TRIPOL Set-up and Observing Manual
— How to observe with TRIPOL? —

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1 Introduction

Triple Range Imager and Polarimeter (hereafter, TRIPOL) is an astronomical instrument designed and developed by Prof. Sato Shuji at Nagoya University and his group members. It is a small, light-weight, and versatile instrument for small aperture telescopes.

This document describes (1) how to install TRIPOL, (2) how to set up TRIPOL, and (3) how to observe with TRIPOL.

2 Hardware Installation of TRIPOL

TRIPOL consists of following components:

- 3 SBIG ST-9XEI CCD cameras,
- optics (beam splitters),
- polarizer and wave-plate,
- a PC,
- wave-plate rotator controller,
- cables (USB, network, power),
- AC adapters.

The structure of TRIPOL system is shown in Fig. 1. Fig. 2 shows the optical components in the main body of TRIPOL. We need to (1) connect each component via cables, and (2) plug power-plugs.

For the observation using 1-m telescope at Lulin, the instrument has to be attached to the telescope. Fig. 3 is a photo of TRIPOL attached to 1-m telescope in June 2011. A control PC and AC adapters have to be fixed, Fig. 4 shows a way we fixed these on the side of the telescope in June 2011.

3 Software set-up of TRIPOL

To prepare for the observation, we need to do following steps.

1. Switch on the power of 3 CCD cameras.
2. Switch on the power of the control PC.
3. Set up the network configuration of your PC using DHCP.
4. Log in to the control PC using SSH.
   - `% ssh -X -l observer 192.168.11.90`
   - About the password, please ask Daisuke.
5. Start the server program on the control PC.

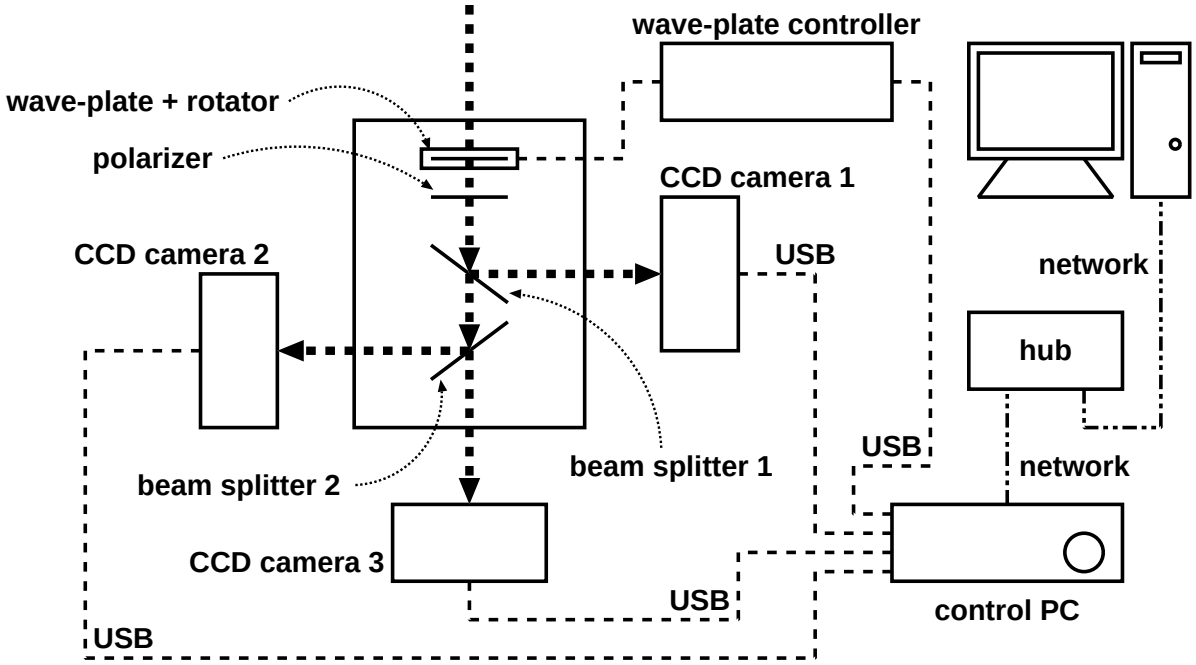

Figure 1: The structure of TRIPOL system.

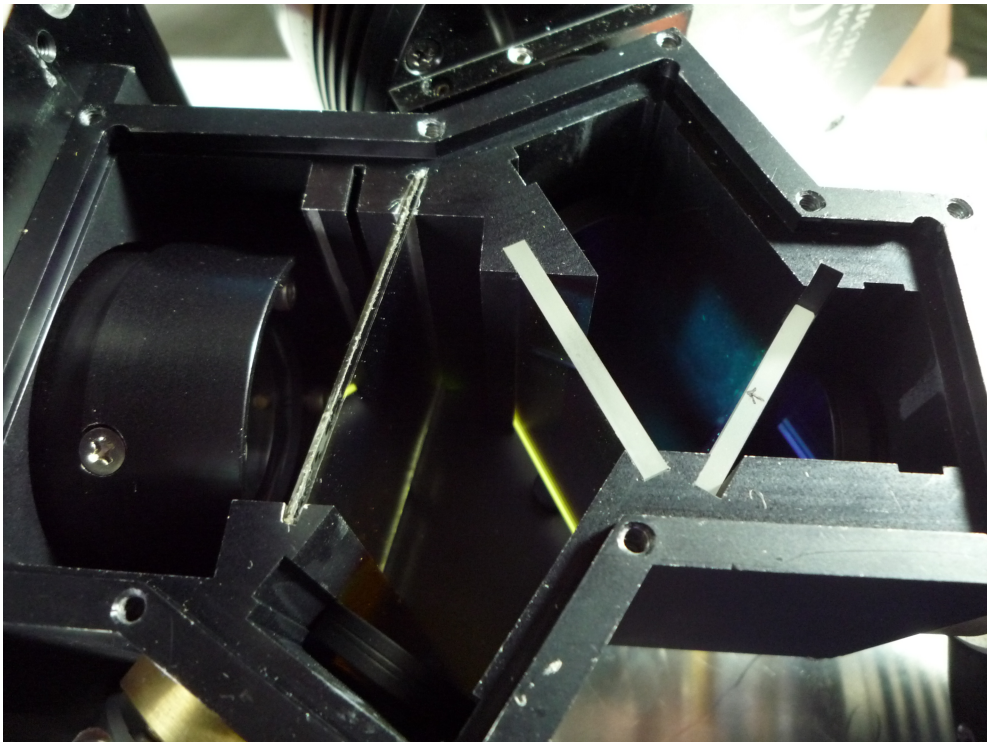

Figure 2: Optical devices in TRIPOL. The photo was taken by Tse-Chuan.

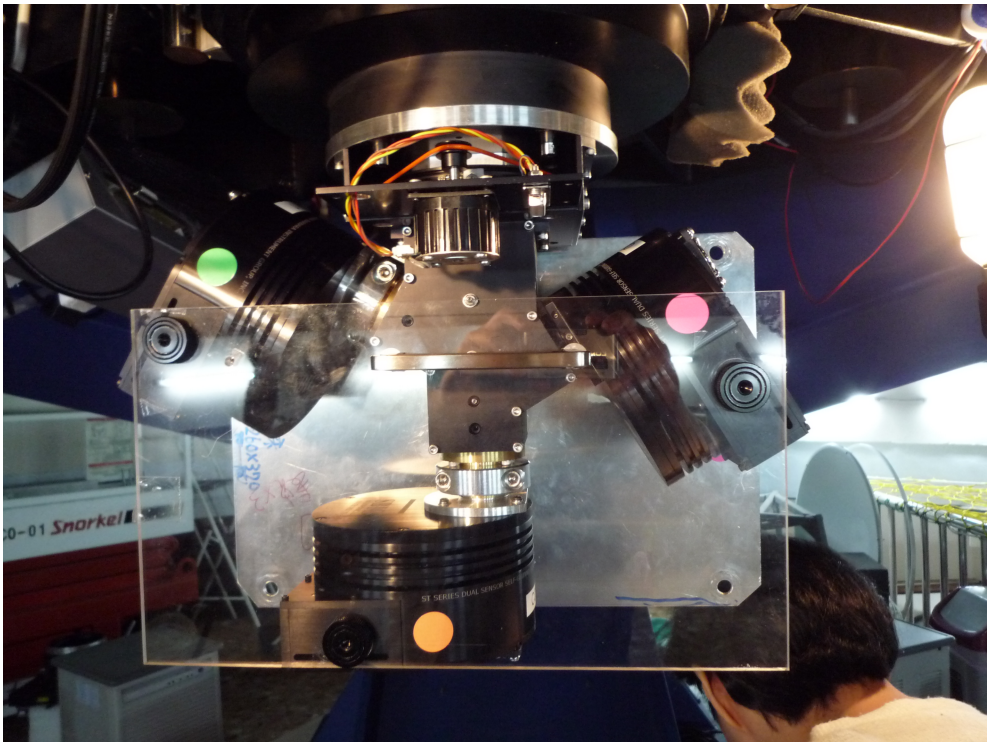

Figure 3: TRIPOL attached to 1-m telescope at Lulin. The photo was taken by Tse-Chuan.

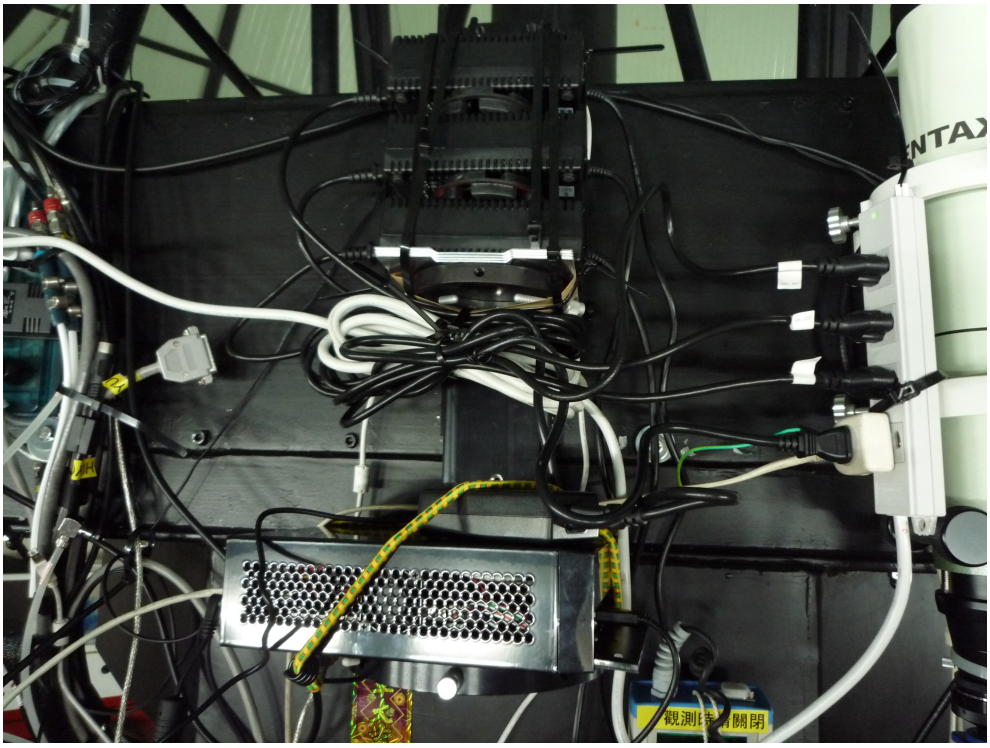

Figure 4: TRIPOL control PC and AC adapters on the side of 1-m telescope. The photo was taken by Tse-Chuan.

- `% start_ccd`

6. Start SAOimage DS9 program.
   - `% start_ds9`
7. Set the CCD cooling temperature.
   - `% set_temp -10`
8. Check the current CCD cooling temperature.
   - `% print_temp`
   - or `% print_temp -s`
   - An example of the output of "`print_temp -s`" command.

     ```
     % print_temp -s
     g: 26.83 -9.79 1 100%
     r: 28.05 -9.79 1 100%
     i: 27.44 -9.79 1 100%
     ```

   - Format: band, current temperature, target temperature, cooling on/off, and cooling load
9. Prepare "target file".
   - Prepare "target file" and place it at the home directory.
   - An example of "target file".

     ```
     HD154445   2000 17 05 32.24 -00 53 31.7
     Hiltner960 2000 20 23 28.44 +39 20 56.1
     VI_Cyg_12  2000 20 32 40.94 +41 14 26.2
     Beta_UMa   2000 11 01 50.47 +56 22 56.6
     BL_Lac     2000 22 02 43.30 +42 16 40.0
     ```

10. Set the observing site specific information.
    - Check site.def file at `/usr/local/tripol/site.def`.
    - It is currently as follows.

      ```
      observat = 'Lulin' / Observatory Name
      latitude = '+20:28:07' / [deg] Latitude of the Site
      longitud = '120:52:25' / [deg] Longitude of the Site
      height = 2862 / [m] Altitude of the Site
      telesco = 'LOT 1m f8' / Telescope Name
      instrume = 'TRIPOL' / Instrument Name
      ```

    - These information will be added to the FITS file.
11. Other information to add to the FITS file.
    - If you want to add more information in FITS header, you can create a file `template.*` at `/dev/shm`.
    - For example, type following command.

      ```
      % echo "observer = 'Kinoshita Daisuke, Chen Tse-Chuan'" > /dev/shm/template.observer
      ```

4 Observation with TRIPOL

1. Check the sequential number for FITS files to be generated.
   - `% counter_check`
   - An example of the output.

     ```
     % counter_check
     /data/110803/rawdata
     25
     ```

   - Next data to be generated are:
     - `/data/110803/rawdata/g110803_0025.fits`
     - `/data/110803/rawdata/r110803_0025.fits`
     - `/data/110803/rawdata/i110803_0025.fits`
2. Set the focus position of the telescope.
   - `% mfocus 12.345`
   - Then, a file `/dev/shm/template.focus` is created.

     ```
     % ls -l /dev/shm/template.focus
     -rw-r--r-- 1 observer observer 23 2011-08-03 16:59 /dev/shm/template.focus
     % cat /dev/shm/template.focus
     focus = 12.345 / focus
     ```

   - Later on, the focus value will be recorded in the data we obtain.
   - If you want to stop recording focus value, then type following command.

     ```
     % mfocus clear
     ```
3. Taking quick-look image without rotating wave-plate.
   - `% TL 6 1`
   - Above command will take 1-sec test exposure, and show the image on SAOimage DS9 after the data acquisition, but does not record the data on the harddisk.
   - Usage:

     ```
     % TL
     usage: TL mode exptime(sec) [object_name] [num]
     ```

   - "mode" is always "6".
4. Taking quick-look image at 4 position angles.
   - `% PTL 1`
   - Above command will take 1-sec test exposure at 4 position angles (0, 45, 22.5, and 67.5 deg), and show the Stokes U and Q.
   - Usage:

     ```
     % PTL
     usage: PTL exptime(sec)
     ```
5. Taking scientific data with wave-plate rotated.
   - Set target name.

     ```
     % point2 target_20110616.list BL_Lac
     ```

   - Before taking image, we need to type "point2" command. Then, the coordinate of the target (RA, Dec) will be recorded in the FITS file.
   - Usage of "point2":

     ```
     % point2
     usage: point2 object_list_file object_name
            point2 clear
     ```

- Start the exposure.

  ```
  % PLo 6 15 BL_Lac 8
  ```

- Above command will take 8 sets of 15-sec exposures. Thus, 96 FITS files (4 positions × 8 sets × 3 cameras) are created in total.
- Usage of "PLo":

  ```
  % PLo
  usage: PLo mode exptime(sec) [object_name] [num]
  ```

6. Taking scientific data without wave-plate rotated.
   - `% Lo 6 30`
   - Above example takes a single 30-sec exposure.
   - Usage of "Lo":

     ```
     % Lo
     usage: Lo mode exptime(sec) [object_name] [num]
     ```

7. Taking dark frames.
   - `% dark 15 30 60 180`
   - Above example will take dark frames of 15-sec, 30-sec, 60-sec, and 180-sec. 10 FITS files will be taken for each exposure time.
8. Taking twilight flatfield.
   - `% twflat -p 10`
   - Above example will take 10 sets of twilight flatfield data with the wave-plate rotated.
   - The exposure time is fixed to 5-sec.
9. How to stop the exposure at the middle of the series of data acqusition?
   - `% xstop`
10. How to shutdown TRIPOL system?
    - Stop the cooling of the CCD cameras.

      ```
      % set_temp 99
      ```

    - Switch off the control PC. (You do not need to type "halt" or "shutdown -h now" command as the root, but you can just push the power switch button of the PC.)
    - Switch off the CCD cameras.

5 Some more information

- The data produced by TRIPOL are stored at the directory `/data/YYMMDD/rawdata` on the control PC. YY, MM, DD are year, month, and day of the observing night.
- The data can be downloaded using `scp` command. Please do not delete original data on the control PC.
- The user interface of TRIPOL system is shown in Fig. 5. We type commands on a terminal, and obtained images are shown on SAOimage DS9.
- Files such as `template.focus`, `template.wpr`, and `template.point` are on the RAM disk (`/dev/shm`), and those files are disappeared when the PC is switched off.
- Data acquisition commands are based on a set of commands developed for IRSF/SIRIUS. If you want to know more about commands like `PLo`, `TL`, and `point2`, then you need to go through the observing manual of "SIRIUS".

- IRSF/SIRIUS Observing Manual:
  `http://www.kusastro.kyoto-u.ac.jp/~nagata/Irsf/IRSFmanual.htm`
- SIRPOL related documents:
  `http://optik2.mtk.nao.ac.jp/~kandori/SIRPOL.html`

- A sample of the header part of a FITS file generated by TRIPOL is shown in Table 1.
- About the packing of the instrument, please contact to Chen Tse-Chuan for details.

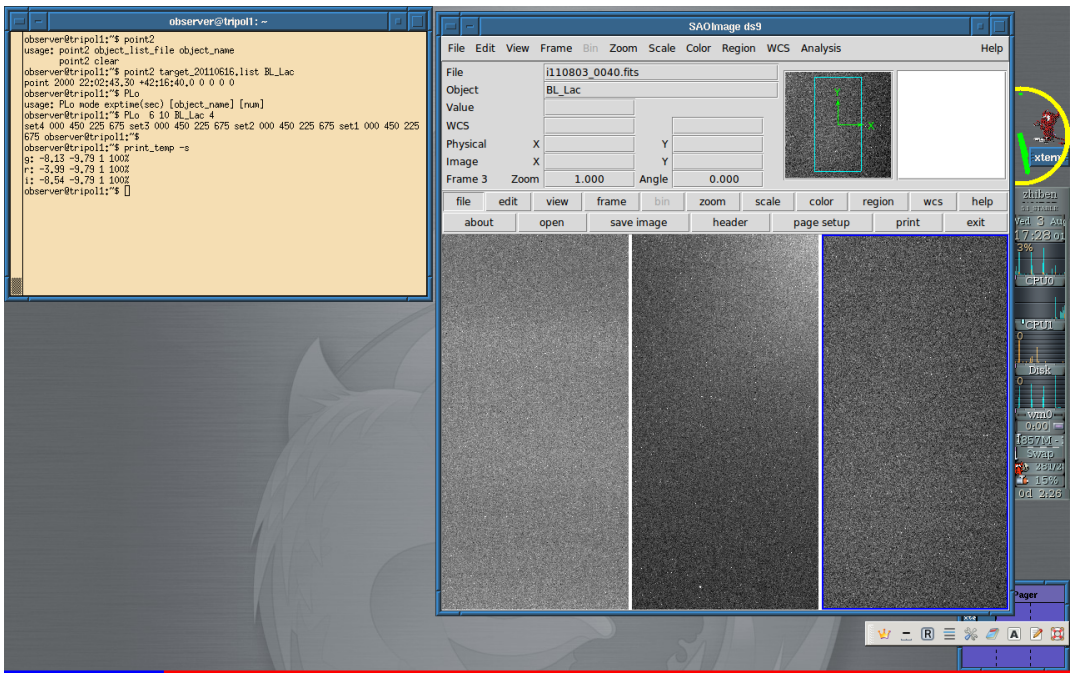

Figure 5: The user interface of TRIPOL.

```
SIMPLE  =                    T / file does conform to FITS standard
BITPIX  =                   16 / number of bits per data pixel
NAXIS   =                    2 / number of data axes
NAXIS1  =                  512 / length of data axis 1
NAXIS2  =                  512 / length of data axis 2
EXTEND  =                    T / FITS dataset may contain extensions
COMMENT   FITS (Flexible Image Transport System) format is defined in 'Astronomy
COMMENT   and Astrophysics', volume 376, page 359; bibcode: 2001A&A...376..359H
BZERO   =                32768 / offset data range to that of unsigned short
BSCALE  =                    1 / default scaling factor
EXPOS   =                 5.00 / [sec] exposure time
XWIDTH  =                  512 / [pixel] image width
YHEIGHT =                  512 / [pixel] image height
XORG    =                    1 / [pixel] image origin X
YORG    =                    1 / [pixel] image origin Y
XBIN    =                    1 / [pixel] X binning
YBIN    =                    1 / [pixel] Y binning
CCDMODE =                  0x0 / ccd readout mode
SHUTTER =                    1 / shutter command 1:open, 2:close
CCD_TEMP=                -9.79 / [degC] ccd temperature
CCD_COOL=                  154 / ccd cooling power, 0 to 255
CAMERA  = 'SBIG ST-9 3 CCD Camera' / camera model
CAM_NO  = '91005855'             / camera serial number
XPIXSZ  =                20.00 / [um] pixel width
YPIXSZ  =                20.00 / [um] pixel height
EGAIN   =                 1.83 / [e-/ADU] typical conversion factor
EXPDATE = '2011-06-17'           / yyyy-mm-dd, local date on ccd controller
EXPSTART= '00:26:01.413'         / hh:mm:ss, exposure start time on controller
EXPEND  = '00:26:06.807'         / hh:mm:ss, exposure  end  time on controller
READSTAR= '00:26:06.807'         / hh:mm:ss, readout start time on controller
READEND = '00:26:07.885'         / hh:mm:ss, readout  end  time on controller
HISTORY  Copy of image g110616_0050.fits rotated 90 degrees
IMROT   = '-r 90   '             / imrot option
OBSERVAT= 'Lulin   '             / Observatory Name
LATITUDE= '+20:28:07'            / [deg] Latitude of the Site
LONGITUD= '120:52:25'            / [deg] Longitude of the Site
HEIGHT  =                 2862 / [m] Altitude of the Site
TELESCO = 'LOT 1m f8'            / Telescope Name
INSTRUME= 'TRIPOL  '             / Instrument Name
OBJECT  = 'VI_Cyg_12'            / Object Name
DATE    = '2011-06-16T16:26:00' / YYYY-mm-ddThh:mm:ss UT
DATE_UTC= '2011-06-16'           / YYYY-mm-dd
TIME_UTC= '16:26:00.824'         / hh:mm:ss
DATE_LT = '2011-06-17'           / YYYY-mm-dd
TIME_LT = '00:26:00.824'         / hh:mm:ss
FOCUS   =               33.289 / focus
EPOCH   = '2000    '             / epoch
RA      = '20:32:40.94'          / hh:mm:ss.s RA (pointing base)
DEC     = '+41:14:26.2'          / dd:mm:ss.s Dec (pointing base)
RA_OFF  =                    0 / [arcsec] Ra offset
DEC_OFF =                    0 / [arcsec] DEC offset
POL-AGL1=                 45.0 / [deg] pol rot angle 1
FILTER  = 'g       '             / Filter Name
ACQSTART= '00:26:00.904'         / data acquisition start time on tripol1
ACQEND  = '00:26:07.897'         / data acquisition  end  time on tripol1
END
```

Table 1: A sample FITS header produced by TRIPOL.