The Supernova Operation at Mt. Hopkins

Tom Matheson
Maryam Modjaz

November 22, 2005

1 Introduction

This is a simple tutorial in the operation of the supernova observations at Mt. Hopkins. This covers how to decide which SNe to request, how to contact the observers, and how to collect the data once it has been taken. The focus is on optical spectroscopy and photometry. The IR photometry program is new and will have its own tutorial.

2 Spectroscopy

For spectroscopy of nearby SNe, we use the FAST spectrograph on the 1.5m Tillinghast telescope at F. L. Whipple Observatory on Mt. Hopkins. The spectrograph is usually operated in queue mode by two professional observers. They are Perry Berlind (`perry@linmax.sao.arizona.edu`) and Mike Calkins (`mcalkins@cfa.harvard.edu`). Lately, people from FLWO or the CfA will run the telescope when they are not available. The schedule listing the current observer is available on the OIR/TDC web page (`http://tdc-www.harvard.edu/schedules/`). There is also a computer account for the observer (`observer@flwo60.sao.arizona.edu`). You should send an email to this account as well as directly to the scheduled observer with the SN requests for that night. Also note that the observers might not always check the observer@flwo60 account, so try to make sure that you have the observer's email address. Check the schedule in advance and ask Mike, Perry or Emilio Falco, the FLWO director (`efalco@cfa.harvard.edu`), if you don't know the observer's email address.

The SN program gets the equivalent of six (6) nights per trimester with FAST. This is approximately one hour per night. Our typical exposure time (for things with $15 < m < 18$) is twenty minutes, so we usually do three SNe per night. Occasional bright objects can be fifteen minutes, and faint things can be thirty (or two twenty-minute exposures). You can generally just warn Mike or Perry that the object is faint, and they will judge whether or not conditions warrant more time.

The format we use in the email looks like this:

```
sn2004ao 20 minutes 17:28:09.35 +07:24:55.5 2000.0 6.3E 23.8S 14.9 Ib
```

This lists the name of the SN, exposure time, RA, DEC, epoch of coordinates, offsets from nucleus in arcsec, magnitude (at discovery), and type (often ?? for candidates). This is enough for Mike and Perry. Other observers are more comfortable with a link to a finder chart as well, usually from the KAIT web page (`http://astron.berkeley.edu/ bait/kait_lwd.html`) or the Rochester page of all nearby SNe (`http://www.rochesterastronomy.org/supernova.html`). We also have now our own SN webpage with finding charts of our objects (`http://cfa-www.harvard.edu/oir/Research/supernova/RequestsSN.html`).

The FAST spectrograph is used in a queue mode, meaning that several programs are executed in a given night. There are two main observing setups, distinguished by the spatial binning used during the observation. The redshift surveys use a bin-by-4 mode to enhance the signal. We like to separate the SN from the host, so some spatial resolution is useful. For SNe, we use the bin-by-2 mode. Lately, the standard mode is the bin-by-2 mode. We also request that observations for SNe and standards be done at the parallactic angle (at low airmass, secz $\leq$ 1.05, this is not always necessary). The default strategy with FAST is to do a comparison lamp after every object, which is fine for our purposes. The usable wavelength coverage is 3500 Å to 7400 Å, and before Sept 2004 it used to be 3720 Å to 7540 Å.

The wavelength range for the FAST includes the Balmer break, implying that a sdO star is the best calibrator. Recent improvements to the optics have enhanced the blue throughput, however, introducing a severe second-order light contamination. It is especially bad for a blue object like a sdO star. There is no perfect solution, but the best compromise is to use two standard stars with different colors. Calibrating the objects in the blue with the sdO star and in the red with a sdF star. This means that both a red and a blue standard should be observed every night. If this is not possible, the stability of FAST allows you to employ a standard from a nearby night. Here is a list of the good standards to use (note that other standards are observed with FAST–don't use them):

Star	type	Coords. (J2000.0)
HD 19445	red	03:08:25.589 +26:19:51.39
HD 84937	red	09:48:56.100 +13:44:39.32
BD+26 2606	red	14:49:02.357 +25:42:09.16
BD+17 4708	red	22:11:31.374 +18:05:34.17
Hiltner 600	red	06 45 13.371 +02 08 14.70
Feige 34	blue	10:39:36.740 +43:06:09.25
BD+28 4211	blue	21:51:11.022 +28:51:50.36
Feige 110	blue	23:19:58.398 -05:09:56.207

Perry and Mike know to do this, but I usually remind them at the start of a run. Other observers will need explicit instructions, as well as a target list of the exact standards that we want. At the end of this tutorial there is a little write-up of instructions to be sent to the novice observer.

The day-to-day operation begins with an assessment of which three SNe to request for that night. It is usually a mix of new and untyped SNe and older SNe that we are following. If there are many new ones, don't hesitate to ask for more than three, just give the whole list and ask that they do what they can. Mike and Perry are eager to help. Once you have the three, send an email to the scheduled observer and the observer account for FAST. It is a good idea to check the coordinates to make sure the object is still observable and not near the moon (FAST operates in fairly bright time on occasion, and this can be a serious problem).

After the data is taken, you will usually (but not always) get an email with a report on how things went. Even without an email, I log in to the computer at the 60" and look to see what happened. I can then ftp the data back to the CfA. You can log in using the observer account on flwo60.sao.arizona.edu (username: `observer` password:). You then change to the data directory (`/fast/flwo1/2005/11/22` for November 22nd 2005). You should pull over all the flats and biases in binby2 mode (if you list files with the size, they are twice the size of the binby4 files), as well as the standards and SNe and their comparison lamps. A better and faster way is to copy the data over from a Cfa disk, which automatically graps the data by noon of the following day, and which lives on /data/fast1/transfer (you need to get permission to access that directory).

At the CfA, I store the raw data in directories sorted by the local date at the start of the night. It would be better to use UT date, but the tradition here is by local date. For example, the data from the directory described above would be in a directory here labeled `fast-04Jul17`. I reduce the data in a different directory.

For the untyped SNe, once you have an identification, the information needs to be passed along to Dan Green at the IAUC. His email is `dgreen@cfa.harvard.edu`, but you should also send it to `cbat@cfa.harvard.edu`. In addition, there is a general announcement list of SNe people around the world who we let know as soon as we have an identification. The content of the report is more than just the classification. For Ia SNe, we report an expansion velocity based on minimum of the Si II λ6355 line and an age, either from Adam's spectral-feature aging routine or some other estimate. For Type II SNe, we report an expansion velocity measured from the minimum of the Hβ line and a brief description of the spectrum (blue continuum, P-Cyg lines, etc.). There is less to report for SNe Ib/c, but a comparison to other SNe is often appropriate. If there is reddening apparent, report the Schlegel et al. value (NED does this for the host when you look up the velocity anyway) and measure the equivalent width of the Na I D line.

3 Photometry (optical)

The photometry with the Kepcam on the 1.2m telescope at FLWO is handled slightly differently. This telescope is classically scheduled, so the observer is different on any given night. The OIR/TDC web page (`http://tdc-www.harvard.edu/schedules/`) will list the observer (although it is often the PI, so send the mail early enough that it can be forwarded to the correct person). In addition, you should email the observer account at the 48" (`4obs@flwo48.sao.arizona.edu`) with the request (again they observer might not always check that account, so extra care is needed – you can always call the mountain!). New observers don't often know to check this, so I usually ask Perry or Mike to make sure that they do. Occasionally, the SN conflicts directly with an observers objects. In this case, I usually can negotiate a solution, but our proposal is always highly ranked, and they should make the observation as requested. It's just best not to force the issue unless you really need the observation.

In order to follow transient objects, there is a service observing component that all users are supposed to execute. They are only required to give up at most 10% of their night. We now ask for two SNe per night, with a total exposure time of 15-18 minutes. We also get our own nights (now a couple per dark run) to get calibrations (photometric and templates) as well as fainter objects. We usually get a full $UBVri$ sequence. With the Kepler team doing their observing with the Sloan filters starting in Sept 2004, we have had to use the sloan ri set rather than our Harris RI filters. There are ways to automate this telescope, so we have scripts that will go to the field, position the SN properly, and execute the exposures for all five filters. (When observing on our own nights, there are scripts for flats and standards too.)

The requests look like this:

```
sn2005hg 17 01:55:41.87 +46:47:47.4 2000.0
UUBVri 300 300 240 180 120 120  20 minutes
source /home/observer/scripts/do05hg
```

This lists the SN name, magnitude (at discovery), coordinates, epoch, exposure time per filter and total time, along with the way to activate the script to run the observation. Inexperienced observers will need some coaching with the script. A copy of a typical script is in Appedix A. To make one for a new SN, copy the old script to a new file with the name of the new SN. In the script itself, you need to change the name of the SN, the coordinates, and the exposure times per filter. The script also includes instructions to position the SN in middle of chip 2 of the Kepcam, but we want to read out all amps. In general, they will not do flats (we use the flats from our nights for the whole dark run). Sometimes, they will do biases.

The next morning, it is unlikely that the observer will let you know what happened. You can copy over the data from the CfA permanent archive at `/data/kepler/Archive/rawdata/kepcam`. You can also log into the Kepcam observer account on flwo48.sao.arizona.edu (username: `observer` password:) and pull over the data. The data directory is `/rdata/kep/2005.1122` for Nov 22nd, 2005. Get the SN observations, as well as flats and biases, if they were done.

NOTE: The note below only refers to 4shooter data: At the CfA, I initially store the data in directories names like this: `4sh-04Jul17`. Since the 4shooter has four chips, and we only need chip 3, we cut that chip out. The simplest way to do this is to use IRAF to imcopy extension 3 from the fits file to a different directory, called `cut-04Jul17`. You can observe with just chip 3, so sometimes you can skip this step and just ftp the data from flwo48 directly to a cut directory. When the new chip is online, this step will be meaningless.

4 Photometry (IR) – Obsolete

The StelIRCAM on the 1.2m telescope at FLWO provides us with IR photometry. This instrument is not used as extensively as the 4shooter, so it can't provide the kind of light curve coverage that would be most useful. In addition, it requires fairly bright SNe, bright enough that they are rare. This means we haven't gotten a lot of IR data in a few years. This will change soon with the reactivation of the 2Mass instrument on the 1.3m telescope at FLWO. Josh Bloom and I are sorting out how the SNe will be handled, but this will be an automated operation, with priority lists of objects that we submit.

5 Appendix A

```
#Script to automate taking exposures of a supernova bla
#in UBVRI filters
# Adapt this script to other SNe by changing coordinates.
# R.A. Jansen April 4 1995.
# P.M. Garnavich Feb 1997
# S. Jha Sept 1997
# S. Jha June 1999 added abort features
# T. Matheson Oct 2000 added printout of abort so user knows what
# to do
# T. Matheson Dec 2002 changed filter order to VRIBU
# T. Matheson Dec 2002 created script generator
# Watch out for 4-shooter offset !!!!!
```

```
# M. Modjaz Sep 2004 modified for Minicam using suggestions by
# Dave Latham, Ted Groner
# takes a 20 sec exposure in V so that observer
# can check position of SN
# M. Modjaz Apr 2005 include on coordinate line also epoch (2000.0)
# M. Modjaz Sep 2005 modified for Kepcam
#-----------------------------Make changes here for new SNe
# set name of SN
set name='sn05hg'

# set exposure times for different filters
set expU=300
set expB=240
set expV=180
set expR=120
set expI=120

# set coordinates of SN
echo -n "sending coordinates 01:55:41.87 +46:47:47.4 2000.0"
tele coords 01:55:41.87 +46:47:47.4 2000.0
sleep 3
#------------------------------------------------------------

# move telescope to SN coordinates
echo -n "Starting slew ..."
tele enable
echo "NOTE:"
echo "You can abort this sn script at any time by typing snabort"
echo "in any xterm window (not the rtshell) on flwo48.  This creates"
echo "a temporary file (called /home/4obs/scripts/.SNABORT). When"
echo "the script is about to start the next exposure it checks for"
echo "this file, and if it exists, the script stops (and gets rid of"
echo "the file).  If you type snabort and change your mind before the"
echo "script stops, you can type snunabort, which just deletes the"
echo ".SNABORT file."
echo " "
echo " "
echo "This observation requires the target on amp2 of KepCam."
echo "If you have already centered the array there, just hit ENTER."
echo " "
echo "Otherwise go to the Offset Menu and manually offset."
echo "To put it onto amp 2, use an offset of -200 -200 from the "
echo "the center of the whole array."
echo " "
echo "Hit ENTER when properly positioned..."
set foo1=$<
```

```
set OFILT=`tele filter`
echo -n "START FILT = " $OFILT
set SFILT=`grep -n $OFILT /Realtime/lib/filt.dat | cut -f1 -d:`
echo " SLOT = "$SFILT

#set OTYPE=`ccd filetype`
#echo -n "Setting filetype to "
#ccd filetype iraf

if (  test -f /tmp/ccd_ram_prog  ) then
cp /tmp/ccd_ram_prog /tmp/rudy.pre.prog
endif
echo "Setting for small files"
ccd program off

#-----------------------------------------------------------------
echo -n "Find guide star (segment ??).  (Guiding not necessary if"
echo -n "all exposure times less than 300 seconds)"
echo -n "Hit ENTER when ready..."
set foo1=$<
#-----------------------------------------------------------------

# make sure right name appears in title and comment field
object "$name"
#setcom 4shooter Object "$name"
setcom kepccd Object "$name"

# make sure abort stuff is in place
if (!($?scriptdir)) then
echo "No scriptdir set, using default:  $HOME/scripts"
set scriptdir = $HOME/scripts
endif

if (!($?snabortfile)) then
echo "No abortfile set, using default:  $scriptdir/.SNABORT"
set snabortfile = $scriptdir/.SNABORT
endif

if (-e $snabortfile) source $scriptdir/snabort.script
# change filter to V and take exposure of expV
# seconds, respectively
echo -n "Moving filter wheel to "
tele filter 3
# tele filter 7
echo "Start V exposure 20 sec at "`date`
```

```
ccd gowait 20
dstore
echo "Check position of supernova.  Hit $<Return$> when ready ..."
set foo1=$<

echo "Starting V exposure 1 ($expV sec) at "`date`
ccd gowait $expV
# fresh
dstore
echo "V exposure 1 done"

if (-e $snabortfile) source $scriptdir/snabort.script
# change filter to R and take an exposure of expR
# seconds
echo -n "Moving filter wheel to "
tele filter 4
#tele filter 8
echo "Starting R exposure 1 ($expR sec) at "`date`
ccd gowait $expR
#fresh
dstore
echo "R exposure 1 done"


if (-e $snabortfile) source $scriptdir/snabort.script
# # change filter to I and take an exposure of expI
# # seconds
echo -n "Moving filter wheel to "
tele filter 5
echo "Starting I exposure 1 ($expI sec) at "`date`
ccd gowait $expI
#fresh
dstore
echo "I exposure 1 done"


if (-e $snabortfile) source $scriptdir/snabort.script
# change filter to B and take exposures of expB
# seconds
echo -n "Moving filter wheel to "
tele filter 2
echo "Starting B exposure 1 ($expB sec) at "`date`
ccd gowait $expB
#fresh
dstore
echo "B exposure 1 done"
```

```
if (-e $snabortfile) source $scriptdir/snabort.script
# change filter to U and take exposures of "expU" seconds
echo -n "Moving filter wheel to "
tele filter 1
# tele filter 4
echo -n "Moving Focus -115 for UH "
tele focus -115
echo "Starting U exposure 1 ($expU sec) at "`date`
ccd gowait $expU
dstore
echo "Starting U exposure 1 ($expU sec) at "`date`
ccd gowait $expU
#fresh
dstore
echo "U exposure 1 done"
echo -n "Moving Focus Back "
tele focus +115

# tell the observer to stop auto-guiding
echo -n "Turn OFF Autoguider (not necessary).  Hit ENTER when ready..."
set foo2=$<

echo -n "Returning Filter wheel to Filter $OFILT"
tele filter $SFILT
if (  test -f /tmp/rudy.pre.prog  ) then
echo "Returning program to original state"
ccd program -f /tmp/rudy.pre.prog

rm -f /tmp/rudy.pre.prog
endif

#echo -n "Setting file type to $OTYPE"
#ccd filetype $OTYPE

# end message
echo " "
echo "All Done, Thank You"
echo " "
```

6 Appendix B

Dear Observer,

We would like to request under the supernova service program the following supernovae to be observed tonight.

The finding charts can be found at http://www.supernovae.net/snimages/ and the nomenclature of the below list is: SN name, exposure time, RA, Dec, Epoch Offet from Nuclues, Magnitude at discovery, Type (?? = unclassified).

We'd like to observe the SNe and their standards in the bin-by-2 mode and it would be great if you could observe the SNe at their parallactic angle, especially when observing the SNe (and their standards) at a larger airmass (secz $\leq$ 1.05), as to minimize differential light loss produced by atmopheric dispersion. As I'm sure you know, the range of accessible PAs is -45 to 110 and the PA shouldn't be changed by increments more than 70 degrees. Also, remember that the value of the PA is degenerate by 180 degrees.

We would like to observe a blue and a red standard star, also in the binby2 mode and at parallactic angle. Examples of standards are:
Blue: Feige 34, BD+284211, Feige 110
Red : HD19445, HD84937, BD+262606, BD+174708
Lately, we've have also been observing
Blue: G191B2B and Red: Hiltner600.

As a reminder, you'd also need to take the Flats and Bias' in the bin-by-2mode.

Thanks, Maryam