NICMASS/COUDE FEED OPERATING MANUAL

Introduction

NICMASS is a 256×256 HgCdTe NICMOS3 array camera on loan from the University of Massachusetts which is being used at Kitt Peak for high-resolution infrared spectroscopy at the Coude Feed. Because this is a visitor instrument being offered for use on a shared- risk basis for Kitt Peak observers, this manual will not attempt to be as comprehensive as the standard instrument manual. There is an on-line description of the instrument available at the URL http://scruffy.phast.umass.edu/Irlab/NICMASS/nicuser.html (there is a bookmark for this URL available from the KPNO home page), so this manual will confine itself to the operation of this instrument at the Coude Feed. This system is supported only at a single camera location (#5) in the coude spectrograph. We presently have experience with only two gratings: B (R ~ 7000) and E (R ~ 44000).

1. Instrument Description

The NICMASS camera consists of a cryostat containing the detector array and filters, and the array controller box containing the electronics to drive the array. Other than the cooled filters, there are no optical elements in the cryostat, so the array is located at the focal plane of the spectrograph camera, much in the manner of optical CCDs. Because of the speed (f/3.6) of camera #5, each pixel in the array views a substantial field, and, even within the H photometric band, thermal background from the spectrograph room reflected from the grating (which is essentially a blackbody) limits the performance of the system.

The instrument is supported on a stand which installs on the same rails used for mounting the CCD Universal Dewar. Unfortunately, the IR array is installed sufficiently deep within the cryostat to preclude use of the fully adjustable mount used with the CCD dewars, so the process of alignment of the NICMASS system is rather crude. Nonetheless, once it is installed, the system is quite mechanically stable so long as it is not bumped.

Operating Configurations

	Low Resolution	High Resolution
Grating	B	E (echelle)
Resolution (2 pix)	7000	44000
Order	1	56/λ
Filters	I,J,H	Custom 1% NB
Collimator	long	short
Camera	5R	5R
Pixel Scale	2.71 arcsec	1.82 arcsec

1.1. The Detector Array

The NICMOS3 HgCdTe array is a 256×256 device with 40 μm pixels. There are separate readout amplifiers for top and bottom halves. As a result, there will appear to be slight differences in the quadrants, although the detector array itself is seamless across the borders. The half of the array used is cosmetically quite good, with the only substantial nonoperative portion being a small artifact on the middle right generally referred to as the "snail".

There are three particular properties of the NICMASS array which are relevant to its use as the Coude Feed:

1. The read noise is approximately 140 e, which is rather high. This had little practical effect when NICMASS was used as a broadband imager, but it does affect the performance in high-resolution spectroscopy with the Echelle grating at wavelengths < 1.5 microns, where the background, even in a 1 hour exposure, is insufficient to limit the noise.
2. The dark current is nonuniform, being largest at the bottom edges of the top and bottom

halves of the array and decreasing upward. This is probably a transient effect in the analog amplifiers.

3. There is a weak "echo" effect, in which a strong source in the lower half of the array will appear at the same position in the upper half of the array.

As a result of these three effects, the camera is set up so that the spectrum lies along the rows of the array, centered near the top of the bottom half (e.g., centered near row 80). This ensures that the spectrum lies in a low dark current region with no possible "echo" effects. Since the spatial extent of the spectrum with the longest decker (#1) is only 40 pixels with grating E and 26 pixels with grating B, this setup is fairly easy to accomplish. The only disadvantage is that the "snail" artifact appears in the far right (short wavelength) portion of the spectrum, effectively decreasing the spectral coverage to 240 pixels. This is a relatively small price to pay for the resultant performance gains of operating in this portion of the array.

NICMASS Detector Summary

Array	256×256 HgCdTe
Pixels	40 μm square
Response	0.9 - 2.55 μm
Gain	38 electrons/ADU
Read Noise	140 electrons
Operating Temperature	77 K
Plate Scale	1.82 arcsec (short collimator)
	2.71 arcsec (long collimator)

2. NICMASS Operation

The NICMASS system is a self-contained unit consisting of the cryostat, electronics, and computer. The computer is a 486-33 PC with dedicated software for operating the array, moving the filters, and writing the data files. At the Coude Feed, the computer is installed in the observing room and connected to the instrument through a permanently installed cable. The operating software is contained within the MS-DOS environment, so observers will have to have some familiarity with this structure. There is a primitive quick-look facility on the PC, but no real analysis is possible. The PC contains an Ethernet card through which the data may be transferred to the Coude Feed workstation for conversion into IRAF images.

The actual operation of the NICMASS system is through a menu which controls functions such as changing filters, setting the integration time, entering title information, and initiating the observation. The user should be warned that this system is not as user-friendly or bulletproof as many of the KPNO "observatory" systems. Nonetheless, it does work fairly reliably if one is careful and provides a unique capability for high-resolution infrared spectroscopy on a very stable platform.

2.1. Setup and Initiation

The initial setup will be performed by the Support Scientists and should be of no concern to the observer. Briefly, the vacuum jacket on the cryostat is evacuated for a couple of hours and the cryostat is then filled with liquid nitrogen. Approximately three hours will be required to achieve equilibrium, although the array itself will be operable within 30 minutes. The system is then installed at the #5 camera position in the spectrograph room. A small power supply is also set up at the camera station next to the NICMASS system. Two cables are then installed: one is a short (1-m) cable from the power supply to the electronics box on NICMASS; the other is the in-place cable from the observing room, which has three connectors (power supply, filter motor, and electronics box). **Under no circumstances should the short length of cable between the electronics box and the cryostat itself be removed!** This cable connects directly to the array and static discharge damage could result if it is removed. Once the cables are attached at this end, the power supply may be turned on; the electronics will enter a closed-loop cycle, as indicated by the colored LEDs on the top of the box.

In the observer's room, the PC, monitor, and keyboard can be set up in a convenient spot and cabled appropriately. The in-place cable from the instrument has two connectors on this end, both of which connect to ports on the back of the PC (labeled "custom NICMASS" and "camera"). One will note an additional port on the back of the PC labeled "Ethernet"; this is for the Blue Ethernet cable, which is connected only for the transfer of data to the Sun workstation.

Before turning on the PC and monitor, check that the "A" drive contains a floppy disk and is locked in. This disk contains the system files and is necessary for the PC to boot up. The PC may be booted up before the NICMASS camera is turned on, but all further steps will require the camera to be powered up.

1. Turn on the PC power switch. The computer will autoboot and should eventually return a message to enter the command 'feed' to load the coude feed microcode. The "c:\" prompt should be displayed.
2. After verifying that the NICMASS camera has been powered up (check for the cycling of the colored LEDs), enter 'feed'. This will load the assembly code specific to operation at the Coude Feed and eventually change to the c:\lab\nicmass\feed directory from which the system is operated.

The use of the word "enter" in this document assumes the command to be followed by a carriage return (<cr>). However, when running the NICMASS system from the menu, the carriage return key must NOT be used!!

3. The contents of the directory may be checked with the command 'dir' (note: 'dir | more' will scroll through a page at a time). Approximately 180 Mb are available for data storage (somewhat over 1300 images). If there is old data you wish to delete, change to the data directory(s) in question and delete the data with 'del*.*'. Be absolutely certain that any data has been backed up before doing this!!
4. From within the c:\lab\nicmass\feed directory, create one or more data directories for your data. Many observers choose names such as n1, n2, etc., for each night's data.
5. From the c:\lab\nicmass\feed directory, enter the command 'menu'. This will bring up the Observing Menu which controls the array. **All commands associated with taking data must be done from within the menu structure. Steps such as creating new data directories or transferring the data to the Sun workstation are done from outside the menu. MENU COMMANDS DO NOT REQUIRE A <CR>!!**.

At this point, the system is ready for optical alignment. However, since this requires operation of the NICMASS camera, the menu operation will be covered first.

2.2. The NICMASS MENU

Entering 'menu' from the c:\lab\nicmass\feed directory brings up the observing menu. Each line on the menu consists of a 'hotkey', which will initiate the function, a description of the function, and the current value for those which involve parameter selection. Selecting an item with the appropriate hotkey will prompt for a new value, which must be entered with the <cr> key (fun, isn't it?). Items which do not involve parameter setting, such as beginning an integration, are initiated immediately by the 'hotkey' (e.g., selecting 'i' immediately begins an integration). Many of the commands are used infrequently, and some are appropriate only for the use of NICMASS as an imager. Some of the important items are:

I Immediately begins an integration

N Set up for more than a single integration, for flatfields or bias frames. For example, if N=20, then 'I' will initiate 20 separate integrations, each of which is stored as a separate image

T Enter the integration time for the next exposure. With the feed microcode, integration times from 0.6 to 6000 sec are permissable.

W Set the filter to the desired filter

D Define the directory in which the data are to be stored. This must be of the form \lab\nicmass\feed\n1\. **The trailing backslash is imperative!** Also note that DOS utilizes a backslash as a directory separator, rather than the UNIX /. If the directory selected does not exist, the data may go anywhere!

P Enter a filename for the data files. Files in the data directory are of the form DDDD_WW.EEE, where DDDD is the filename, WW is the filter, and EEE is the numerical extension. **For proper display using 'R', the filename must be no more than four characters long! Remember that DOS files are limited to eight characters with a three character extension!**

E Set the extension number (e.g., 001) for the data file. Setting this value backwards will cheerfully overwrite old data without warning.

O Enter a title for the observation. This string will appear in the IRAF short header.

R Recall an existing data frame (in the same directory) for quick-look inspection. This command will prompt for the extension number of the data frame and refresh the screen with a miniature display of the image (defaulted 0 to 10000 ADU range) and four scrollable cursors, separated by 64 pixels in the column dimension, which display row plots on the right half of the screen. From within this display,

  X Can be used to either escape from this display, back to the menu (hit 'X' a second time) or to reset the display limits (hit any other key). The system will then prompt for new display limits, *in the order MAX, then MIN.* These must be between -10000 and +10000 ADU.

X Exit menu.

2.3. System Alignment

This manual will assume complete knowledge of the operation of the Coude spectrograph on the part of the user, so that steps such as installing and moving the grating will not be covered in detail. The system alignment involves locating the beam with a bright continuum source, tilting and height adjustment to get the spectrum on the right part of the array, coarse focusing by sliding the dewar stand on the rails, and fine focusing using the spectrograph camera focus control and an emission line source. Most of these functions will be carried out by the support staff. Users may have have to adjust the focus.

1. If desired, one may check for ballpark alignment by installing the Hg lamp in front of the spectrograph slit, rotating the grating to 5460 Å in the appropriate order (m=2 for grating B, m=103 for grating E), and visually checking for the green emission line on the NICMASS dewar window with a white card. This can provide an indication if the dewar is much too high or low.
2. Set the grating to the wavelength to be used for observing and the NICMASS filter to the proper filter (see Appendix III). **Make sure that the grating drive power is OFF, except when actually executing a motion command!** Project the quartz comparison source into the spectrograph, with a 100 micron slit, and the longest decker (#1). Take a 1 sec exposure and look for illumination. It may be necessary to install one or more diffusers in front of the continuum source to prevent saturation of the array.
3. If the illumination can be seen, put in the narrowest decker (#10) to provide a very narrow slit illumination. This can be used for adjustment of the dewar height and tilt, and for crude focusing:

* If the top and bottom of the "spectrum" are very soft, or two parallel spectra (the central obscuration in the out-of-focus image) are seen, adjust the dewar position on the rails by ~ 1mm increments (or smaller) until a reasonably tightly focused spectrum is obtained.
* As mentioned above, the recommended position of the spectrum on the array is near the middle of the "snail" defect, or about row 80. Height adjustment can be done using the four brass thumbscrews on the dewar mount, but one must be careful to move all four the same amount and verify that the dewar is resting on all four; i.e., it does not rock back and forth. The sense of adjustment is that moving the dewar physically up will move the spectrum up (i.e., increasing row numbers) on the array. Keep in mind that the pixels are 40 μm square, so a 1 mm motion will move the spectrum about 25 rows.
* Although it is not necessary to have the spectrum absolutely parallel with the rows (IRAF can deal with this), the quick-look facility in the menu is virtually worthless unless one is quite close to this condition. In addition, the flatness of NICMOS3 arrays across a given pixel is a subject of debate, so alignment of the spectrum with the rows, at least approximately, may be desirable from a scientific point of view. Unfortunately, the quick-look facility can be used only approximately to ascertain whether the spectrum is more or less aligned with the rows (the best check is to move the cursor one row at a time and see how evenly one comes up on the spectrum; if the maximum moves spectrally as one scans spatially, then the spectrum is tilted). The geometry is that raising the right side of the dewar, as viewed from the back, will lower the right side (short wavelength) on the screen display.

Once the height, tilt, and approximate focus are obtained, tighten the nylon screws securing the dewar mount to the rails so it will not move further.
4. Open up the decker to the longest value (#1), turn off the quartz lamp, and turn on the Th-Ar arc source. Keep the slit width at 100 μm. With grating B, there will probably be some arc lines within the free spectral range (about 280 Å), but this is unlikely with grating E; in the latter case, move to a broadband filter so that many orders, some of which will contain arc lines, are falling on the array. It will be necessary to use a longer exposure (20 - 60 sec) to get good S/N on the arc lines. Take several exposures, moving the camera flat (without the central hole) about 0.2 mm in between, using the knob behind the mirror and the dial indicator position readout. Afterwards, examine the images using the fast-look utility to determine which has the narrowest profile. With the 100 μm slit, it should be possible to get most of the line onto a single pixel.

3. Observing

Since the vast majority of high-resolution spectroscopy is for applications such as radial velocity determination, which require extreme stability, most observing runs with NICMASS utilize a single grating/filter setting for the entire night (or observing run). This generally limits the observations to a set of object, flatfield, and bias exposures. Because of the small free spectral range of the array, particularly with grating E, lamp exposures are generally not useful for wavelength calibration, and telluric absorption lines generally are far more useful for that purpose. Based on our experience with this system, a slit width of 300 μm is generally recommended as a compromise between the pixel size and the typical image quality at the Coude Feed. Although this is less than the nominal two pixel resolution, use of a much wider slit may contain the seeing disk sufficiently to affect the quality of the data for accurate radial velocity determination.

3.1. Flatfielding

Flatfielding is necessary to calibrate out the pixel-to-pixel variations in responsivity, and is performed using the quartz lamp. The same grating setting and slit width as were used for the observations should be used. Although the illumination function along the slit may not be identical to that of the sky, the quartz lamp seems to remove most of the variations in a spectrum resulting from pixel responsivity. To avoid possible saturation effects in the array, adjust the quartz lamp or install diffusers to obtain a flux rate of about 1000 ADU/s and take exposures of about 5 sec. We generally recommend at least 10 - 20 separate flatfield exposures to improve S/N and allow removal of an anomalous frame, should one occur.

To remove the dark current and some artifacts, it is necessary to obtain "bias" exposures at the same integration time as the flatfields. These may be obtained just after the flats by turning off the quartz lamp and/or closing the dark slide behind the spectrograph slit. For statistical reasons, an equal number of exposures to the flatfields is recommended.

3.2. Observing

At this point, actual observing is pretty straightforward. This manual will assume that the user is sufficiently familiar with the Coude Feed telescope to carry out the steps of unstowing, entering stars into the caches, and presetting the telescope. Abbreviated checklists are given in Appendix I. One procedural difference from optical observing common to all infrared observing is the requirement to subtract the background and (for NICMASS) the spatially variable array dark current from the data. With NICMASS, this is accomplished by observing each object at two or more spatially separate positions along the spectrograph slit. Subtraction of these images in postprocessing will automatically remove any thermal background within the spectrograph, array dark current, and emission features from the sky such as OH airglow. For standards, at least three positions are recommended to aid in the removal of defects in the spectra resulting from bad or high dark current pixels in the array; this is particularly important if the standards are to be used for wavelength calibration or division for the removal of telluric absorption features.

A recommended procedure for this is to turn up the acquisition/guiding TV gain until the slit can be clearly seen (make sure no bright stars are in the field!), and mark three positions along the slit for the leaky guider cursor. One position should be near the center of the slit, the two others perhaps midway between the middle and ends of the slit. It is important that the spectra be completely separated, but one should avoid being too close to the ends of the slit, as this makes spectral extraction more tricky. Keep in mind that with the large pixels of NICMASS, only 40 rows are illuminated with grating E, so the arrangement suggested above will result in the spectra being separated by only 10 rows (only 7 with grating B). For faint objects requiring long exposures, use of the two outboard positions is sufficient. Make a note of the leaky guider cursor readings corresponding to the desired positions on the slit and use them for guiding during exposures.

The actual integration times will depend on the grating and filter used; a rough guide to some configurations is noted in Appendix III. Conditions such as poor seeing or light clouds will naturally affect these values. A good procedure is to observe a bright standard (which one will want to do for wavelength calibration purposes anyway) and note the signal in ADU/sec for that star. This may then be used as a guide to estimate integration times for fainter stars. We have routinely obtained 3600 sec exposures with NICMASS under conditions of extremely low background (e.g., grating E at 10830 Å). Although the microcode in NICMASS can handle exposures up to 6000 sec, it is probably better from the point of removing systematic effects to do a number of 3600 sec exposures rather than a smaller number of 6000 sec ones.

NOTE: The PC is usually quite dependable, but it is not particularly tolerant of slipups on the part of the observer. In particular, when using the menu, one must continually keep in mind that the functions do NOT require a <cr>. The unwary observer who selects 'D', followed by <cr> will find that she has, in effect, entered a blank line into the data directory parameter, and will become aware of that just after the previous menu has scrolled off the monitor screen. It is a very good idea to make a (handwritten) copy of the menu parameters just in case something like this happens. In addition, hitting a key during an integration will cause the integration to abort and can leave the system in a hung state. If this happens, the only recourse is to reboot the PC (using the red "hard boot" button on the front of the CPU box) and bring the system up again. Fortunately, the menu should have been stored, so it will not be necessary to re-enter all of the observing parameters. Nonetheless, should this occur, it is suggested that a short

(1 or 5 sec) "test" integration be taken just to make sure that all is well. On the other hand, if a very long integration is inadvertantly started, it is best to abort by hitting a key on the PC keyboard.

4. Data Reduction

Reduction of NICMASS data is quite straightforward through the use of the IRAF ’twodspec.apextract’ package (or any other spectroscopic extraction program). This manual will not cover this procedure in detail, but will touch on points specific to NICMASS such as the transfer of the data to the Sun and wavelength calibration.

4.1. Data Transfer to the Sun

The NICMASS images are stored on the PC in the data directory selected from the menu (e.g., \lab\nicmass\feed\n1\). Each image consists of two files, one containing the header information, the other the pixel data. For any sort of analysis other than the built-in quick-look task, the data must be transferred to the Coude Feed Sun workstation (presently Indigo) and then run through a concatenation program (’fitsall.cl’) which combines the two files into a single FITS file for each image. At this point the data may be converted into IRAF images for analysis or written to tape for eventual reduction using another package.

The data transfer process is a bit convoluted, but if the directions below are followed, it seems to work quite well. One tricky point is that the script ’fitsall.cl’ which combines the NICMASS files must be used on Indigo under IRAF, but it is not usually resident on that machine. When possible, the support scientist will attempt to transfer this file from the PC to Indigo on the first night of the NICMASS run. However, if this file cannot be found on Indigo, a working solution is to find the file on the PC (try the \lab\nicmass directory) and copy it into the data directory (e.g., \lab\nicmass\feed\n1). Then, when the data are transferred to Indigo, the ’fitall.cl’ script will be as well.

Before doing the data transfer, the Blue Ethernet cable must be connected to the ’Ethernet’ port on the back of the PC. After transferring the data, we recommend that the cable be disconnected. There is some concern that network-wide messages through the Ethenet could disrupt the normal operation of the PC for data taking, so the conservative approach is to disconnect the cable except when transferring data.

Transferring Data from PC to Sun

1. Connect Blue Ethernet cable to back of PC (’ethernet’ connector).
2. Change to data directory on PC (e.g., \lab\nicmass\n1).
3. Login to Indigo: ’telnet indigo’ (account = ’feed’)
(password = ’96?tears’ [listed on terminal])
4. On Indigo, create and change to intended data directory.
5. Open ftp with ’alt T’; respond to account with ’<cr>’; respond to password with ’alt W’.
6. Enter ’bin’ (binary mode for ftp)
7. Enter ’prompt’ (turns off interactive mode)
8. Enter ’mget *.*’ (gets data)
9. Enter ’bye’ (exit ftp)
10. Enter ’logout’ (logout from Indigo)
11. Disconnect Blue Ethernet cable.

Concatenating PC Data Files to FITS

1. Locate file "fitsall.cl". If not on Indigo, it must be located on PC and ftp'd over.
2. Move file "fitsall.cl" to directory containing the data files copied from PC.
3. Enter 'task fitsall=fitsall.cl' (identifies "fitsall.cl" as an IRAF foreign task)
4. Enter 'fitsall' Program will prompt for number of files and will create files with "fx" basename.
5. The task "fitsit.cl" is similar, but will instead prompt for the first and last image number for doing partial lists.
6. The files "fx001,...." may be converted to IRAF images with 'rfits' in the approv'd manner.

4.2. Data Preparation

If one wishes to reduce the data within IRAF, three basic steps outside of the normal spectral reduction are suggested:

1. Conversion of the FITS files fx... to IRAF images using the 'rfits' task.
2. Trimming the data. Since only about 40 rows are illuminated by the slit, trimming the images to include only the illuminated rows is recommended. This not only makes the data files smaller, but avoids the problems which occur when arithmetic steps such as division (flatfielding) are carried out using images with values near zero.
3. The dispersion axis must be inserted into the header for spectroscopic extraction packages such as 'apall' to be happy. Since the dispersion lies along the row coordinate, the following command will do the trick:

```
hedit *.imh dispaxis "1" add+
```

4.3. Wavelength Calibration

The traditional technique for spectroscopic wavelength calibration is the use of an emission arc lamp to produce a grid of lines of precisely known wavelength for input into an IRAF task such as 'identify'. The Th-Ar lamp at the Coude Feed does produce a grid of well-identified lines into the near-infrared, but the practical use of this with NICMASS is limited due to the small wavelength coverage of the array, particularly with grating E. With a coverage of only 40 Å at 1.6 μm, and even with the 280 Å coverage of grating B, the odds of finding one or more arc lines in a given spectrum are quite small. The same is true of the OH airglow lines, which are generally quite useful for calibration at much lower spectral resolutions.

An effective technique is to use telluric absorption lines in high S/N spectra of early-type stars, which are generally free of intrinsic absorption features. Most of the regions which have been observed with grating E have several telluric features which are well defined at that resolution. Accurate wavelengths for these features may be derived from the *Atlas of the Solar Spectrum in the Infrared from 1850 to 9000 cm^{-1}* (Livingston & Wallace) or from the *Atlas of the Infrared Spectrum of Arcturus* (Hinkle, Wallace, & Livingston). Once the lines are identified in the stellar spectrum, their wavelengths can be entered into a table and used with the IRAF 'identify' routine for wavelength calibration. Use of grating E and the C6 filter at 1.62 μm presents a special case in that there are essentially no telluric lines within the filter bandpass. However, the wavelength can be successfully calibrated using the Fe and Si lines which appear in the spectra of a K-type star. Such a calibration will yield the correct dispersion, but will have a zero-point error from the stellar radial velocity. Fortuitously, a pair of OH airglow lines which fall in this wavelength region can be used to determine this zero-point offset, and the resultant spectra can be shifted appropriately by editing the CRVAL1 field in the image header. Although these lines are quite faint, their detectivity can be enhanced by slicing a long exposure into individual rows (using the IRAF task 'imslice') and then median combining the slices into a one-dimensional spectrum with 'imcomb'.

Appendix I: NICMASS/Coude Feed Checklist

1. Spectrograph Room

* Top off dewar with LN_2, using funnel. Do not bump dewar.
* Verify that the NICMASS power supply is ON and that the LEDs on the electronics box are cycling. If not, push red RESET button on top of electronics box to reinitialize.
* Verify that the proper grating, collimator (short for grating E, long for grating B), and corrector (red) are installed.
* Open/remove covers from collimator mirror, grating, red corrector (both sides), camera, and flat mirror. Be very careful not to bump the camera or flat mirror while removing the covers. We suggest simply placing the covers on these mirrors rather than using the captive screws.
* Check that the lights are out when leaving the spectrograph room.

2. Coude Feed Telescope

* Arrange for the shed and the entrance tube cover to be opened by the 2.1-m telescope operator.
* Turn on the telescope power on the panel to the left of the slit head.
* Remove covers from the slit/decker head, #3 mirror, and light path between #3 mirror and slit. Check that dark slide behind slit is open and that no 2×2 inch filters are in the beam.
* Verify proper slit (300 μm) and decker (#1) settings.
* If bright stars are being observed, place a neutral density filter in front of the acquisition TV.
* In the control room, turn on the DTI-21 leaky memory, the leaky, acquisition TV, and leaky guider interface switches, and the VDU and TV monitors.
* On the telescope control computer, click on the "OPEN/STOW" window and then on the "OPEN" button. You should get a message that the telescope is unstowing and all of the status indicators should be green. Close this window.
* Turn the TV power ON. Check that the ND FILTER is ON and ICCD gain potentiometer is fully CCW, then push the INTENS ON button.

3. NICMASS Computer

* Ensure that the Blue Ethernet cable is not connected to the PC.
* If the PC is not already powered up, turn on the power and wait for the C:\ prompt after the system boots.
* Enter 'feed' to load the Coude Feed microcode.
* Create a data subdirectory within the \lab\nicmass\feed directory.
* Enter 'menu' to bring up the observing menu.
* Set up the proper data directory with the 'D' key (NO <CR>, remember the trailing '\').
* With no star in the field, turn up the TV gain slowly, until the slit is visible. Set up two or three observing positions on the monitor.
* System is now ready for observing.

4. Observing

* Load object into telescope computer from a cache or the terminal. Acquire and set up on the slit.
* We recommend observing objects at two (three for standards) separate locations on the slit for sky subtraction and bad pixel removal.
* Keep good logs, as there is no telescope information included in the image headers.
* Flatfields: use the quartz lamp and the same slit, grating positions as used for observing. Try to get ~ 1000 ADU/s flux and take 10 - 20 separate images at about 5000 ADU. Close dark slide behind slit, turn quartz lamp off, and obtain another 10 - 20 images at the same integration time for bias and dark current removal.

5. End of Night

* Stow the Coude Feed telescope using the "STOW" button in the OPEN/STOW menu. This will take a few minutes.
* Turn off the TV, the interface switches, and the monitors. Leave the DTI-21 leaky unit ON.
* In the slit room, replace the slit assembly cover, the #3 mirror cover, and the beam path cover.
* In the spectrograph room, replace the covers on the grating, collimator, red corrector, and flat and camera mirrors. Gently place the covers for the flat and camera mirrors in place, rather than using the captive screws, to avoid moving these mirrors.
* Leave the NICMASS dewar power ON.
* Top off the NICMASS dewar with LN_2.
* Once the telescope is stowed, turn off the SYSTEM POWER switch in the slit room.
* Inform the 2.1-m telescope operator that you are finished observing so they can close the outside shed.
* If desired, hook up the Blue Ethernet cable to the PC and transfer the data to the Sun using the procedure outlined in the manual. Disconnect the Ethernet cable afterwards.

Appendix II: NICMASS Filters

Command	Filter	λ_1	λ_2
BL	DARK		
HE	1.083 + I blocker	1.080	1.089
JH	1.083 (bad)		
FE	Fe II	1.632	1.648
H2	S(1)	2.110	2.128
C6	CO 6-3	1.629	1.656
HM	mid-H	1.635	1.645
CK	K continuum	2.235	2.295
CO	CO 2-0	2.274	2.320
JJ	J	1.09	1.38
HH	H	1.51	1.79
KS	K’	2.03	2.42

Appendix III: Operating Configurations

Below is listed some information regarding the configurations in which NICMASS has been used. Any use outside of these must be considered *terra incognita* to be explored by the user at their risk. Note in particular that since grating E is blazed in 1st order at 56.29 μm, it will be used in very high orders (30 - 50) and will thus require a narrowband filter for order separation. Only the HE filter (with an NOAO I band blocker in series) and the C6 filters are known to be effectively blocked against long wavelength leakage, which produces additional thermal background limiting the integration time and sensitivity. The high background noted for the CO filter is a consequence of the thermal background at this wavelength and does not indicate a leak; however, the resultant maximum integration time of 8 sec with grating B severely limits its use to bright stars. Grating B is always used in 1st order, so the blocking filter is used to reduce the spectrograph background on the array.

The signal levels are normalized to a 0.0 mag star and are given in ADU/s. These were determined from extracted spectra and thus represent the sum over the rows illuminated by the spectrum. Depending on the seeing and guiding performance, the signal in a given row may be a factor of two or three less.

The wavelengths given below are the actual wavelengths determined from calibrated spectra. **The wavelengths actually entered into the grating setup window will be different!** As a very rough rule of thumb, one must enter a wavelength about 20 Å smaller than that desired for grating E, and 160 Å smaller for grating B. This offset is most probably a result of the array being slightly off-center within the camera 5 assembly. In any case, determination of the proper grating position must be done empirically on a real object with identifiable spectral features.

Grating	Wavelength (μm)	Filter	Background (ADU/s)	Signal (ADU/s; 0 mag)
E	1.0830	HE	< 0.1	35
	1.6210	C6	0.5	120
B	1.210	JJ	7	2500
	1.624	HM	20	
	1.749	HH	22	600
	2.293	CO	1100	