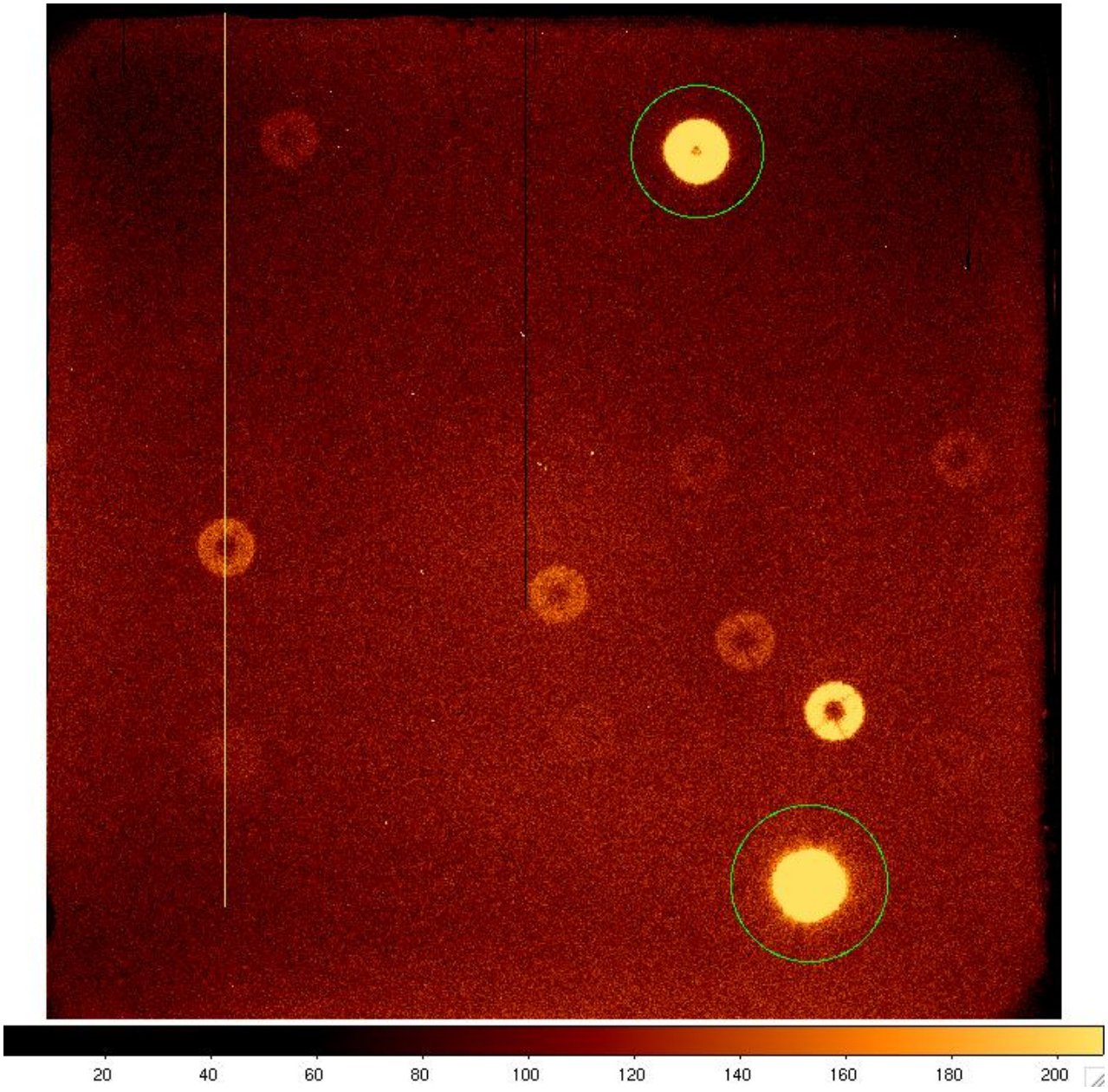

Figure 1: Raw EFOSC2 frame with WASP-5 (lower right) and comparison star circled.

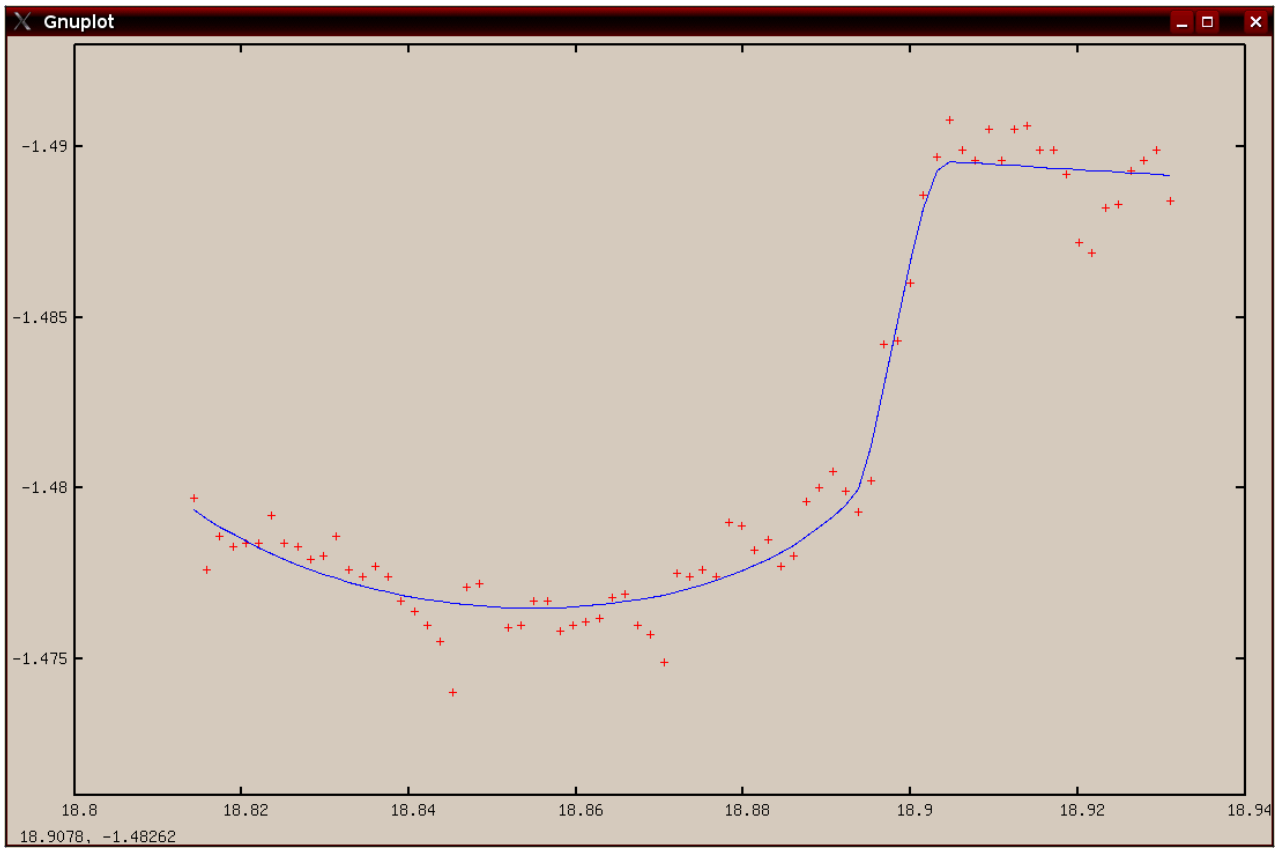

Figure 2: Light-curve of WASP5.

with the NTT is that it is not possible to use the autoguider with the telescope this badly defocused, so it is not possible to keep the stars on exactly the same pixels (which helps this method). However, the tracking of the NTT is very good and this is a minor problem.

Note that this mode is not officially commissioned at the NTT, and interested users must remember that it is to be used at their own risk, but it does appear to be possible. It is especially important for visitors to remember that in the new La Silla minimum operations mode ESO astronomer support is not provided and the visitor will have to work carefully with the TIO to ensure that the defocusing is done as they wish.

6 Acknowledgements and References

We thank John Southworth for performing the analysis on the test data and providing expected signal-to-noise ratio calcutions.

- Gillon, M, et al. 2009, A&A, 496, 259
- Southworth, J., et al. 2009a, MNRAS, 396, 1023
- Southworth, J., et al. 2009b, MNRAS, in press

___oOo___