CHROTEL

Camera Commands

David Elmore HAO
Thomas Kentischer KIS

Version 5
16 September, 2005

The communication between telescope PC and camera PC is done by simple ASCI commands via a TCP/IP connection. Commands are sent on port 1999 and status returned on port 1998. Packets are 80 bytes long. The connection is opened by the sender and closed again after delivery of the command or status packet.

The command format is a single letter followed by arguments. Command numeric arguments require no separator, but a single <space> is acceptable. The 'h' and 'j' command must have a single <space> between their string arguments.

a (int)#1

Expose camera for channel #1: 1,2,3
    1: Cak Channel
    2: Hα Channel
    3: He Channel (make one scan)
    Do summing and mean if sum!= 1
    if a file is opened, write data to file after exposure.
    Return: acc/nac and if acc then
        ok/no when exposure (and write) is done

E (char*)#1

Toggle TCP/IP status on/off
#1: client computer name receiving the status
Return: acc/nac

e (int)#1 (int)#2

Set exposure time
#1: Channel (1: CaK, 2: Hα, 3 He)
#2: Exposure time in msec
Return: acc/nac

h (char*)#1<space>(char*)#2<space>(char*)#3 *Add ChroTel FITS header entry*
Upon file close, these entries are merged with the SGL FITS header for the currently open file.
#1: Keyword
#2: Value
#3: Comment
Return: acc/nac

i (char*)#1

Remove ChroTel FITS Header Entry
#1 = Keyword
Return: acc/nac

j (char*)#1<space>(char*)#2   *Dump Image Directory to the Unix-Server*
#1: Filename to be dumped
  (Wildcards allowed)
#2: Full path of destination dump directory
Return: acc/nac if acc then
        ok/no when dump is done

k (char*)#1

Delete File in image directory
#1: Filename (Wildcards allowed)
Return: acc/nac if acc then
        ok/no when dump is done

o (int)#1 (int)#2

Open/close file

#1 = 1: open File
     if #2 = 0, generate Observation Filename with :
          Wv_O_ddmmmyy_hh_mm_ss.FIT
     Wv is the current wavelength CA, HA, or HE as
specified in the most recent 'e' command.
     if #2 = 1, generate Flatfield Filename with:
          Wv_F_ddmmmyy_hh_mm_ss.FIT
     if #2 = 2, generate Dark Filename with:
          Wv_D_ddmmmyy_hh_mm_ss.FIT
     if #2 = 3, generate Target Filename with:
          Wv_T_ddmmmyy_hh_mm_ss.FIT
#1 = 0: merge FITS header entries into open file and close the
file.
Return:
     acc/nac

p
    Ping camera
    Return: acc/nac   if acc then
        ok/no upon completion or failure

s (int)#1
    Sum #1 frames and calculate mean frame
    Return: acc/nac

t (char*)#1
    Set date and time
    #1: yy_mm_dd_hh_mm_ss
    Return: acc/nac

v (int)#1(float)#2
    Revise the Helium wavelength table entries
    #1: Wavelength table entry number 0 <= #1 <= 31 (%02d)
    #2: Wavelength in nanometers (float)
    Wavelengths defaults for the first seven table entries are:
    1083.315, 1083.213, 1083.100, 1083.030, 1082.960, 1082.847,
    1082.745.
    Return: acc/nac

w (int)#1 (int)#2
    Select Wavelength table range of entries for the He-filter
    #1: First wavelength number (0 <= #1 <= 31 %02d)
    #2: Number of wavelengths (1 <= #2 <= 32 %02d)
    Return: acc/nac

y
    Restart camera process
    Return: acc/nac

z
    Stop camera process
    Return: acc/nac

?[c]
    Help (keyboard only)

File Format

All Files were written in FITS format. Each wavelength will be recorded in a separate FITS file. Data files are I16 except average images that are F32. Each file has a 2880 byte header followed by two 2880 byte extensions. The first 23 entries can be a z ChroTel Single Image, Multiple Frame Image, or Average image. Following these entries are entries provided by the SI application containing camera parameters.

FITS-Header (Single Image)

```
SIMPLE   =                       T / FITS Standard
BITPIX   =                      16 / FITS Bits/Pixel (-16 signifies [U16]
NAXIS    =                       2 / Number of Axes
NAXIS1   =                    2048 / Length of Axis 1 (Columns)
NAXIS2   =                    2048 / Length of Axis 2 (Rows)
NAXIS3   =                       1 / # of Frames
BSCALE   =                       1 / Scaling Factor (Default=1)
BZERO    =                0.000000 / Offset Factor (Default=0)
DATE     = '26/08/2005'           / Date Format is dd/mm/yyyy
TIME     = '19:01:04.953'         / Time at Start of Exposure, 24 Hour Format
STATUS   = RAW         /data status
TELESCOP= CHROTEL      /telescope
SITE     = IZANA       /site
WAVE     = 636         /Wavelength
TT_RMS   = 123         /actual image motion [counts]
LL       = 95          /mean light level at PSD [counts]
AZ       = 180.        /azimuth of the Sun [deg]
EL       = 75.         /elevation of the Sun [deg]
B0       = -5.5        /actual B0[deg]
P0       = 22.3        /actual P0[deg]
Z0       = 320.        /actual image rotation angle [deg]
R0       = 960.        /actual sun radius
N_SUM    = 1           /Number of images summed
```

FITS-Header (Multiple Frame – He wavelength sequence)

```
SIMPLE   =                       F / FITS Standard
BITPIX   =                      16 / FITS Bits/Pixel (-16 signifies [U16]
NAXIS    =                       2 / Number of Axes
NAXIS1   =                    2048 / Length of Axis 1 (Columns)
NAXIS2   =                    2048 / Length of Axis 2 (Rows)
NAXIS3   =                       7 / # of Frames
BSCALE   =                       1 / Scaling Factor (Default=1)
BZERO    =                       0 / Offset Factor (Default=0)
DATE     = '26/08/2005'           / Date Format is dd/mm/yyyy
TIME     = '19:00:38.828'         / Time at Start of Exposure, 24 Hour Format
STATUS   = RAW         /data status
TELESCOP= CHROTEL      /telescope
SITE     = IZANA       /site
WAVE     = 1083        /Wavelength
TT_RMS   = 123         /actual image motion [counts]
LL       = 95          /mean light level at PSD [counts]
AZ       = 180.        /azimuth of the Sun [deg]
```

```
EL      = 75.          /elevation of the Sun [deg]
B0      = -5.5         /actual B0[deg]
P0      = 22.3         /actual P0[deg]
Z0      = 320.         /actual image rotation angle [deg]
R0      = 960.         /actual sun radius
N_SUM   = 1            /Number of images summed
```

FITS-Header (Average – dark and flat)

```
SIMPLE  =                       T / FITS Standard
BITPIX  =                     -32 / FITS Bits/Pixel (-16 signifies [U16]
NAXIS   =                       2 / Number of Axes
NAXIS1  =                    2048 / Length of Axis 1 (Columns)
NAXIS2  =                    2048 / Length of Axis 2 (Rows)
NAXIS3  =                       1 / # of Frames
BSCALE  =                       1 / Scaling Factor (Default=1)
BZERO   =                       0 / Offset Factor (Default=0)
DATE    = '26/08/2005'            / Date Format is dd/mm/yyyy
TIME    = '18:54:55.655'          / Time at Start of Exposure, 24 Hour Format
STATUS  = RAW          /data status
TELESCOP= CHROTEL      /telescope
SITE    = IZANA        /site
WAVE    = 393          /Wavelength
TT_RMS  = 123          /actual image motion [counts]
LL      = 95           /mean light level at PSD [counts]
AZ      = 180.         /azimuth of the Sun [deg]
EL      = 75.          /elevation of the Sun [deg]
B0      = -5.5         /actual B0[deg]
P0      = 22.3         /actual P0[deg]
Z0      = 320.         /actual image rotation angle [deg]
R0      = 960.         /actual sun radius
N_SUM   = 16           /Number of images summed
```

FITS-Header Extensions (SI Camera Entries)

```
NPARAM  = 64           /number of parameters to follow
PARAM1  =                     30.5 / CCD Temperature
PARAM2  =                     32.0 / Backplate Temperature
PARAM3  =                      0.4 / CCD Chamber Pressure
PARAM4  =                      0.0 / Spare 3
PARAM5  =                      0.0 / Spare 4
PARAM6  =                      0.0 / Spare 5
PARAM7  =                      0.0 / Spare 6
PARAM8  =                      0.0 / Spare 7
PARAM9  =                      0.0 / Shutter Status
PARAM10 =                      0.0 / XIRQA Status
PARAM11 =                      0.0 / Spare 10
PARAM12 =                      0.0 / Spare 11
PARAM13 =                      0.0 / Spare 12
PARAM14 =                      0.0 / Spare 13
PARAM15 =                      0.0 / Spare 14
PARAM16 =                      0.0 / Spare 15
PARAM17 =                     29.0 / Serial Origin
PARAM18 =                   1024.0 / Serial Length
PARAM19 =                      1.0 / Serial Binning
PARAM20 =                      0.0 / Serial Post Scan
```

```
PARAM21 =                    22.0 / Parallel Origin
PARAM22 =                  1024.0 / Parallel Length
PARAM23 =                     1.0 / Parallel Binning
PARAM24 =                     1.0 / Parallel Post Scan
PARAM25 =                    13.0 / Exposure Time (ms)
PARAM26 =                     0.0 / Continuous Clear Disable
PARAM27 =                     1.0 / DSI Sample Time
PARAM28 =                     0.0 / Analog Attenuation
PARAM29 =                  2128.0 / Port 1 ADC Offset
PARAM30 =                  2140.0 / Port 2 ADC Offset
PARAM31 =                  2081.0 / Port 3 ADC Offset
PARAM32 =                  2125.0 / Port 4 ADC Offset
PARAM33 =                    10.0 / TDI Delay
PARAM34 =                     0.0 / not used
PARAM35 =                     0.0 / not used
PARAM36 =                     0.0 / not used
PARAM37 =                     0.0 / not used
PARAM38 =                     1.0 / CCD Attenuation
PARAM39 =                     7.0 / Number of Frames
PARAM40 =                     0.0 / Spare 23
PARAM41 =                     0.0 / Spare 24
PARAM42 =                     0.0 / Spare 25
PARAM43 =                     0.0 / Spare 26
PARAM44 =                     0.0 / Spare 27
PARAM45 =                     0.0 / not used
PARAM46 =                     0.0 / not used
PARAM47 =                     0.0 / not used
PARAM48 =                     0.0 / not used
PARAM49 =                   804.0 / Instrument Model
PARAM50 =                   213.0 / Instrument SN
PARAM51 =                     0.0 / Hardware Revision
PARAM52 =                     0.0 / Serial Phasing
PARAM53 =                     1.0 / Serial Split
PARAM54 =                  1049.0 / Serial Size
PARAM55 =                     0.0 / Parallel Phasing
PARAM56 =                     1.0 / Parallel Split
PARAM57 =                  1047.0 / Parallel Size
PARAM58 =                   250.0 / Parallel Shift Delay
PARAM59 =                     3.0 / Number of Ports
PARAM60 =                    10.0 / Shutter Close Delay
PARAM61 =                    67.0 / CCD Temp. Setpoint Offset
PARAM62 =                     0.0 / not used
PARAM63 =                  2430.0 / CCD Temp. Setpoint
PARAM64 =                    16.0 / Data Word Size
COMMENT  Temperature is above set limit Light Exposure, Exp Time= 00.013
END
```

Observations

Startup

Every morning Chrotel starts a setup procedure. The Lyot filter temperature controllers should be left on overnight.

1.) Start 15 Minutes after Sunrise.
2.) Start the camera *SI Image SGL* application and in that application enable CCD cooling and enable TCP/IP commands.
3.) Open a C Shell and run *camera.*
4.) Check Environment Parameters (Humidity, Irradiation). If there are clouds, rain or fog, repeat the check in intervals of 10 minutes.
5.) Make telescope reference movements.
6.) Drive telescope to sun position
7.) Activate slow sun tracker and center sun
8.) Start fast sun tracker

→ p	← acc	ping camera
	← ok	
→ t 12:12:12,12,12,04	← acc	set time/date
→ E name_of_computer	← acc	enable status output

9.) Set Camera parameters

→ e 1 200	← acc	set exposure times
→ e 2 100	← acc	
→ e 3 200	← acc	

10.)   Set He-Filter scan parameters

→ w 0007	← acc	set He scan parameter

11.)   Switch to dark position and make dark exposures

→ s 16	← acc	Set Sum
→ e 1 200	← acc	set Ca & exposure time
→ o 1 2	← acc	Open File
switch to Cak Filter		
→ a 1	← acc	Expose CaK
	← ok	
→ o 0	← acc	close File
next filter (Hα)		
→ e 2 200	← acc	set Hα & exposure time
→ o 1 2	← acc	Open File
→ a 2	← acc	Expose Hα
	← ok	
→ o 0	← acc	close File

next filter (He)

→ w 00 01	← acc	**only one He wavelength**
→ e 3 200	← acc	**set He & exposure time**
→ o 1 2	← acc	**Open File**
→ a 3	← acc	**Expose He**
	← ok	
→ o 0	← acc	**close File**

10.)   Copy Files to Unix Server

→ j *.FIT z:		**remote directory**
		mounted on z:
	← acc	

11.)   Delete File

→ k *.FIT	← acc

12.)   Switch to flat position and make flat field exposures

→ s 16	← acc	**Set Sum**

switch to CaK Filter

→ e 1 200	← acc	**set Ca & exposure time**
→ o 1 1	← acc	**Open File**
→ a 1	← acc	**Expose CaK**
	← ok	
→ o 0	← acc	**close File**

next filter (Hα)

→ e 2 200	← acc	**set Hα & exposure time**
→ o 1 1	← acc	**Open File**
→ a 2	← acc	**Expose Hα**
	← ok	
→ o 0	← acc	**close File**

next filter (He)

→ e 3 200	← acc	**set He & exposure time**
→ o 1 1	← acc	**Open File**
→ a 3	← acc	**Expose He**
	← ok	
→ o 0	← acc	**close File**
→ s 1	← acc	**Reset Sum**

13.)   Copy File to Unix Server

→ j *.FIT z:	
	← acc

14.)   Delete File

→ k *.FIT	
	← acc

Observing Loop 1

The following observing loop will be repeated after T_cyc (ca. 10 -60 sec, TBD).

Start

1. Check Environment Parameters (close telescope if needed)
2. Load header information

      → h TT_RMS 20 actual rms image motion   **← acc**
      → h LL 100 mean light level at PSD   **← acc**
      → h AZ XX.XX azimuth of the sun   **← acc**
      → h EL YY.YY elevation of the sun   **← acc**
      → h B0 ZZ.ZZ actual B0   **← acc**
      → h P0 UU.UU actual P0   **← acc**
      → h Z0 VV.VV image rotation angle   **← acc**
      → h R0 WW.WW actual sun radius   **← acc**

3. Switch to CaK Filter

→ e 1 200	**← acc**	**set Ca & exposure time**
→ o 1 0	**← acc**	**Open File**
→ a 1	**← acc**	**Expose CaK**
	← ok	
→ o 0	**← acc**	**close File**
next filter		
→ e 2 200	**← acc**	**set Hα & exposure time**
→ o 1 0	**← acc**	**Open File**
→ a 2	**← acc**	**Expose Hα**
	← ok	
→ o 0	**← acc**	**close File**
next filter		
→ e 3 200	**← acc**	**set He & exposure time**
→ o 1 0	**← acc**	**Open File**
→ a 3	**← acc**	**Expose He**
	← ok	
→ o 0	**← acc**	**close File**

4. Copy File to Unix Server

      → j *.FIT z:

                             ← acc

5. Delete File

      → k *.FIT

                             ← acc

Repeat

It has to be clarified, if the Files on the Camera PC have to be deleted after the file transfer. There may exist other, different observing modes-

Spectral Instruments Camera Control

Spectral Instruments delivered the camera without a C language software developer's kit. SI has not yet had time to develop an SDK for this first camera of its type. SI did provide a camera control program called *SI Image SGL*. *SI Image SGL* allows the user to set up all camera parameters and record images in many modes from the user GUI. An auto-scaled display is part of *SI Image SG*. It also allows external control of the camera via a TCP/IP port. Unfortunately, this TCP/IP interface does not provide control of all the settings available from the GUI, but has the basic commands needed so that we can program Chrotel.

The software control of Chrotel data collection consists of two applications. *SI Image SGL* controls the camera and, after initialization, waits for commands on its TCP/IP port. The *Camera* application runs on the same computer. It parses commands from the Sun Workstation and sends commands to *SI Image SGL* via TCP/IP. Data files are written to disk by *SI Image SGL* in FITS format. The *Camera* application then reads the header, adds ChroTel specific keywords to the header, and writes it back to the front of the data file. There are three types of images written by *SI Image SGL,* single frames for Ca and Ha which are 2k x 2k I16, multiple frames in a single file for He which are n x 2k x 2k I16, and average frames for flat and dark images which are 2k x 2k 32 bit floats, normalized by the number of frames acquired. All image data are in the range 0 to 16363.

SI Image SGL is started by the user at the beginning of the day on the camera control computer. The user must use the GUI to initialize the camera and enable CCD cooling. Initialization sets the number of pixels in X and Y, initial pixels in X and Y, binning, channel gains, and channel offsets. Values are read from a camera initialization file. The last user step is to set the program for TCP/IP control. Once in TCP/IP mode, only a few commands are available. Of interest to ChroTel are commands to set exposure time, number of exposures to record, set the mode (Single, Average, or Multiple Frame), set the number of exposures, and initiate exposures. Data are written to a temporary file, ChroTel specific information added to the FITS header, and then copied to the date/time formatted data file.

The SI FITS header is as follows. This three record (3 x 2880 bytes) goes on the front of each file from *SI Image SGL*. Entries from the workstation are merged with these entries, and the location of N_PARAM is moved down to allow ChroTel specific entries above it. The number of parameters is reduced to 64 to make room.

```
SIMPLE  =              T / FITS Standard
BITPIX  =            -16 / FITS Bits/Pixel (-16 signifies [U16]
NAXIS   =              2 / Number of Axes
NAXIS1  =           2048 / Length of Axis 1 (Columns)
NAXIS2  =           2048 / Length of Axis 2 (Rows)
NAXIS3  =              1 / # of Frames
BSCALE  =              1 / Scaling Factor (Default=1)
BZERO   =              0 / Offset Factor (Default=0)
DATE    = '06/07/2005'     / Date Format is dd/mm/yyyy
TIME    = '20:16:17.000'     / Time at Start of Exposure, 24 Hour Format
N_PARAM =             80 / Number of Parameters
PARAM1  =          -30.0 / CCD Temperature
PARAM2  =           27.5 / Backplate Temperature
PARAM3  =            0.1 / CCD Chamber Pressure
PARAM4  =            0.0 / Spare 3
PARAM5  =            0.0 / Spare 4
PARAM6  =            0.0 / Spare 5
```

```
PARAM7  =            0.0 / Spare 6
PARAM8  =            0.0 / Spare 7
PARAM9  =            0.0 / Shutter Status
PARAM10 =            0.0 / XIRQA Status
PARAM11 =            0.0 / Spare 10
PARAM12 =            0.0 / Spare 11
PARAM13 =            0.0 / Spare 12
PARAM14 =            0.0 / Spare 13
PARAM15 =            0.0 / Spare 14
PARAM16 =            0.0 / Spare 15
PARAM17 =            0.0 / Serial Origin
PARAM18 =         1024.0 / Serial Length
PARAM19 =            1.0 / Serial Binning
PARAM20 =            0.0 / Serial Post Scan
PARAM21 =            0.0 / Parallel Origin
PARAM22 =         1024.0 / Parallel Length
PARAM23 =            1.0 / Parallel Binning
PARAM24 =            1.0 / Parallel Post Scan
PARAM25 =           30.0 / Exposure Time (ms)
PARAM26 =            0.0 / Continuous Clear Disable
PARAM27 =            1.0 / DSI Sample Time
PARAM28 =            0.0 / Analog Attenuation
PARAM29 =         2128.0 / Port 1 ADC Offset
PARAM30 =         2140.0 / Port 2 ADC Offset
PARAM31 =         2081.0 / Port 3 ADC Offset
PARAM32 =         2125.0 / Port 4 ADC Offset
PARAM33 =           10.0 / TDI Delay
PARAM34 =            0.0 / not used
PARAM35 =            0.0 / not used
PARAM36 =            0.0 / not used
PARAM37 =            0.0 / not used
PARAM38 =            0.0 / CCD Attenuation
PARAM39 =            1.0 / Number of Frames
PARAM40 =            0.0 / Spare 23
PARAM41 =            0.0 / Spare 24
PARAM42 =            0.0 / Spare 25
PARAM43 =            0.0 / Spare 26
PARAM44 =            0.0 / Spare 27
PARAM45 =            0.0 / not used
PARAM46 =            0.0 / not used
PARAM47 =            0.0 / not used
PARAM48 =            0.0 / not used
PARAM49 =          804.0 / Instrument Model
PARAM50 =          213.0 / Instrument SN
PARAM51 =            0.0 / Hardware Revision
PARAM52 =            0.0 / Serial Phasing
PARAM53 =            1.0 / Serial Split
PARAM54 =         1024.0 / Serial Size
PARAM55 =            0.0 / Parallel Phasing
PARAM56 =            1.0 / Parallel Split
PARAM57 =         1024.0 / Parallel Size
PARAM58 =          250.0 / Parallel Shift Delay
PARAM59 =            3.0 / Number of Ports
PARAM60 =           10.0 / Shutter Close Delay
PARAM61 =           67.0 / CCD Temp. Setpoint Offset
PARAM62 =            0.0 / not used
PARAM63 =         2430.0 / CCD Temp. Setpoint
PARAM64 =           16.0 / Data Word Size
PARAM65 =            0.0 / Spare 16
PARAM66 =            0.0 / Port Select
PARAM67 =            0.0 / not used
PARAM68 =            0.0 / Spare 19
```

```
PARAM69 =           0.0 / Spare 20
PARAM70 =           0.0 / Spare 21
PARAM71 =           0.0 / Spare 22
PARAM72 =           0.0 / Spare 23
PARAM73 =           0.0 / Spare 24
PARAM74 =           3.0 / Acquisition mode
PARAM75 =           0.0 / Spare 26
PARAM76 =           0.0 / Spare 27
PARAM77 =           0.0 / Spare 28
PARAM78 =           0.0 / Spare 29
PARAM79 =           0.0 / Spare 30
PARAM80 =           0.0 / Spare 31
```

- End -