BiSON Birmingham Solar-Oscillations Network

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Repairs to Jabba at Carnarvon in 2016 August

Steven J. Hale
The University of Birmingham, Edgbaston, Birmingham B15 2TT

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High-Resolution Optical-Spectroscopy Group

School of Physics and Astronomy
The University of Birmingham
Edgbaston, Birmingham B15 2TT, United Kingdom
Telephone: +44-121-414-4551

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Steven J. Hale
The University of Birmingham, Edgbaston, Birmingham B15 2TT

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Abstract

A major leak on the water-cooling loop inside the spectrometer caused serious damage to the printed circuit boards inside the rear connections box. The dome azimuth drive had problems with a damaged gearbox output shaft. Peltiers failed in two detectors. The linear polariser failed resulting in almost zero ratio. Repairs were completed sufficiently to get the site back online and operational, but significant work is still required. The water-cooling loop can not be reactivated without major repairs to the spectrometer chassis. The data now show a strong low-frequency footprint caused by the use of a lens from a pair of polarising sun-glasses as a substitute polarising filter. A CCD-based guider monitor was used to assess the guiding performance of the mount.

1 Introduction

Steven Hale visited Carnarvon from August 5 to 23. The previous visit was in 2016 March [1] where a fault with the Schott KG4 infra-red filter was identified.

Two faults were scheduled for inspection on this visit. In 2016 July the regular site check revealed a leak from the water cooling loop at the rear of the spectrometer. This gave an explanation for the recent electrical issues with the site, notably bad temperature signals from the interference filter, and both the forward-port and aft-port detectors. The forward-port detector also had data problems where the output would either go to zero or become very high and noisy until the power was cycled. Additionally, the dome azimuth drive has had repeated problems with the main pinion working loose and slipping.

2 Water Leak

Jabba was experiencing several seeming unrelated problems. Both the forward-port and aft-port detectors, and the interference filter, all had unstable temperature readings. The forward-port detector also needed to be occasionally power-cycled to correct a bad data output state.

The fault was caused by a water-coolant leak inside the spectrometer which damaged the internal connections circuit board at the rear of the housing. The chassis is made up from four tubes held together by several bulkheads. The coolant runs through all four of these tubes. At the front of the spectrometer the plumbing connections are made externally using fittings that connect directly to the end of the tubes. At the rear of the spectrometer the connection between tubes is made internally by drilling into the tube and then welding or soldering a piece of pipe between the holes. The rear ends of the tubes are capped off and covered by the electrical connections box. The point of the leak was at one of these internal joints, and so rather than the water dripping away safely as it would from the front plumbing fittings, the water instead sprayed all over the connections circuit board.

Both boards that make up the Jabba connections box [2] have been damaged. The "internal" side of the board took most of the damage in comparison to the "external" side, but both should be replaced. The leak had clearly been ongoing for some time before it became noticeable. As expected the connections for the two port detectors and the interference filter were the most heavily damaged, with some of the pins corroded enough to break off during an attempt to clean them. The board is populated with several spare connectors for unused features, and these were able to be salvaged in order to replace the other damaged headers. The board was cleaned up as well as possible. The connection for the forward-port detector was beyond repair, and so the pins for this connector had to be cut off to isolate it from the external side of the connections box. A separate cable was then made up to reconnect directly to the forward-port detector. After a considerable amount of work all electrical connectivity was restored and all components were operating correctly. The entire electrical connections box should be replaced on the next visit.

The water leak could not be repaired. This will require Jabba to be removed from the mount and almost completely disassembled in order to gain access to the internal coolant joints. The site has been left with the water loop disabled. During the current colder winter months this is acceptable, but the instrumentation will not perform well during the summer. A plan will need to be put in place regarding further repairs.

3 Dome Azimuth Drive

For the month or so prior to the trip, the dome azimuth drive had been having problems. The main pinion has repeatedly come loose on the gearbox output shaft. It has been refitted and tightened several times but the problem reoccurs. Shortly before this visit, it was noticed that the output shaft was cracked along the keyway and the pinion could not be refitted.

The entire azimuth motor and gearbox assembly was removed from the dome and taken to Portside Engineering in the town. The workshop cleaned up the damaged shaft and re-fitted the drive pinion. Some slight adjustment to the pinion position was needed when re-installing in the dome. The pinion seems very tight on the shaft, and the set-screw was tightened with thread-lock. It seems unlikely that the fault will happen again, although the workshop were unsure how long the repair would last. If it does continue to be a problem, there is a new motor and gearbox and other spares in the shipping container located near the main OTC buildings.

4 Detector Peltiers

The Peltier coolers in both the forward-port and aft-port detectors were replaced. The failure is thought to be unrelated to any other problems. It is unknown why the Peltiers in Carnarvon seem to fail more regularly than other sites. Perhaps it is due to the coastal location and subsequent high humidity.

The temperature set-point of all four detectors was raised to 25 °C in order to reduce the work load on the Peltiers while the water cooling loop is not operational. Even with this higher set-point it is likely that they will be overwhelmed as the chassis heats up during mid-summer days.

5 Linear Polariser

The noise level from Jabba had been slowly increasing [3] ever since the spectrometer was re-installed in Carnarvon in 2009 July [4]. This increase in noise was caused by a gradual decrease in light throughput. The fault was identified as a failed Schott KG4 infra-red filter during the previous site visit in 2016 March [1]. The filter had become faded and slightly opaque across part of its surface, and so it was removed from the spectrometer which resulted in the sensitivity returning to expected levels.

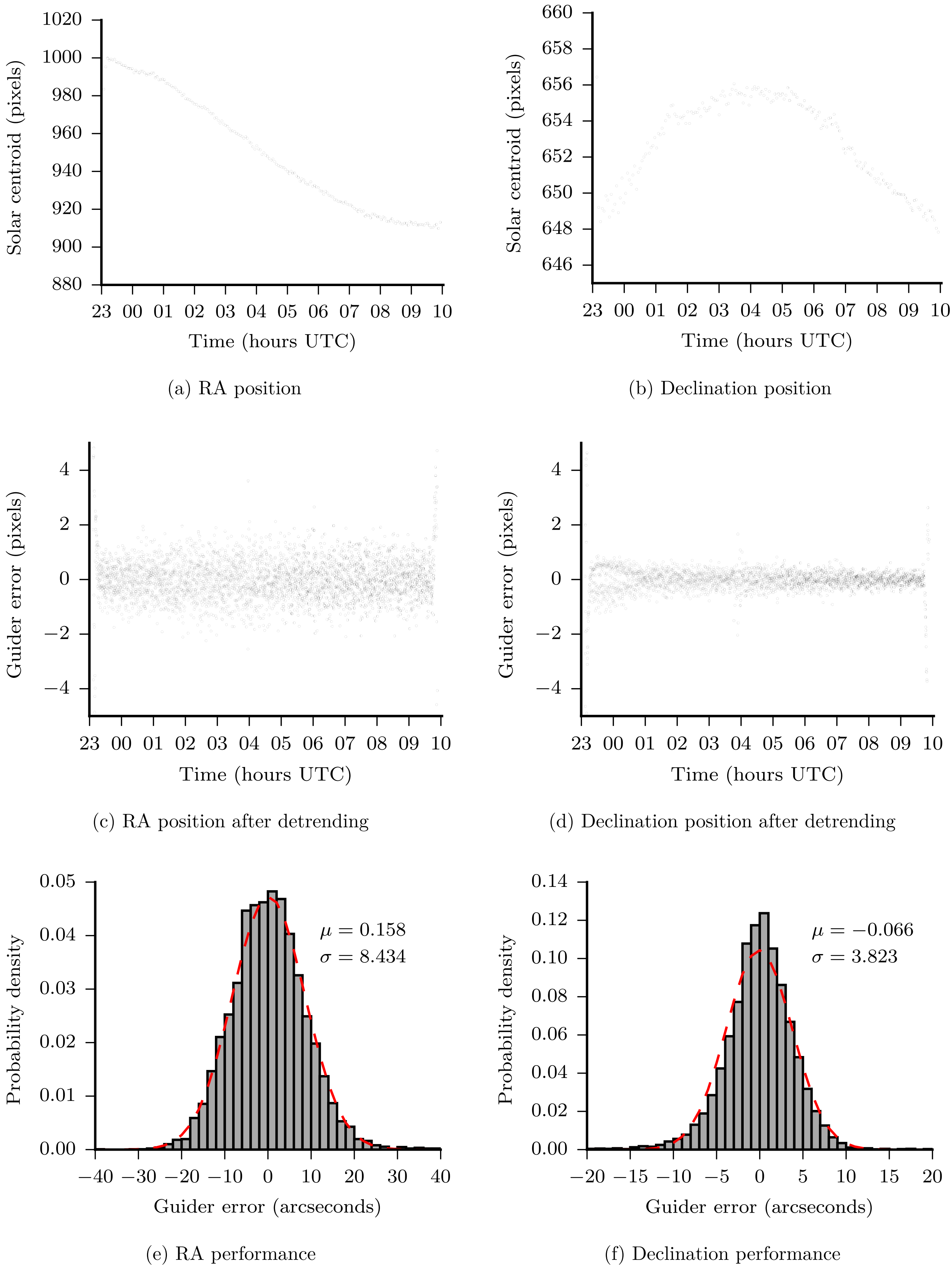
Following the repairs on this visit, it was discovered that the polarisation ratio was again very low. This had not been noticed previously due to the long periods of missing data caused by the faulty azimuth drive, and the signal problems caused by the water leak. Further inspection revealed the linear polariser had degraded, to the point of becoming mostly just clear plastic. It is not known whether this fault is related to removing the KG4 filter back in March.

There were no spare polarisers available to replace the failed component. Carnarvon used to have a shop selling camera equipment that may have had stock of a standard camera polariser, but this must have ceased trading some time ago. The local chemist did have a stock of polarising sun-glasses, which were purchased to use as a temporary replacement. One of the sun-glasses lenses was installed, and the sensitivity returned to the expected level. Unfortunately Jabba now has terrible low-frequency performance with a "footprint" similar to its early years of operation. The low frequency problem was originally solved by tilting the front red filter, indicating the fault was caused by on-axis back-reflections from the filter. It is likely that this new low-frequency problem is caused by back-reflections from the sun-glasses lens. It should be replaced as soon as possible with a new piece of scientific-grade polariser with anti-reflection coating.

During the diagnosis of the fault, the two Pockels cells were swapped over to check for any issues between them or the cell drivers. The original positions of the two Pockels cells in Jabba were L13 in the magnetic position and L14 in the velocity position [5]. Currently L14 has been removed and is on the shelf in the electronics area of the dome. The velocity position is occupied by L15. There is currently no magnetic Pockels cell. There is no reason to consider either of these two cells to be defective, and so they should be reinstalled in their original positions along with the new polariser on the next visit.

6 A CCD-based Guider Monitor

On 2016 August 16 a CCD camera with an 80 mm focal length objective lens was attached to the mount and images captured throughout the day at a cadence of one image every five seconds. The images have been processed using OpenCV to determine the centroid position of the Sun in each image, and so measure the guider performance. The CCD camera is a Starlight Express



(a) RA position

(b) Declination position

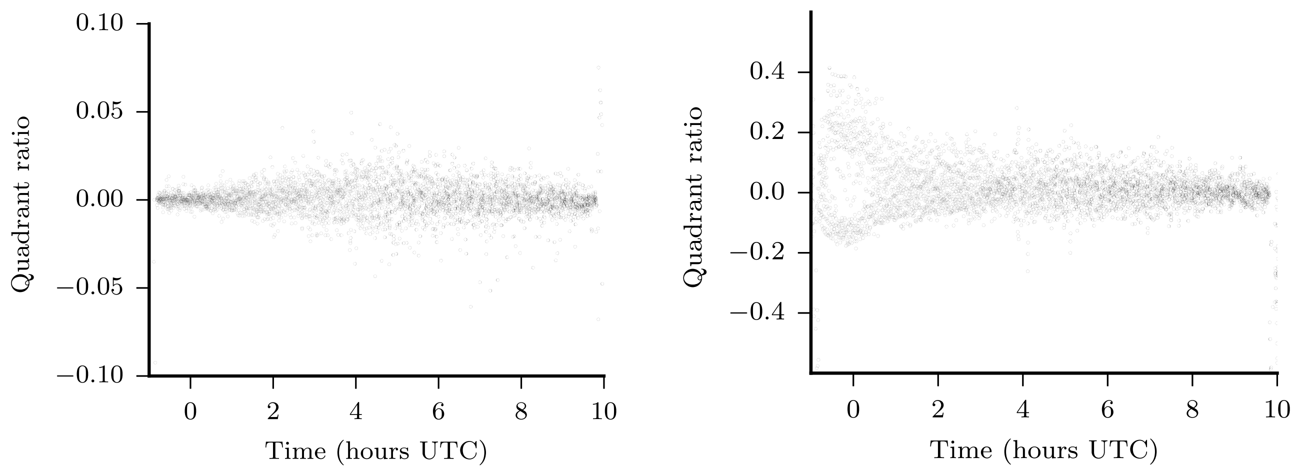
(c) RA position after detrending

(d) Declination position after detrending

(e) RA performance

(f) Declination performance

Figure 1: CCD guider monitor position values from 2016 August 16.



(a) RA quadrant ratio

(b) Declination quadrant ratio

Figure 2: Mount controller quadrant photodiode telemetry from 2016 August 16.

Superstar autoguider camera with 4.65 µm square pixels. With an 80 mm focal length objective lens this means each pixel is equivalent to a 12″ field of view.

The results are shown in Figure 1. Panel (a) and (b) show the centroid positions of the solar image. The trend throughout the day is possibly due to slight camera movement. It was not possible to attached the camera directly to the mount due to insufficient room, and so the camera was simply cable-tied firmly to the front of Jabba. However this movement seems unlikely, and the drift is more likely to be caused by previously reported mount flexure [6]. It has long been considered that Jabba suffered from chassis flexure, and the spectrometer was stiffened considerably when reinstalled in 2009 July [4]. No performance analysis has ever been performed on the mount, and this is possibly the first time that any flexure has been measured quantitatively. A shift of 100 pixels is equivalent to a third of a degree alignment change from sunrise to sunset, which is a rather large error considering the Sun is half a degree in extent. Carnarvon was the first BiSON site to make use of an equatorial mount, and has a smaller mount than that installed at later sites. The other sites in the network are unlikely to experience this problem.

Panel (c) and (d) in Figure 1 show these results with a 10 minute moving mean subtracted to detrend the data. Finally panel (e) and (f) show histograms of the performance calibrated in arcseconds. The red dashed-line indicates the equivalent Gaussian profile for the measured mean and standard-deviation.

For comparison, Figure 2 shows the telemetry from the mount controller FINE guider telescope quadrant photodiode. The quadrants have been combined into ratios for RA and declination, where R are the respective ratios

$$R_{\mathrm{RA}} = \frac{Q_{\mathrm{right}} - Q_{\mathrm{left}}}{Q_{\mathrm{right}} + Q_{\mathrm{left}}} \ , \tag{1}$$

and

$$R_{\mathrm{dec}} = \frac{Q_{\mathrm{up}} - Q_{\mathrm{down}}}{Q_{\mathrm{up}} + Q_{\mathrm{down}}} \ , \tag{2}$$

and Q are the values from each quadrant. It is not possible to convert the quadrant voltage outputs to arcseconds without measuring the voltage change induced by a known position offset, and this has unfortunately not yet been done. The mount controller shows no drift throughout the day, and this is expected since the guider could not work with a drift of a third of a degree. Clearly the drift seen by the CCD guider monitor attached directly to Jabba must be either camera movement or mount flexure between the guider and the spectrometer.

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