Automatic and GO Wavecals, for CCD and MAMA Spectroscopic Observations

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ABSTRACT

In this report we describe the implementation of automatic and GO wavecals for CCD and MAMA spectroscopic science. Each time the Mode Select Mechanism (grating wheel) is moved to select a new optical element or tilt a grating, the resultant spectrum is projected onto the detector with an error (lack of repeatability) of ~2-6 pixels. In addition, thermal changes in STIS may cause flexure in the optical bench which may cause the projection of the spectrum onto the detector to slowly drift over the course of time. To correct for the spectral zeropoint uncertainty and drift, the ground system will automatically insert short wavecal (line lamp) observations into a series of external observations using a dispersive optical element. The calstis pipeline will process the wavecals along with the science data in order to correct for zeropoint shifts. In addition GOs can insert additional wavecal exposures into their observations if they require particularly high wavelength accuracy.

1. Why are automatic wavecals taken?

Each time the Mode Select Mechanism (MSM or grating wheel) is moved to select a new optical element or tilt a grating, the resultant spectrum is projected onto the detector with an error (lack of repeatability) of ~2-6 pixels. In addition, thermal changes in STIS may cause flexure in the optical bench which may cause the projection of the spectrum onto the detector to slowly drift over the course of time. The expected timescales for such thermal drifts are of the order of 40 - 60 minutes, and will be measuring during a Servicing Mission Orbital Verification test in the spring of 1997.

If an internal calibration lamp exposure (wavecal) is taken near in time to the science exposures and without moving the MSM between the wavecal and the science exposure, then that wavecal exposure can be used, in post-observation data processing, to calibrate the zero point of the wavelength (dispersion) and spatial (cross dispersion) axes in the spectroscopic science data. For STIS, these science-associated wavecal exposures will be automatically taken for the observer. This assures high quality data for the observer and for the HST archive. The wavecal exposures are processed with the science data in the cal-

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stis pipeline; the output calibrated science data will have been corrected for this shifting of the spectrum on the detector (see STIS ISR 95-006 and the STIS Instrument Handbook)

2. When is an automatic wavecal taken?

An automatic wavecal is taken each time a spectroscopic science observation sequence is taken at a new central wavelength setting or with a new grating. An automatic wavecal will be taken immediately preceding the science exposures it is intended for. An additional automatic wavecal will be taken at the end of each science exposure, if 60 minutes have passed since the last auto-wavecal. The time (60 minutes) between wavecal exposures should be a parameter which is easily changed in the system since the appropriate scientific value will be determined in an on-orbit SMOV calibration experiment. There is an indication from ground testing that this time constant will be different for different grating modes of STIS; thus ideally this automatic insertion time should be a grating-dependent parameter. A spectroscopic science observation is defined as an observation of an external target with LAMP=NONE, and OPMODE=ACCUM or TIME-TAG. Note that no automatic wavecals are taken with imaging observations (i.e., when the optical element is a mirror).

3. Can autowavecals be turned off?

An available-but-unsupported parameter, WAVECAL, will exist. The default value of WAVECAL=YES, indicating that automatic wavecals are to be taken. If WAVECAL=NO on any one exposure in a visit, all automatic wavecals will be turned off for all exposures (CCD and MAMA) in the visit.

4. What is an automatic wavecal?

An automatic wavecal is a line lamp exposure which uses either the HITM or LINE (calibration insert mechanism) lamps. Tables defining the allowed configurations for automatic wavecals are provided. The autowavecal tables will be used to define the exposure parameters for the automatic wavecals.

5. How are automatic wavecals generated?

The ground system must generate an automatic wavecal for spectroscopic science exposures. The science exposure is characterized by the APERTURE, GRATING and CENWAVE. The automatic wavecal exposure is characterized by the APERTURE, GRATING, CENWAVE, LAMP, LAMPSETTING, and EXPTIME (exposure time). The ground system maintains an automatic wavecal table for each grating. Table 1 shows the required columns of that table. This table contains in it all the allowed auto and GO wavecal exposures. CCD auto/GO wavecals are always taken as full frame exposures with unbinned pixels; MAMA auto/GO wavecals are always taken as full frame exposures with binned (BINAXIS1=BINAXIS2=2) pixels. Observers should note that these configurations are the only configurations in which automatic/GO wavecals can be taken; if their science is carried out with an alternate slit then the slit wheel will be moved for the wavecal to the wavecal slit and then repositioned to the science slit for the science exposures. The slit wheel repositioning accuracy is very high (0.007 arcseconds, ~60% better than the
peakup accuracy) so there should be no need for concern, special construction of exposure sequences or additional peakups unless extremely high accuracy is needed.

To determine the auto-wavecal exposure setup, the ground system first selects the appropriate autowavecal table for the science observation’s GRATING. The ground system must then select the appropriate row of the wavecal table for the automatic wavecal. The following set of sequential steps are used to select the proper table row for a science observation (if a match is found stop, if no match is found continue to the next step, if no match is found after passing through 1,2,3 and 4, do not schedule an automatic wavecal for the science observation):

1. Search for the lamp=HITM entry with the science observation’s GRATING, APERTURE, and CENWAVE.

2. Search for the lamp=LINE (or CIM) entry with the science observation’s GRATING, APERTURE, and CENWAVE.

3. If the science observation uses APERTURE=50CCD, search for the lamp=HITM entry with default=DEF and the science observation’s GRATING and CENWAVE.

4. Search for the lamp=LINE (or CIM) and default=DEF entry with the science observation’s GRATING and CENWAVE.

<table>
<thead>
<tr>
<th>grating</th>
<th>cenwave</th>
<th>aperture</th>
<th>lamp</th>
<th>lampset</th>
<th>def</th>
<th>exptime</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>HITM or LINE</td>
<td>1 or 10</td>
<td>DEF or blank</td>
<td>(in seconds)</td>
</tr>
</tbody>
</table>

CCD wavecals should be taken with GAIN=4 and as single exposures (i.e., CRSPLIT=NO). MAMA exposures are taken as single ACCUM mode exposures.

6. How do GOs insert additional wavecals?

GOs can insert wavecals exposures by specifying an exposure with TARGET=WAVE. The GO specifies the CONFIG, APERTURE, GRATING and CENWAVE as well as the exposure time for the GO wavecal exposure. The basic parameters of the wavecal exposure, excluding exposure time (GRATING, CENWAVE, APERTURE, LAMP, LAMPSET) are selected from the appropriate row of the autowavecal table, according to the same rules as used to generate automatic wavecals for science exposures. The only user tunable parameter on GO wavecals is the exposure time, which should generate an error message if specified to be greater than 5 minutes. If EXPTIME=DEF, then the default exposure time from the automatic wavecal table will be used. The insertion of GO wavecal exposures has no affect on the automatic wavecals, which are taken as if no additional wavecals were inserted. The GO inserted wavecals will be processed through the pipeline independently.
of the science data as isolated line lamp exposures.

7. Special Considerations for MAMA Wavecals

The special rules for turning on of lamps for MAMA auto and GO wavecals with regard to use of the external shutter and operational lamp usage are described below. These rules do not apply to CCD observations. In addition we note that as much flexibility as possible should be built into the design of the maintenance of the allowed configurations for MAMA wavecals; over time we expect the lamp performance to degrade and it will therefor be necessary to periodically (once a year throughout the lifetime of STIS) upgrade the MAMA auto wavecal tables.

The External Shutter and Operational Usage of the Line Lamps

The external shutter should be closed for all HITM MAMA lamp exposures (it will be open for HITM CCD exposures). This is required to allow us to reliably predict the illumination of the MAMA detectors during lamp exposures; for HITM observations the external sky will shine through if the external shutter is not closed.

The line lamps are capable of operating at settings of 3.8, 10, or 20 mAmps. Currently only the 3.8 and 10 settings are used. There is an IM system line lamp (used with the calibration insert mechanism [CIM] in place and specified as LAMP=LINE) and HITM lamps, used with the CIM open (specified as LAMP=HITM1 or HITM2).

The 3.8 mAmp setting is used in those cases where the 10 mAmp setting causes an overlight condition on the MAMA detectors. The lamps always turn on at 20 mAmp first, spiking to this setting briefly (<=40 milliseconds) before settling back to the commanded value. We adopt the conservative approach of assuming that the lamp spike is a potential overlight hazard and adopt procedures to assure that the light from the lamps does not illuminate the detector until the spike has completed. For LAMP=HITM* automatic/GO wavecals, there is no worry about the turn on spike since the CIM mirror (blocking the detectors view of the HITM) will be in place when the HITM lamps are turned on.

However, for LAMP=LINE automatic/GO wavecals, as with the MAMA Engineering Wavecals the following sequence for MAMA wavecals which employ the LINE (IM) lamps should be followed. All lamps must be off at the start of this sequence.

• External shutter will be closed. (for a series of internals the shutter will be closed before the start of the first internal and not reopened until the next external alignments, see above).
• Position grating and aperture wheel to desired configuration
• Remove CIM
• Turn desired lamp on to desired setting. Wait 1 second.
• Insert CIM
• Perform local rate check.
• Perform exposure
• Turn lamp off.

8. Wavecal Tables

The CCD and MAMA auto/go wavecal tables\(^1\) driving the implementation and the associated documentation describing their creation are each maintained on the STIS WWW site under the calibration information button. The exposures times actually implemented will typically be rounded up to the nearest second, from those given in the tables.

Acknowledgments

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\(^1\)We note that the auto-wavecals tables are in error if either of the following two easily identifiable conditions are found: (1) there is more than one entry in an autowavecal table for a given GRATING, CENWAVE, APERTURE, LAMP and LAMPSET combination, (2) there is more than one GRATING, CENWAVE, LAMP entry in the table with DEFAULT=def.