Andor camera and mirror alignment quick info

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Description

A new camera has been mounted on the NAOMI optical instead of AG7. The camera has is made by Andor, model Ixon DU-897. It has 512x512 pixels and is electron multiplying type (EMCCD). It can produce full frame images at more than 30 Hz and even much faster than that with smaller readout windows.

The camera is located close to the previous position of AG7. In front of it is a pair of negative lenses needed to change the pixel scale to approximately 0.015 arc-seconds, giving the total field of view on-sky of 7.7 arc-seconds. The physical size of pixels is 16 micrometers. The CCD is back-illuminated and has 90 % quantum efficiency over the entire optical range as well 65 % at 850 nm and 35 % at 900 nm.

The camera is connected to a Linux PC which sits under the optical bench next to OASIS at the same place as previously AG7 controller and power supply. *(note: this PC is going to be replaced by a machine which allows installation of more RAM. Also, a new cable will be purchased and the PC will be finally moved to the electronics room in GRACE)*. The PC's name is *andorpc* and can be logged into using whtobs account. Normally this shouldn't be necessary, though.

The cooling of this camera is thermoelectric. With an additional water cooling it can cool down to -100 degrees C. Currently this is not implemented and the camera is cooled down -40 degrees C.

The camera has a mechanical shutter so dark exposures are possible without using any external shutter.

Usage

Deformable mirror flattening

The basic function of the camera is to be used for mirror flattening for observations with OASIS. Its main advantage over AG7 is much faster framing speed in the mirroralign application. The fastest that has been measured was 30 Hz. As this is quite close to the highest DM update frequency that can be achieved it would be necessary to properly analyse if flattening can be performed without the danger of the exposures and mirror movement going out of sync. Successful mirror flattening has been done with the framing frequencies of about 20 Hz..

Apart from the speed, the camera has also better noise properties than AG7 because it is cooled.

Lucky imaging

The EMCCDs are especially suited for lucky imaging observations because they allow co-addition of many short exposure images without introducing excessive readout noise. The idea of using lucky imaging in conjunction with adaptive optics has been proven successful with LuckyCam on the Palomar 5 m telescope and with Fastcam on the WHT.. Ideally there should be more good quality images when using lucky imaging together with the AO system so the observing efficiency should

improve. Apart from the hardware also proper software is required to select the lucky images which will be added together. Initially we plan to use Registax to verify if the lucky imaging works.

Adaptive optics characterisation

With the camera capable of framing at several 100 Hz it becomes possible to use it for characterisation of the adaptive optics system since each update of the DM and tip-tilt mirrors should be visible immediately. This will surely be a very valuable tool for the upgrade of the AO system.

Operating the Andor camera with NAOMI for mirror flattening

The differences from the operation with AG7 are very small from the user's point of view. Due to the obsolete version of Python used on the lpss42 computer for NAOMI software all recent developments have been done with a newer version of Python (major version number is 2.4 which is still old in the year 2010). The new version of *mirroralign* is installed now both on lpss42 and sextans and it runs locally on both machines.

Mirror flattening

The mirror flattening application can be started in any the following ways from the lpss42 naomi or sextans whtobs (when in GLAS mode and after obssys) account:

- From the terminal:

    - Flattening with the Andor camera: `mirroralign-andor`

    - Flattening with the INGRID camera: `mirroralign-ingrid` or simply `mirroralign`

- From TopGui

    - Flattening with the Andor camera: select camera AG7 from the selector box. Note the GUI hasn't been changed to show Andor camera as an option.

    - Flattening with the INGRID camera: select camera INGRID from the selector box.

There are some changes when mirroralign is used with the Andor camera. Apart from those which are also valid for INGRID there is also (see Fig. 1 for reference):

- It is possible to set the CCD temperature from the GUI (1)

- The actual temperature is displayed and updated periodically (2)

- It is possible to set the EMCCD gain in the range of 2 to 300 (3).

- The "Subtract background" value has been set to 300 (4). It is important to adjust this value if the pixel values on the dark image deviate from 0 by more than few tens of counts or if they are negative.

- Several parameters have been preset specifically for the Andor camera:

    - Exposure time to 0.035 s (5). .

    - Temperature demand to -40 degrees.

    - Gain index to 20

- Tip-tilt to 48 nm/subaperture (6).
- Piston to 177 nm (7).

These values may change in the future to further optimise the flattening performance and should not be taken as fixed.

Not much has changed with regard to the flattening with INGRID, except that:

- the little third window showing the graph of the FWHM is not present anymore
- the merit function is being calculated also when the application is just displaying the image (8).

The value of the calibration lamp iris can be around -150 for exposure time of 0.035 seconds or 0 for exposure time of 0.015 seconds. This value depends also on the dichroic used so it is essential to observe the maximum values at the GUI. They shall not exceed 3000 counts even when the deformable mirror is fully phased and optimised.
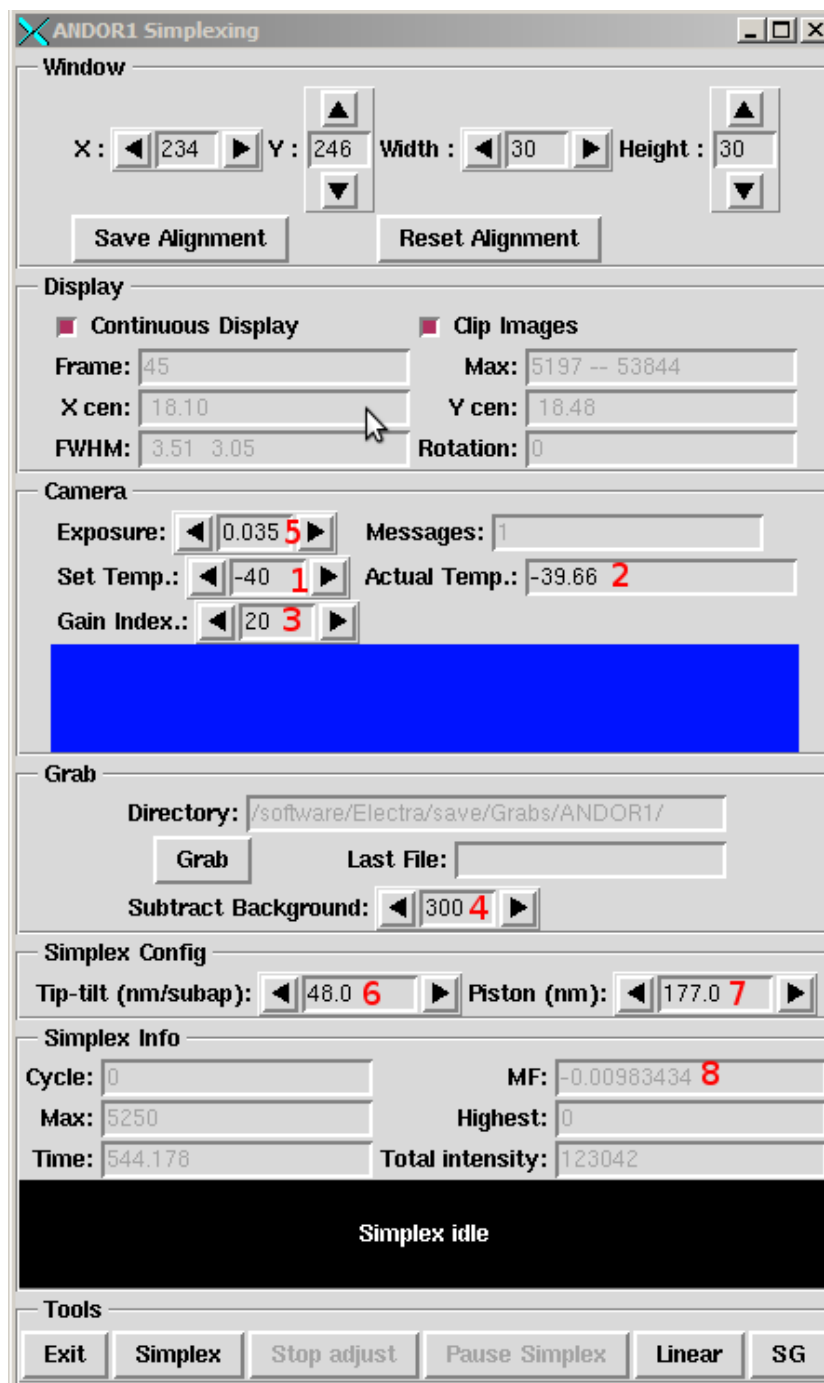
Fig. 1: Appearance of the mirroralign application for Andor camera

Lucky imaging

For lucky imaging it is necessary to take a large number of short exposure images. Under the current philosophy of DAS control this is done in two steps:

```
rspec andor1 1000

run andor1 0.1
```

This will take 1000 images of 0.1 s exposure time. All images are contained in a single FITS file with 1000 extensions. The file size for 1000 full frame images is about 512 MB. With the current configuration of the andorpc this is somehow the limiting number of images, but will be extended with a new host PC.

To get the maximum sensitivity of the camera, it is also necessary to set the EMCCD gain to the maximum. This can be done from the mirroralign GUI. The highest possible value is 300. It is recommended to return the gain to 20 after finishing with the lucky imaging exposures.

Image acquisition

Although the Andor camera's FOV is rather small, it is big enough to find sufficiently bright targets without using the acquisition camera within the WHT pointing error. So it can be used as a first attempt to locate an object instead of using AG3, what should save quite a lot of time.

Possible problems and fixes

All software problems known from before are likely to appear with the new configuration.

- **The AO host (lpss42 or sextans) computer misbehaving:** this can be due to various reasons, such as losing one of the NFS disks, being rebooted or having a failure of the GLAS software. First attempt should always be GlasRestart on sextans or NaomiRestart on lpss42. **Possible symptoms:** mirroralign would not start with either camera. Try first to run mirroralign-andor from a terminal to see possible error messages.

- **Andor camera not responding**: This will be reflected either from mirroralign GUI where camera related errors will appear or during runs from the ICS machine. Things to check
    - ping andorpc. If it is not responding, try to power-cycle it.
    - If andorpc is alive log in as user whtobs, type obssys, shutdownobssys, startobssys.
    - If the camera still doesn't respond, power-cycle the computer.

- **The deformable mirror not possible to flatten well:** Use first the IR dichroic for spotAlign (or FISBA) and white light flattening. Then switch to the dichroic which is going to be used with OASIS or Andor and do mirroralign from that starting point. Note that since the introduction of the new humidifier this should not happen too often as it possible to use the previous mirror configurations.