PROCEEDINGS OF SCIENCE

Detecting and Observing Transients & Targets of Opportunity at SAAO & SALT

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In the realm of time variability studies of astrophysical phenomena, the study of transient systems over all wavelengths is becoming a growth industry, particularly with the advent of faster, wider and deeper panchromatic imaging surveys of the sky. Future optical transient detections by the likes of PanSTARRs and LSST will result in the discovery of up to ~10^6 alerts per night. Several high energy (X-ray and γ-ray) satellite based instruments (e.g. Swift, Integral, MAXI) continue to discover a wide range of high energy transients, including Gamma Ray Bursts (GRBs). Optical transient detection and/or followup systems (to high energy alerts) have been instrumental in rapidly (within ~100 s) locating and monitoring the optical afterglows of GRBs (e.g. Watcher, ROTSE, PROMPT, BOOTES and MASTER). In addition, over the last ~7 years or so, several other optical imaging surveys have begun from which new transient detections are being made. They include CRTS, MASTER, PTF and ASAS-SN, the latter two aimed at discovering new Supernovae. These have begun to be supplemented by larger scale surveys, like PanSTARRs, GAIA and SkyMAPPER, which although not dedicated to detecting transients, will nonetheless discover many. In this paper we report on the first local optical transient detection system at the SAAO Sutherland station, commissioned in December 2014, namely the MASTER-SAAO node of the Russian-based MASTER II network, and the first to be established in the southern hemisphere. We summarize its performance and results over the ~8 months it has been operating. In addition we discuss the current and future prospects for rapid followup observations at SAAO of transients and other targets of opportunity, with examples of recent observations taken with SALT. Future observations will utilize new robotic telescopes like MONET-South and a new SAAO 1-m robotic telescope, both expected to be operational in 2016, as well as SALT.

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1. Introduction

The study of astrophysical transients has entered a new era with the establishment of a number of new ground-based facilities used in both detection and followup programs (e.g. for alerts from X-ray or γ-ray satellites). Some of these have targeted specific classes of transients, for example supernovae, e.g. PTF [1] and ASAS-SN [2] and Gamma Ray Bursts, e.g. ROTSE [3] and Watcher [4]. Other optical transient detection systems currently operating include the CRTS [5] and MASTER [6], both of which have been successful in detecting a variety of transients, including Cataclysmic Variables, flare stars, long period variable stars, out-bursting blazars as well as Supernovae and GRBs. In addition, both surveys are also discovering Solar System transients, namely comets and minor planets. With the development of recent new facilities (e.g. PanSTARRs [7], SkyMapper [8] and GAIA[9]) and those in the future (e.g. LSST [10]), the opportunity to study the transient Universe will be unprecedented. Indeed the volume of alerts will mean the traditional manner of conducting followup programs will become unmanageable and machine learning techniques will need to be employed in order to sift the wheat from the chaff.

There is a continuing and growing interest amongst South African astronomers to study astrophysical transients, particularly those related to high energy events, like X-ray transients, GRBs, blazar and CV outbursts. Until now, these transient alerts came from ground-based facilities on other continents or from satellite missions. For prompt optical identification and followup, it is often imperative to observe such events at close to the initial alert time as possible. This is particularly the case for GRBs, whose optical fading rates are typically characterised as $F \propto t^{-1.2}$, implying several magnitudes of fading over ~1000 s.

In this paper we report on the establishment of the first comprehensive optical transient detection and followup system at the Sutherland observing site of the South African Astronomical Observatory, namely MASTER-SAAO. We review the specifications of this system and results to date after ~6 months of operations. We will also discuss the plans to exploit alerts from MASTER-SAAO and other facilities by conducting rapid followup observations with telescopes at the SAAO, including the Southern African Large Telescope (SALT).

2. The MASTER Network

The MASTER project (Mobile Astronomical System of TElescope Robots), aimed at the detection of optical transients, was established in Russia in 2002, when the first Russian robotic telescope was installed near Moscow [6]. The network has since expanded and now includes four other nodes in Russia, extending ~80° in longitude, and nodes in Argentina, the Canary Islands and South Africa. In late December 2014 the South African node, MASTER-SAAO, was installed at the SAAO Sutherland station.

The facilities have evolved and most now utilize the MASTER II systems, consisting of dual 40 cm telescopes on a common mount. The Argentina site currently only has a very wide field camera, while the original Moscow node is no longer operational. In Table 1 the locations of the MASTER nodes are shown, while Figure 1 shows a map with the MASTER nodes.

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Table 1: Location of the active MASTER nodes

Name	Country	Location	Longitude	Latitude	Altitude
MASTER-ICATE*	Argentina	San Juan	69°.00W	31°.80S	2430m
MASTER-IAC	Spain	Tenerife	16°.51W	28°.30N	2390m
MASTER-SAAO	South Africa	Sutherland	20°.81E	32°.38S	1760m
MASTER-Kislovodsk	Russia	Caucasus	43°.75E	42°.52N	2067m
MASTER-Ural	Russia	Ekaterinburg	57°.54E	57°.03N	260m
MASTER-Tunka	Russia	Irkutsk	103°.07E	51°.81N	680m
MASTER-Amur	Russia	Blagoveschensk	127°.48E	50°.32N	260m

* currently consisting of wide field camera

Figure 1: location of the MASTER network nodes

The main goal of the MASTER-Net project is to produce a fast and wide sky survey for optical transients down to a limiting magnitude of 19 – 20. The survey is detecting a range of transients, including Galactic sources (CVs, flare stars, eclipsing binaries), AGN (blazars), supernovae and Solar System objects. All MASTER telescopes can also be guided by alerts, and have been used for the detection of prompt optical emission from GRBs, simultaneously in two filters or polarization planes. With the establishment of MASTER-SAAO, the southern hemisphere sky is now being routinely monitored as part of the MASTER program, for the first time.

Six of the MASTER nodes consist of identical dual 40 cm diameter telescopes on a common mount, with Apogee CCD cameras. The telescope tubes can either be co-aligned, each surveying an identical 2° × 2° field, with two different filters or polarizers, or they can be misaligned to allow twice the sky coverage using identical filters. The latter is the default mode for detecting optical transients, which is done without using a filter.

3. The MASTER II System

The relevant attributes of the MASTER II system are presented in Table 2, together with other parameters specific to the MASTER-SAAO survey [6]. The telescope design for the MASTER II system is based on the catadioptric Hamilton design [11], utilizing a double convex entrance lens and Mangin primary mirror, followed by a small field lens. This gives a very wide field, but also a flat focal plane. A schematic of the design is shown in Figure 2, while a photograph of the telescopes with the prime focus CCD cameras is shown in Figure 3.

Table 2: Characteristics of the MASTER II System and MASTER-SAAO Survey

Sub-system	**Parameter**	**Value**
Telescope	Design	Hamilton catadioptric
	Diameter	40 cm
	f/ratio	2.5
	Platescale	206 arcsec/mm; 1.8 arcsec/pixel
	Effective area	940 cm^2/telescope
	Field / telescope	2° × 2°
CCD camera	Type	Apogee Alta U16M
	Size	4096 × 4096
	Pixel size	9μm
Survey	Exposure per field	3 × 60 s (grey/bright Moon)
		3 × 180 s (dark Moon)
	Survey limiting magnitude	19.8 dark Moon); 18.8 grey Moon
	Followup limiting magnitde	22.3 (20 co-added 180 s exp)
	Declination range (survey)	–90° to +30°
	Declination limit (followup)	+40°
	Sky area per night	400 – 500 $degrees^2$
	Cadence	7 – 10 days

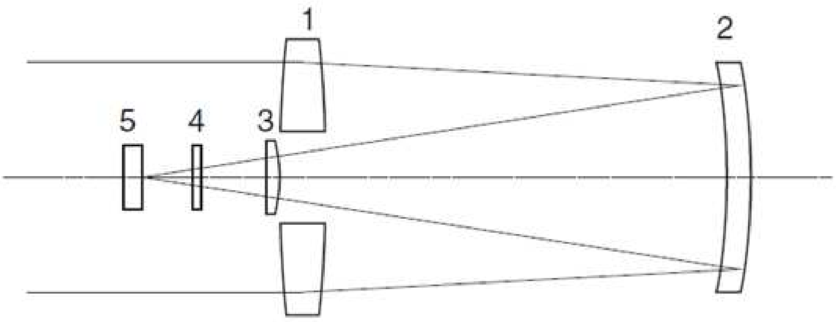

Figure 2: The Hamilton catadioptric optical design used in the MASTER II telescopes. 1 = positive entrance lens, 2 = Mangin mirror, 3 = field lens, 4 = filter, 5 = CCD detector

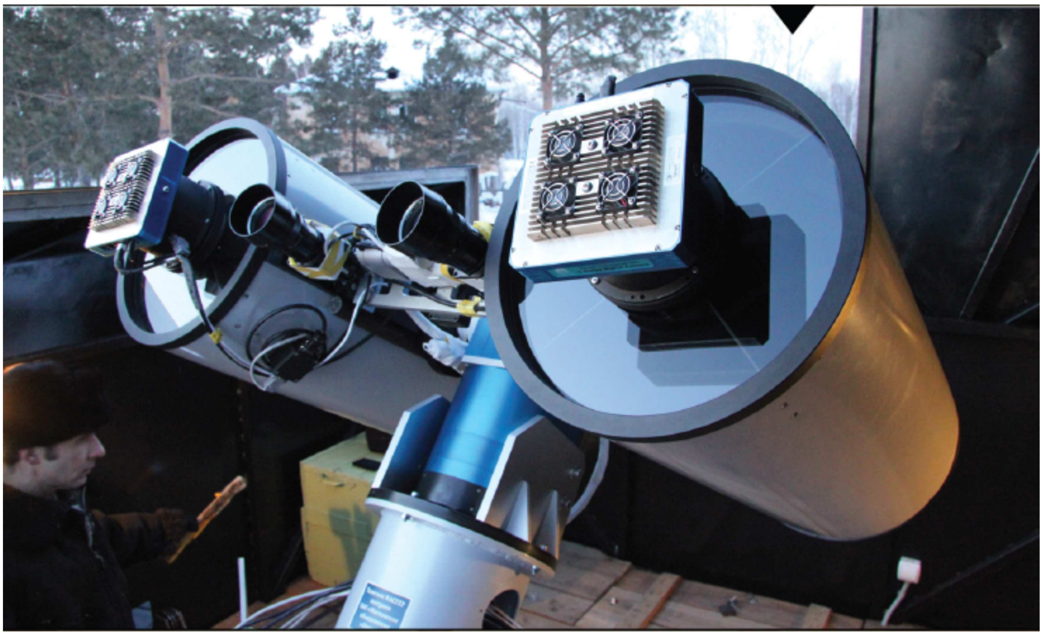

Figure 3: the dual MASTER II telescope tubes with prime focus Apogee Alta U16M cameras. The two small telescopes near the centre are the Very Wide Field (VWF) cameras (see text).

Each telescope can observe with one of four filters (*B, V, R* or *I*) or with a polarizing filters, allowing measurement of Stokes *Q* or *U*, depending on the angle of the polarizers. As well as the two 40 cm telescopes, each mount also has a Very Wide Field (VWF) camera, covering ~1000 degrees^2, but with a shallow limit of $V \sim 12$ in a 1 s exposure.

4. MASTER-SAAO

4.1 Installation

The MASTER-SAAO system was installed in the decommisioned building that once housed the YSTAR telescope (see Figure 4) and commissioned at Sutherland over a ~3 week period, in December 2014. A clam shell dome (AstroHaven) allows rapid slewing over the entire sky, with declination range of –90° to +40°, although the survey only extends to +25° – 30°. There is no limit on the Galactic latitude, unlike the similar CRTS survey [5], which excludes the regions within 10° – 15° of the Galactic plane. However, the Galactic plane is a lower priority, so the amount of coverage is considerably less (by a factor ~ 10× to 20×) than for higher latitudes.

Figure 4: The MASTER-SAAO facility at Sutherland.

4.2 MASTER-SAAO Results to Date

All MASTER optical transient discoveries are listed on the MASTER website (http://observe.pereplt.ru/MASTER_OT.html) and are immediately published as Astronomer's Telegrams (ATels). Any results pertaining to GRB detections are also published in Gamma-ray Coordination Network (GCN) circulars. The MASTER website includes discovery and reference images, coordinates, magnitudes and outburst amplitudes, where there is a pre-existing pre-alert image. MASTER is one of the most successful transient detection systems, as evidenced by the fact that up to 2014 it has been responsible for ~25% of all ATel transient alerts, second only to Swift and the most of any ground-based optical alerts (CRTS is next with

~7%). A total of ~900 transient discoveries have been made by the MASTER network over the last ~4 years.

In the ~8 month period since MASTER-SAAO has been operational (since late Dec 2014), many southern hemisphere optical transients have been detected, while followup optical observations have also been undertaken by MASTER-SAAO of transient alerts from other sources, particularly GRBs and blazar outbursts. Figure 5 shows the sky coverage in the ~8 months of operations, up to early Sep 2015. In Table 3 we list the breakdown of the 143 MASTER-SAAO optical transients discovered so far (excluding minor planets) in terms of object class.

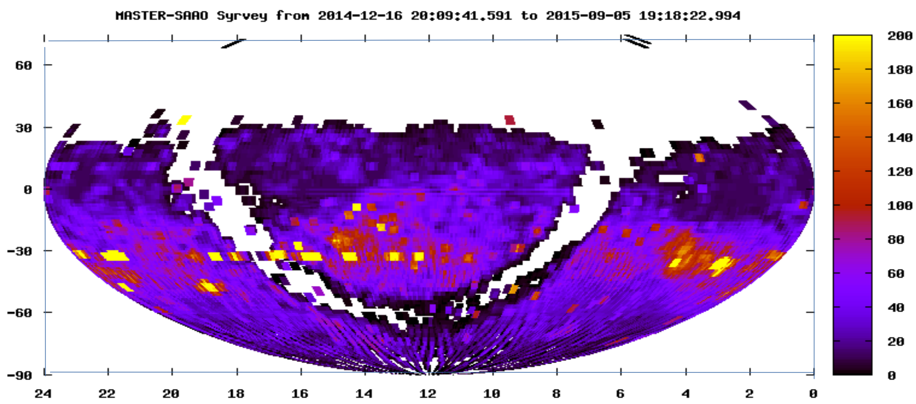

Figure 5: Sky coverage, in equatorial coordinates, of MASTER-SAAO in the ~8 months since it has been operating. The scale indicates the number of 4 degree^2 CCD frames taken to date.

Table 3: Optical Transient Discoveries by MASTER-SAAO (16 Dec 2014 – 9 Sep 2015)

Type	**Class**	**Number**	**Comments**
Galactic objects	Dwarf Novae CV in outburst	109	Criteria is $\Delta m > 2.2^m$
	Novalike CV	1	
	Magnetic CV (polar)	1	Eclipsing. Orb P = 2.2 h
	Flare Stars	3	
	Long Period variables	4	
	Anti-transient	1	Long period eclipser
Extragalactic	Supernovae	20	
	Gamma Ray Bursters	2	Detection from Swift alerts
Solar System	Comets	2	First MASTER discoveries
	Asteroids	Several	To be confirmed

In addition to the transient discoveries following from the MASTER-SAAO survey, a number of dedicated followup observations were also conducted, including of several GRB alerts (only 2 resulted in optical counterpart identifications) and blazar outburst alerts (7 observed).

4.3 GRB Followup

The two GRBs for which optical afterglows were detected by MASTER-SAAO were GRB141225A [12] and GRB 150301B [13]. These afterglows were detected at 113 s and 79 s, respectively, after the Fermi and Swift triggers, at magnitudes of 17.5 and 15.3, respectively. The former showed a power law decline, $F \propto t^{\alpha}$, where $\alpha \sim 0.8$ in the first ~300 s, then a significant dip at 329 s, followed by a steeper decline ($\alpha \sim 1.5$) over the remaining ~1200 s, until it was no longer visible. The decline of GRB 150301B was characterized by a single power law decline with $\alpha \sim 1.2$ until it was invisible after ~2000 s (see Figure 6; [14]). In addition, there is some evidence for a detection of linear polarization at a level of ~8%, although only for some of the measurements [14]. The optical emission in those object is suggested to be a result of a relativistic jet colliding with interstellar gas, compressed in the bow shock, or with the stellar wind of the progenitor [14].

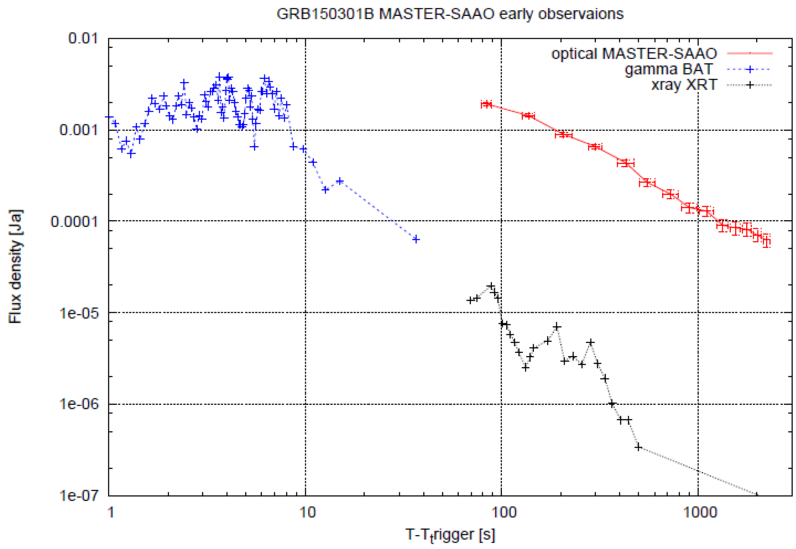

Figure 6: Light curves of the GRB 150301B, including Swift BAT and XRT X-ray observations and optical afterglow measurements from MASTER-SAAO [14].

5. Followup Observations of Transients with SALT

5.1 SALT observing

As SALT is a 100% queue scheduled telescope, in principle it is a lot easier to arrange target of opportunity (ToO) followup observations of transients than with conventionally scheduled telescopes. The major issue in conducting SALT followup observations is target availability and the timescale over which such observations can be attempted. Because of SALT's design, namely the fixed altitude angle of the telescope structure, the instantaneous viewing window for SALT is a 12° wide annulus offset from the zenith by 37°. Thus only ~12% of the visible sky is available to SALT at any given time, which implies that observations have to be carefully planned for when the object of interest is accessible to SALT. For prompt followup observations (e.g. < few 1000 s from an alert), like GRBs, this is a challenge. Nonetheless, several successful ToO programs involving transients have been conducted with SALT (see next section).

The instrumentation available on SALT is well suited to a variety of followup observations of transients, particularly spectroscopy for the characterization of the object and time resolved studies. The four science instruments on SALT [15] currently comprise of:

- SALTICAM, a broad-band UV-visible imaging camera, with high time resolution
- RSS, the Robert Stobie Spectrograph, a versatile prime focus instrument
- SALT HRS, a stable fibre fed high resolution échelle spectrograph
- BVIT, the Berkeley Visible Image Tube photon counting camera (a visitor instrument)

The following table outlines the potential types of transient followup observations that can be undertaken with SALT and the respective instruments and observing modes. The faintness limits for such observations are very dependent on observing conditions and the quality of the primary mirror alignment (in the absence of active mirror control, to be addressed in 2016).

Table 4: SALT Instrument Capabilities for Transient Followup

Type of Observations	Instrument	Mode	Types of Objects
Classification spectroscopy	RSS	Longslit; R ~ 350 – 1000	SNe; XRTs; GRBs; CVs; AGN
Spectral line diagnostics	RSS	Longslit; R ~ 3000 – 6200	CVs; AGN
	HRS	R ~ 16,000 – 80,000	V < 16; bright em. line sources
Radial velocities	RSS	Longslit; R > 2000	binaries
	HRS	R ~ 17,000 – 80,000	V < 14; exoplanets
Time res. Spectroscopy	RSS	Frame Transfer/Slot	2 s/0.1 s resolution; CVs; XRTs
Spectropolarimetry*	RSS	Linear, circular, all-Stokes	GRBs; SNe; CVs; AGN
Imaging polarimetry*	RSS	Linear, circular, all-Stokes	GRBs; SNe; CVs; AGN
High speed photometry	SALTICAM	Frame transfer/Slot	2 s/0.06 s resolution; CVs; XRTs
	BVIT	Photon counting	50 ns time tagging; CVs; XRTs

*mode currently being re-commissioned (Oct 2015)

5.2 SALT results on transients and ToOs

A number of SALT programs have been devoted to the observations of transients and Targets of Opportunity. They have covered a variety of topics which have resulted in a number of publications, with more in progress. In Table 5 we list some of these SALT programs, with some results shown in the following figures. Apart from dedicated ToO or transient followup programs approved by the SALT TACs, Directors Discretionary Time (DDT) has also been used for short one-off observations of compelling transients. However, only ~10 h a semester is available for DDT programs. The figures below show, respectively, SALT spectra of new supernovae candidates [16] and the one successful GRB observation, of GRB 060605 [17].

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Table 5: SALT Transient Followup Programs

Transient Type	**Nature of Progam**	**PI / SALT Partner**
Supernovae	Rapid classification of new SNe	Fesen / Dartmouth
	Observations of new & late time SN Ia	Jha / Rutgers
	Observing SN Ia from Dark Energy Survey	Kasai / UCT
GRBs	Afterglow spectroscopy of GRBs	Buckley / SAAO
Asteroids	Detecting NEOs	Kwiatowski / Poland
X-ray transients	Simultaneous high speed and X-ray photometry	Kotze / SAAO
Super Soft Sources	Observations of transient SSSs	Charles / SAAO, UKSC
mCVs	Followup spectroscopy of CRTS sources	Motsoaledi / UCT, SAAO
Novae	Spectroscopy of new Novae	Woudt / UCT (DDT)
AGN outbursts	Spectroscopy	Kollatschny / Göttingen (DDT)
HMXB outburst	Spectroscopy (+ KAT observations)	Schurch / UCT
BeXRB outburst	Spectroscopy of a SMC X-ray pulsar	Bartlett / UCT (DDT)
MASTER alerts	Spectroscopy of new CV and blazar transients	Kniazev / SAAO (DDT)

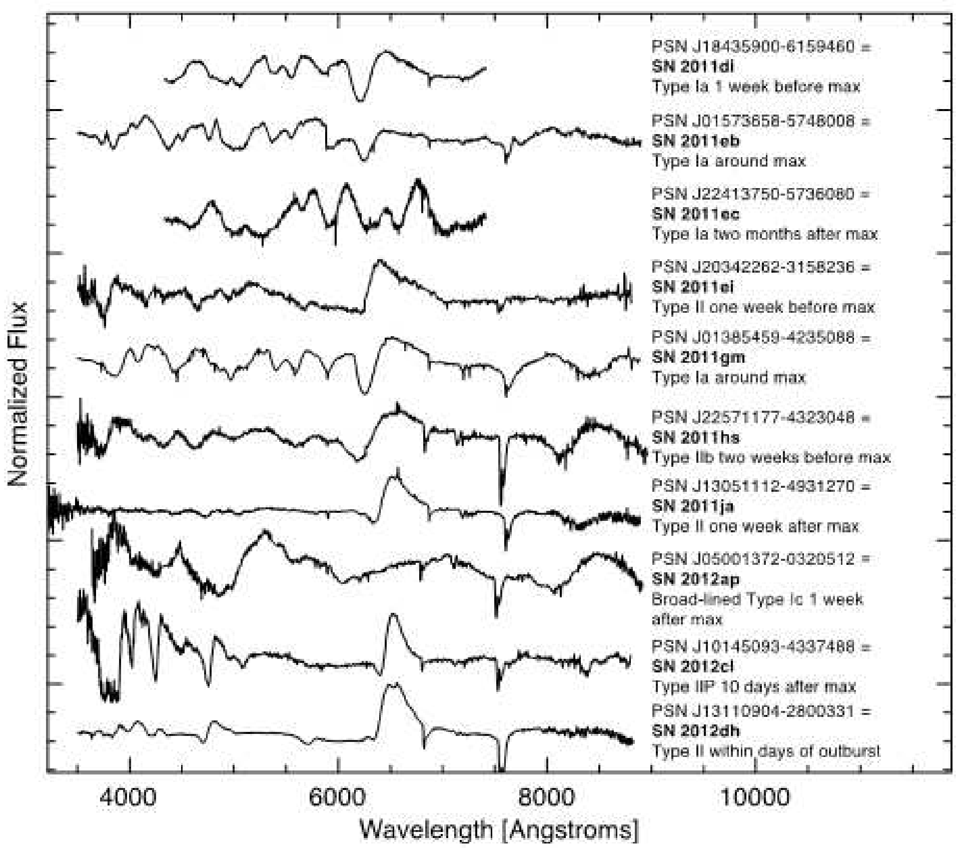

Figure 7: Examples of Supernova spectra taken with SALT as part of a SNe ToO followup program [16]

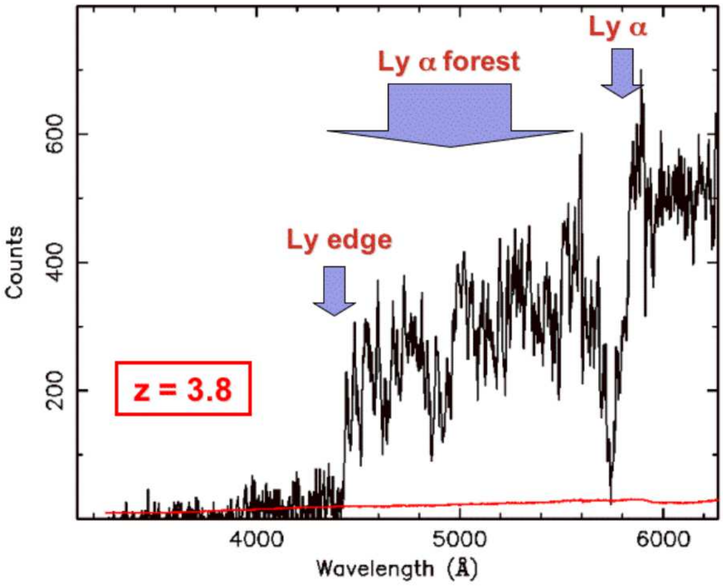

Figure 8: The first GRB spectrum obtained with SALT, of GRB 060605, identified as a Lyman break galaxy at z = 3.8. The GRB had faded to V ~21 at the time of the observation, which was 8 h after the initial Swift alert

5.3 Recent SALT followup observations of MASTER-SAAO transients

Over the ~8 months that MASTER-SAAO has been operating, 143 optical transient discoveries have been made (see section 4.2), of which two new CVs have been observed with SALT, plus one blazar, detected to be flaring by the MASTER-Kislovodsk node. Although it was planned to undertake classification spectroscopy with SALT RSS for some of the more compelling transient detections, a proposal to do this in semester 2015-1 (from 1 May 2015) was unsuccessful, so the only observations done to date have been through an allocation of ~6700 s of SALT Directors Discretionary Time (DDT). From 1 Nov 2015, an approved program of followup SALT spectroscopy will begin for two semesters (until 31 Oct 2016). Below we summarize the initial results of the three DDT observations, all of which are in various stages of analysis and write up as refereed journal papers.

5.3.1 The Dwarf Nova MASTER_OT_J074858.45-655344.6

The majority of all new MASTER-SAAO transient detections (~77%) have been new Cataclysmic Variables of the Dwarf Nova (DNe) sub-class, which undergo recurrent optical outbursts due to accretion disc instability cycles. While the threshold for an alert by MASTER is ~2^m, the amplitudes for many of these new DNe are well in excess of 5^m. The higher amplitude DNe are lower luminosity (so fainter), short orbital period (< 2 h) systems of the SU UMa sub-group, with the WZ Sge stars being the faintest, highest amplitude, lowest accretion rate and shortest period systems of all of them. These characteristics, coupled with their infrequent outbursts (up to decades), make them difficult to detect and study. However, they could represent a “hidden iceberg” population of CVs, which are important in understanding CV evolution, particularly at the extreme short orbital period limit, where gravitational radiation drives the angular momentum loss in these system.

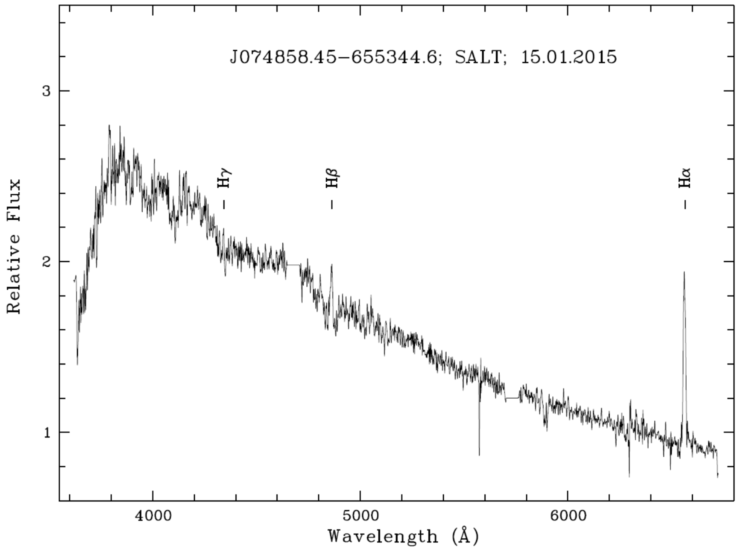

Figure 9: SALT RSS spectrum of the new Dwarf Nova MASTER_OT_J074858.45-655344.6.

MASTER_OT_J074858.45-655344.6 was discovered by MASTER-SAAO on 15 Jan 2015 as a *B* ~ 17^m magnitude transient with a ~3^m amplitude [18] during a search for the optical counterpart of GRB150114, discovered by Fermi. The optical transient was observed the following night with SALT RSS and a 1200s exposure spectrum, covering 3600 – 6600Å at a resolution of 5.6Å, was obtained (see Figure 9). The spectrum shows a rising blue continuum and strong Hα emission, with an equivalent width = 16.6 ± 0.4Å and FWHM = 12.2 ± 0.3Å. The higher order Balmer lines show broad absorption lines with narrow emission cores, with the Hβ peak rising above the continuum level, which is typical of a DNe declining from outburst, and leading to this classification [19]. Clearly this DNe transient was unrelated to GRB150114.

5.3.2 The eclipsing polar MASTER OT J061451.70-272535.5

This transient was discovered on 19 Feb 2015 at an unfiltered magnitude of $18^m.3$ [20] and was observed photometrically at the SAAO using the 1.9 m and 1.0 m telescopes using the SHOC high speed EM-CCD cameras. Time resolved *B*, *V* and unfiltered photometry, with 10 – 45 s time resolution, was obtained over 5 nights [21]. Light curves revealed that the system eclipses, with a period of 2.08 hours. In addition, there are two minima, with an initial sharp drop, where the flux decreases by ~50%, before slowly increasing in brightness again. A second rapid ingress follows, where the system becomes totally eclipsed, followed by a sharp egress (see Figure 10). This was interpreted [21] as evidence for initial obscuration of a bright accretion spot(s) on the white dwarf by the accretion stream, followed by the eclipse of the white dwarf and accretion spot(s) by the secondary star. In addition there is some evidence the system has two accreting poles, due to a possible step in the egress.

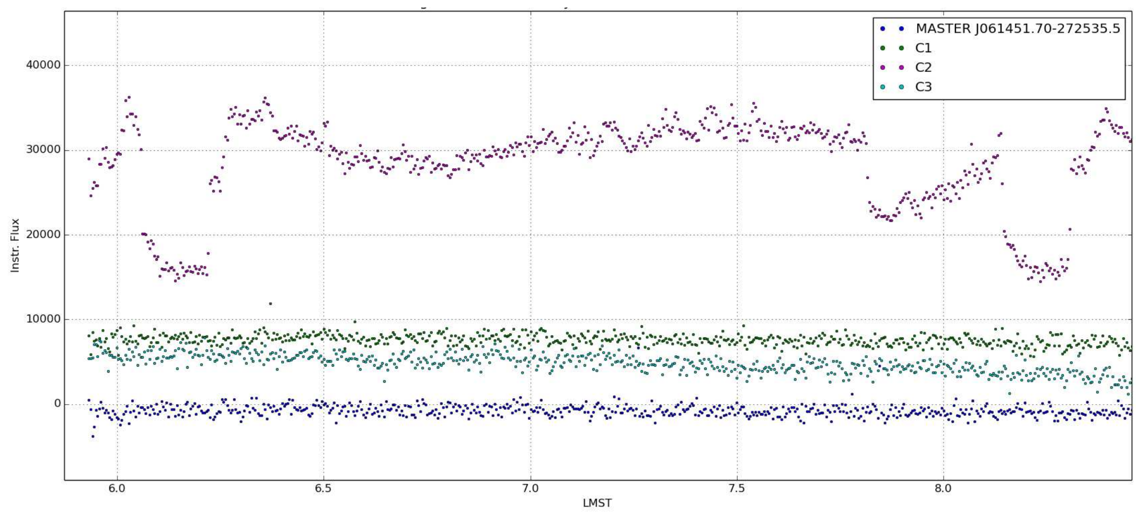

Figure 10: light curve (no filter) of MASTER OT J061451.70-272535.5 taken on 24 Feb 2015 using the SHOC high speed photometer on the SAAO 1.9-m telescope. The eclipse and pre-eclipse dip, due to the obscuring accretion stream, are clearly seen. The points at the bottom of the plot are the fluxes of three comparison stars.

The target was subsequently observed with SALT RSS on 28 Feb 2015 and a 800 s exposure spectrum obtained, covering 4060–7120Å (see Figure 11). The spectrum shows all of the Balmer lines in emission, a strong HeII 4686Å line at a peak flux greater than Hβ, and weaker HeI lines. The lines appear asymmetric and double peaked, with wings extending to shorter wavelengths. This spectrum is typical of a magnetic Cataclysmic Variable, particularly with the strong HeII line, and therefore together with the light curves, we have identified the system to be a new eclipsing polar [21].

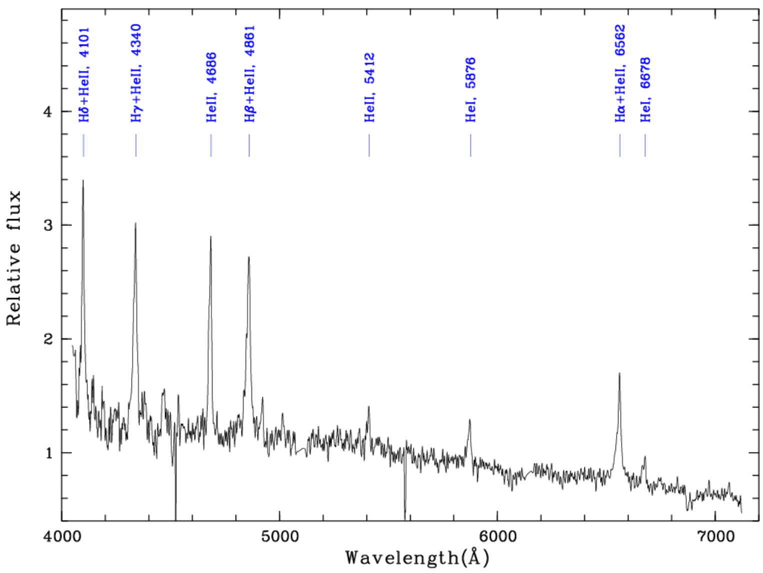

Figure 11: A SALT RSS spectrum of the eclipsing polar, MASTER OT J061451.70-272535.5

5.3.3 The flaring blazar NVSS_J141922.55-083832.0

A flare in the candidate blazar, NVSS_J141922.55-083832.0, was discovered by MASTER Kislovosk on 21 Feb 2015 as an unfiltered $14^{m}.6$ magnitude transient [22]. The source was also detected in the 2nd Fermi catalogue as 2FGL J1419.4-0835, and observed by Swift following the MASTER alert [23], and found to be ~5× brighter than in 2014, when it was barely detected.

NVSS_J141922.55-083832.0 was observed on 1 Mar 2015 with the SAAO 1.9 m telescope using the SHOC high speed EM-CCD camera. *UBVR* measurements confirmed the object was still in a bright flaring state (V ~ 15). Observations were then obtained with SALT RSS on the same night and a 1100 s exposure spectrum, covering 3780 – 6850Å, was obtained (Figure 12). The spectrum shows a single emission line at 5325Å, plus some very broad (~500Å) emission 'humps' at ~4200, 4600 and 6400Å, superimposed on a steeply rising blue continuum. If the emission line is interpreted to be the Mg II 2798Å line (other potential lines, like [CIV], CIII] and Lyα, are unlikely, since other lines would then be expected) then the implied redshift for this blazar is z = 0.903 [24]. The humps could be unresolved Fe emission or possibly cyclotron features.

This blazar has been further observed by Fermi and has been monitored by MASTER, including measurements of polarizations, which indicates it is linearly polarized at the ~10% level. Historical measurements by MASTER have shown that another optical flare occurred in Oct 2014, also detected by Fermi. The SEDs which have been derived from X-ray (Swift & Fermi), UV (Swift), optical (SAAO/ SALT), NIR (Guillermo Haro Observatory [25]) and radio (GMRT) indicate that the system comprises of blackbody (disk), synchrotron (jet) and external Compton components and could be a FSRQ class of blazar, though it is currently unclassified (i.e. BCU) in the 3FGL catalogue.

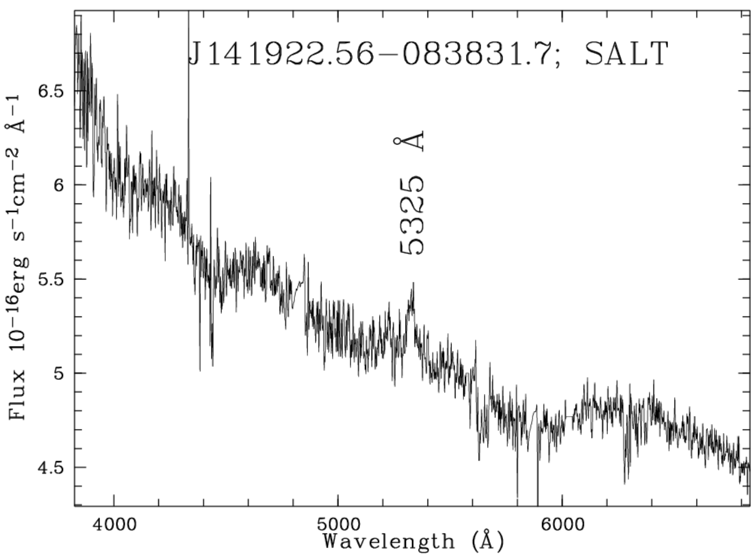

Figure 12: A SALT RSS spectrum of the blazar (and possible FSRQ) source NVSS_J141922.55–083832.0 (= 2FGL J1419.4–0835), with a tentatively identified MgII emission line, implying z = 0.90.

6. Future Strategies for followup of transients with SAAO facilities

While MASTER-SAAO is the first local optical transient detection system to be installed at the Sutherland station of the SAAO, it will be joined in 2016 by another transient detection facility, namely MeerLICHT (http://www.ast.uct.ac.za/meerlicht/MeerLICHT.html). This will be a 0.65 m telescope with a 2 degree^2 field of view, which will simultaneously observe the same fields being observed by the MeerKAT radio telescope, once it begins operations. The aim is to have simultaneous optical image of MeerKAT fields to allow for the potential detections of the optical counterparts of radio transients.

Many transient discoveries require followup observations to confirm their nature and to allow for more probing astrophysical observations. While there have already been several examples of limited followup observations (e.g. by SALT and other SAAO telescopes) presented in the previous section, further plans are underway to expand the nature of these followup observations. These include more comprehensive observations of the whole variety of optical transients currently being detected by the MASTER and other networks, including GRBs, AGN, CVs and X-ray and γ-ray transients. A new SALT program supporting this is about to begin in Nov 2015, while observations with other multi-wavelength facilities are also planned, including HESS II, ASTROSAT (the new Indian optical/UV/X-ray satellite) and eventually MeerKAT, once it begins operations. In addition, new optical followup possibilities will be enabled with the establishment of two new robotic facilities at the SAAO, namely MONET-South and the new 1.0 m Robotic telescope.

MONET-South, owned by the University of Göttingen in Germany (see https://monet.uni-goettingen.de/), is the twin telescope to MONET-North, situated at MacDonald Observatory in Texas, USA. Both are robotic/remotely operated 1.2 m telescopes, with a major science goal being the followup of transients and ToOs. MONET-North has been operating for several years and MONET-South at Sutherland is expected to begin science operations shortly, initially with an imaging camera. A project has currently begun to design and construct an efficient fibre fed low resolution spectrograph (MORISOT). With such an instrument, MONET-South will have the capability to rapidly spectroscopically classify many brighter ($V <$ ~16 – 17) optical transients as well as supporting co-ordinated multi-wavelength ToO observations.

The new SAAO 1.0 m Robotic telescope, which is currently under construction and is being provided by APM in Germany, is expected to be installed at Sutherland in 2016. While the final instrument suite is still to be determined, it will at least initially consist of an imaging camera and high speed EM-CCD camera and, eventually it is hoped, fibre fed low and or high resolution spectrographs. Science goals for this telescope include synoptic monitoring of variable objects (stars and AGN) at a variety of cadences, but also supporting followup observations of transients and ToO.

All of the followup facilities at SAAO will require automated response to transient and ToO alerts that avoids the slow response typical of human initiated observations. Fortunately there exist several robotic telescope observing software protocols [25] (e.g. the RTML protocol [26]) which can efficiently trigger robotic telescopes to conduct followup observations once an alert is received (e.g. from the likes of VO Events [25]). A project to implement the automated followup observations from transient alerts has begun, which should be implemented during 2016.

7. Summary and Final Remarks

In this paper we have presented a review of the new optical transient detection at system at the Sutherland observing station of the SAAO, namely MASTER-SAAO, the first MASTER II system established in the southern hemisphere. We have reviewed the specifications and *modus operandi* for the MASTER II system and its survey for transients and we have presented results from the first ~8 months of operations. This resulted in the discovery of 143 optical transients plus the followup of ~10 other transient detections from other alert systems, including GRB afterglow searches and monitoring of AGN. The results of three followup spectroscopic observations with SALT, on two CVs and a flaring blazar, were reported, but more detailed papers describing these results and their interpretation are currently in preparation. Finally we discussed the future possibilities of more expansive programs on transient followup observations at SAAO, exploiting two new robotic facilities that will become operational over the next year. Our experiences gained in these endeavours will help to inform how to conduct larger scale SALT and SAAO transient followup campaigns in the future, for example, when LSST becomes operational.

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