Remote Operation of Telescope and Camera

Introduction to remote observations with Mees

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University of Rochester

Remote operation of the telescope and camera

Introduction to conducting remote observations with Mees

Software:

- The Sky X, or Stellarium
- Camera plug-in on The Sky X

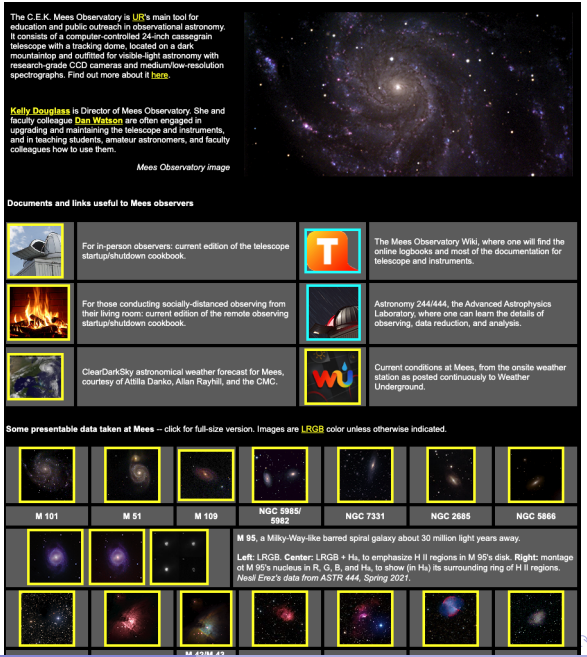
M51, LRGB. L is from Palomar (200-inch Hale telescope); color from Mees

Telescope operation

On the Mees website, you will find system start-up/shutdown recipes for both in-person and remote observations.

- The remote-observation recipe includes basic focusing, guide-star acquisition, and autoguiding instructions.

The following is just commentary on, and supplement to, the recipes. The real lesson for today is in the start-up/shutdown recipes.

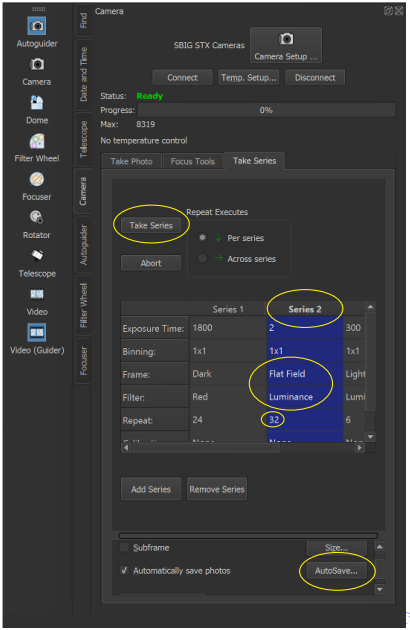


1. Calibration

Make sure that you can find the dark and bias masters for the camera that you will use. They should be on the workstation in 203H, in the D drive.

Plan to take flat fields in every filter and binning that you will use.

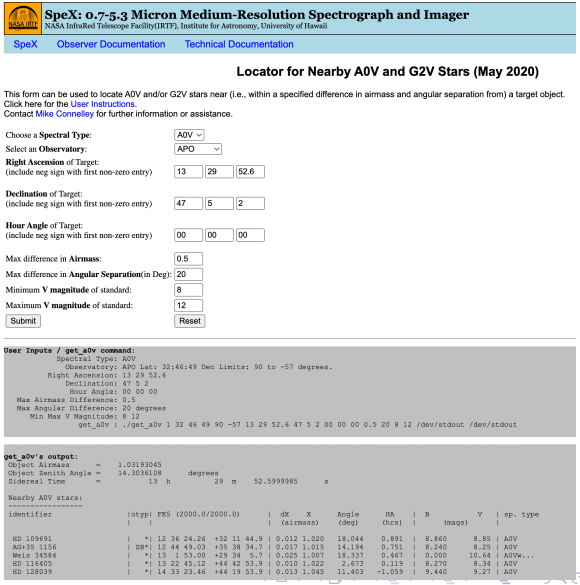
- At least 36 frames each.
- Exposure times such that about half-full wells are produced.
- With the telescope-cap flat-field lamp, this corresponds to an exposure time of 0.5–2 s in the broadband filters and 5–60 times this in the narrowband filters. **See the last page of the remote observing recipe for recommended exposure times for each filter.**



1. Calibration

A0V and G2V flux standard stars can be found close to your target by using the IRTF locator, which comes up automatically on the TCS computer's browser.

- Mees is not on the list of observatory choices, so pick the northernmost one, Apache Point (APO).
- Get 2–3 in the 8–12 mag range: not too bright (nonlinearities), not too dim (S/N).
- Fitting in the magnitude range is more important than being really close to the target, as long as your target and standard observations overlap in airmass.



SpeX: 0.7-5.3 Micron Medium-Resolution Spectrograph and Imager
NASA InfraRed Telescope Facility(IRTF), Institute for Astronomy, University of Hawaii

SpeX | Observer Documentation | Technical Documentation

Locator for Nearby A0V and G2V Stars (May 2020)

This form can be used to locate A0V and/or G2V stars near (i.e., within a specified difference in airmass and angular separation from) a target object.
Click here for the User Instructions.
Contact Mike Connelley for further information or assistance.

Choose a **Spectral Type**: A0V
Select an **Observatory**: APO
Right Ascension of Target: (include neg sign with first non-zero entry) 13 29 52.6
Declination of Target: (include neg sign with first non-zero entry) 47 5 2
Hour Angle of Target: (include neg sign with first non-zero entry) 00 00 00
Max difference in **Airmass**: 0.5
Max difference in **Angular Separation**(in Deg): 20
Minimum **V magnitude** of standard: 8
Maximum **V magnitude** of standard: 12
Submit Reset

```
User Inputs / get_a0v command:
            Spectral Type: A0V
              Observatory: APO Lat: 32:46:49 Dec Limits: 90 to -57 degrees.
        Right Ascension: 13 29 52.6
            Declination: 47 5 2
              Hour Angle: 00 00 00
  Max Airmass Difference: 0.5
  Max Angular Difference: 20 degrees
     Min Max V Magnitude: 8 12
                get_a0v : ./get_a0v 1 32 46 49 90 -57 13 29 52.6 47 5 2 00 00 00 0.5 20 8 12 /dev/stdout /dev/stdout
```

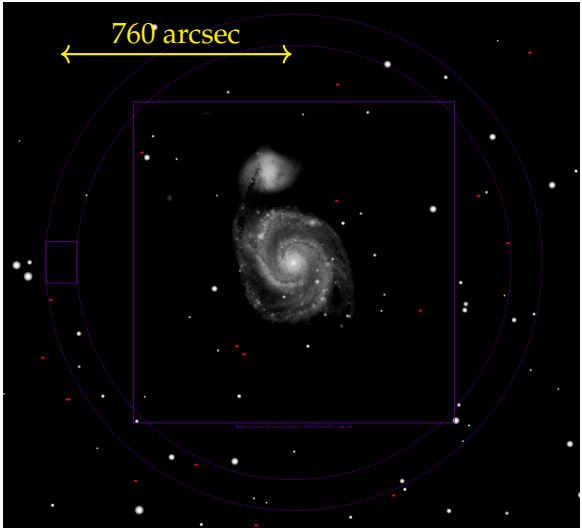
```
get_a0v's output:
 Object Airmass      =     1.03193045
 Object Zenith Angle =    14.3036108       degrees
 Sidereal Time       =            13  h           29  m    52.5999985     s

 Nearby A0V stars:
 -----------------
 identifier                |otyp| FK5 (2000.0/2000.0)      |  dX     X      Angle     HA     |  B                V   | sp. type
                           |    |                          |  (airmass)     (deg)     (hrs)  |        (mags)        |

  HD 109691                |   *| 12 36 24.26  +32 11 44.9 | 0.012 1.020   18.044    0.891  |  8.860       8.85 | A0V
  AG+35 1156               | SB*| 12 44 49.03  +35 38 34.7 | 0.017 1.015   14.194    0.751  |  8.240       8.25 | A0V
  Weis 36586               |   *| 13  1 53.00  +29 34  5.7 | 0.025 1.007   18.337    0.467  |  0.000      10.64 | A0Vw...
  HD 116405                |   *| 13 22 45.12  +44 42 53.9 | 0.010 1.022    2.673    0.119  |  8.270       8.36 | A0V
  HD 128039                |   *| 14 33 23.46  +44 19 53.9 | 0.013 1.045   11.403   -1.059  |  9.440       9.27 | A0V
```

2. Guide star selection and autoguiding

Find your target in TheSkyX to make sure that it will be above about 30° elevation during the time that you want to observe.

Zoom in to the `Telescope` field to see the footprints of the imaging and autoguiding CCDs.

- By default, the autoguider field is due east of the imager.
- For Camera #2, the circles indicate the path through which the autoguider field can be revolved.
- Center to center distance is 760 arcsec in Camera #2 and 700 arcsec in Camera #1.



Camera #2 footprint centered on M 51 in TheSkyX

2. Guide star selection and autoguiding

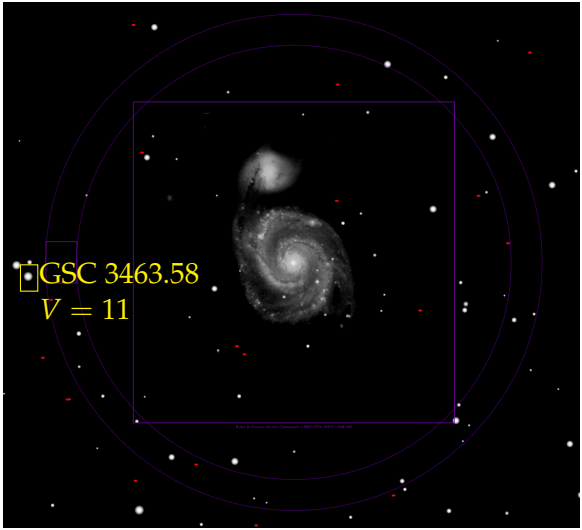
It is important that the guide star be faint enough that it can give a 30–60 s exposure in L without saturating.

- Thus to average the seeing.

It is also important that it be bright enough to give good S/N in a 30–60 s exposure.

- Best to have several autoguiding corrections within the usual 5–10 min imager exposure.

Good results with $V = 10 - 17$. The brighter ones *within this range* often give more robust autoguiding.



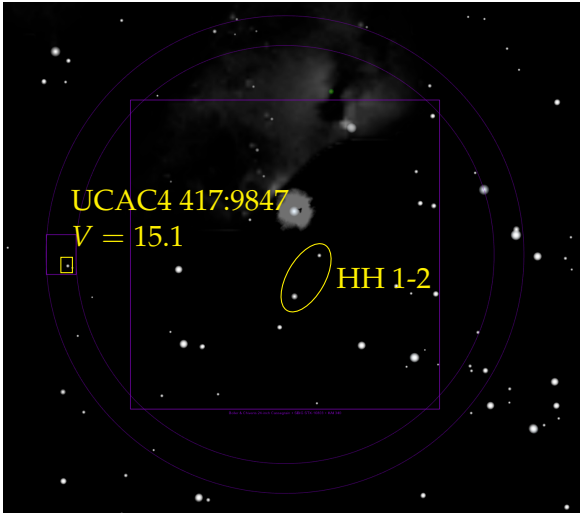
Camera #2 footprint centered on M 51 in TheSkyX

2. Guide star selection and autoguiding

As mentioned, the autoguider is usually due east of the imager.

- Always, for Camera #1, which is used without the rotator.

There will usually be a suitably-bright guide star close enough that an acceptably-small rectilinear offset of the target from the imager-field center gets the star on the autoguider.



Camera #2 footprint centered on HH 1–2 in TheSkyX

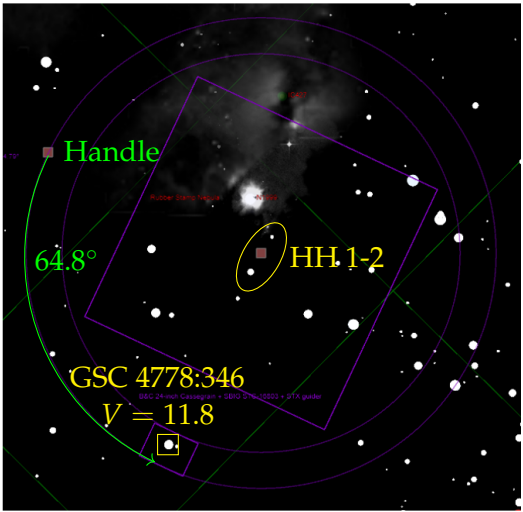
2. Guide star selection and autoguiding

But sometimes — especially for Galactic star formation regions, large targets, or not-so-great observing conditions — there might not be a good combination of offset and guide star.

That is what Camera #2's **instrument rotator** is for.

In TheSkyX on the TCS, you can click on the autoguider footprint and drag it by its handle along its enclosing circle. The rotator will twist the camera accordingly.

You will have to calibrate the autoguider in its new orientation. This is **not difficult**, but it takes 15–20 minutes that you would probably rather spend taking data.

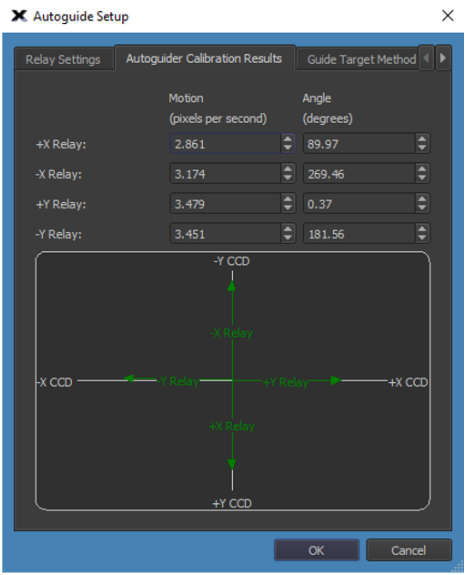


Camera #2 footprint centered on HH 1–2 in TheSkyX

2. Guide star selection and autoguiding

To calibrate the autoguider (**after rotation**):

1. Steer a relatively isolated, not too faint, star into the center of the autoguider field.
2. In `Autoguider > Autoguide > Calibrate`, make sure `Calibrate using PulseGuide` is chosen, along with 30 second calibration times.
3. Click OK and watch the images come out as the telescope is stepped around NSEW.
4. View successful calibration results in `Autoguider > Autoguide > Setup...> Autoguider Calibration Results`, where you can also restore a previous calibration by typing in the values for motion and angle.



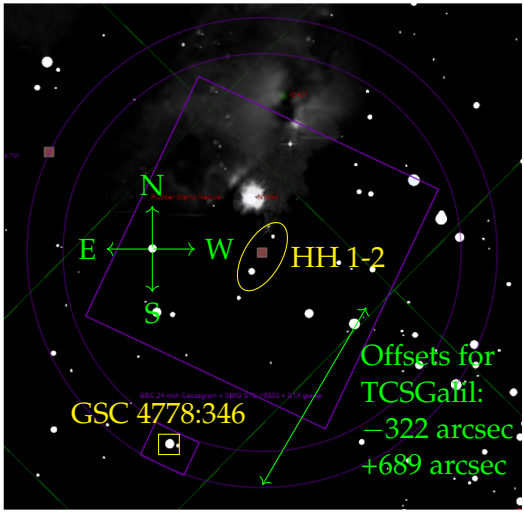
Example autoguider calibration, with the field due east of the imager as usual.

2. Guide star selection and autoguiding

The imager and autoguider are fixed with respect to each other, so the field of the imager rotates as well.

But the telescope knows nothing of this, which is why you have to recalibrate the autoguider. In addition,

- Virtual hand-paddle buttons still move the telescope NSEW, so stars do not move along the CCD's rows or columns when a given button is pushed.
- CenterMe will not give correct offsets when the main imager is rotated.
- The offset for moving the guide star from the imager center to the autoguider center now has a N-S component as well as E-W.

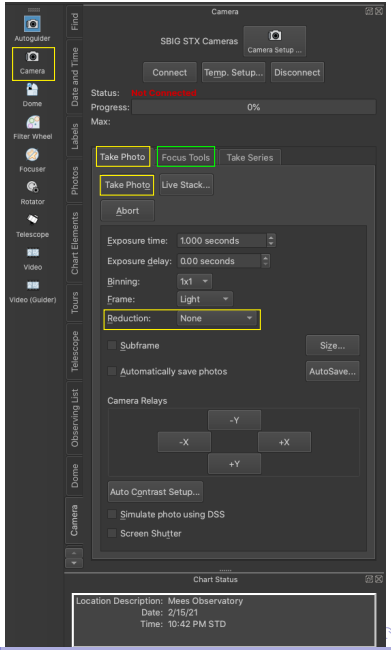


Camera #2 footprint centered on HH 1–2 in TheSkyX

3. Taking data

You will take data with **no reduction**, meaning that you will be correcting for dark current, bias, and flat field later.

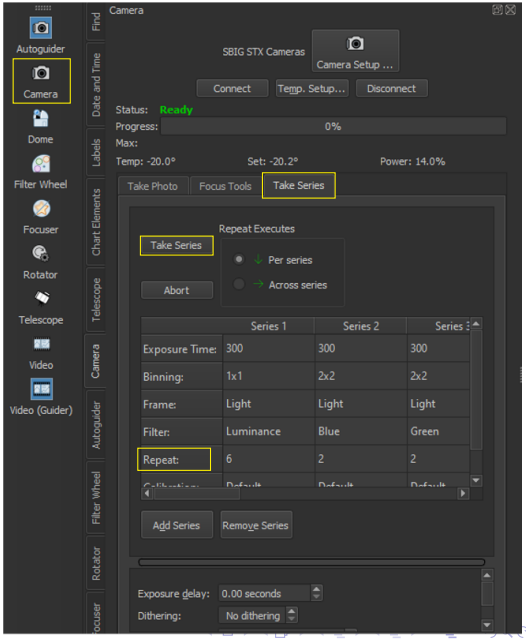
- The main tools are in the `Camera` tab of TheSkyX.
- To take individual images — during setup or star centering, for example — use the `Take Photo` tab and its tools.
- `Take Photo` uses whichever filter is already in the beam. Change it on the `Filter Wheel` tab.
- `Focus Tools` indeed has useful tools for focusing, as described in the Remote Observing Recipe.



3. Taking data

Most of your data will be taken with `Camera`'s `Take Series` tab, which can take long sequences of images of a given object in several filters, binnings, and exposure times.

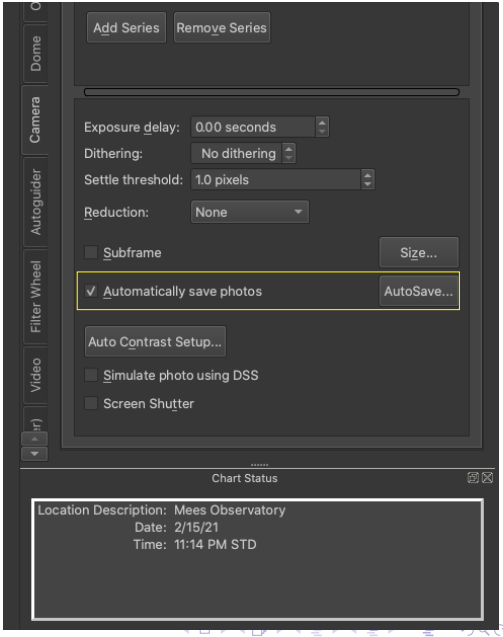
- You will usually see `Take Series` set up for seven series, one for each filter.
  - Tab between elements of the table to change the values.
  - Select the filters that you want to use by entering how many frames you want in `Repeat` for those filters, and zero for others.



4. Saving your data automatically

All of the `Camera` tabs offer an `Automatically save photos` check box, which you should make sure is checked when you begin taking data in earnest.

- You will be prompted to do this if it is not checked and you try to take images in the `Take Series` tab.
- Enter the data file name setup by clicking on the `Autosave...` button.



4. Saving your data automatically

- Make sure that you create and pick your own data directory under `Desktop > Data 2026`.
- The `advanced` version of `Autosave Setup` contains a template construction kit for autogenerated file names.
- It is the most useful to relate the file name prefix to your science target.
  - If you acquire the guide star as in the startup recipe, the `:t` tag will put in the guide star's name, which is also useful.
- `fits`, not `fit` or `FIT`, is the best file name extension to use for data on its way to CCDStack.