Procedure for measuring the angular dependence of the full sky UV collector on a Mk IV Brewer spectrophotometer

National Ultra Violet Monitoring Center
Department of Physics and Astronomy
University of Georgia
Athens, GA 30602

Document 13
Revision A

Prepared by Dr M.G. Kimlin and T.E. Taylor
Last updated March 3, 2003

Introduction

The Brewer Mk IV spectrometer uses a flat spectral diffuser as the input for the full sky UV scans. Theoretically the throughput of the diffuser should fall off as the cosine of the input angle of the light source. Due to imperfections in the surface of the material and other considerations, the throughput of the diffuser actually deviates from a natural cosine decay. Each Brewer instrument requires an angular dependence characterization in order to fully correct the UV data for this phenomenon.

Equipment

Mk IV Brewer spectrophotometer
Optical table
Mounting tree
Cosine arm assembly with translation stages
1000W Lamp mount
Alignment laser with translation stages
1000W FEL lamp
Xantrex power supply
Digital multimeter with two input panels
Standard shunt
Wiring harness for 1000W lamp
Hex wrench set (English sizes)
3/8" box wrench
Bubble level
Lamp alignment jig

Purpose

This Standard Operating Procedure (SOP) outlines the NUVMC technique for measuring the angular dependence of the full sky UV diffuser on a Mk IV Brewer spectrophotometer.

Procedure-Apparatus Setup and Alignment

1. Set up and secure the mounting tree on to the optical table. The cosine arm and the alignment laser will be mounted to this tree. The tree should be positioned so that the cosine arm will mount square with respect to the optics table.

2. Mount the cosine arm assembly with translational stages to the mounting tree.

3. Attach the 1000W lamp mount to the cosine arm.

4. Mount the HeNe aligning laser with translational stages to the mounting tree above the cosine arm assembly.

5. Position the Brewer on a tracker and tripod next to the optical table. It is ideal to use the tracker since the Brewer optics are leveled via the three mounting nubs on top of the tracker unit. This will best simulate the outdoor conditions in which the Brewer takes data.

6. Connect the AC power cable from the AC source to the connector on the bottom of the tracker.

7. Connect the AC cable from the tracker to the connector labeled "AC power" on the Brewer.

8. Connect the data cable from the controlling computer to the connector labeled "computer" directly on the Brewer, i.e. bypass the tracker so that the unit does not move during the cosine measurement.

9. Adjust the Brewer position by sliding the tripod and rotating the tracker so that one of the optical axis of the instrument is parallel to the optics table. That is either the "short" side or the "long" side of the Brewer case should be made parallel to the optics table. The cosine measurement will be taken along the orthogonal axis of the Brewer instrument.

10. Power on the Brewer and the tracker. This will lock the tracker and therefore keep the alignment of the Brewer steady during the cosine measurement.

11. Establish communication with the Brewer via the controlling PC. The NUVMC normally sets up the controlling computer in a room separate from the room containing the cosine apparatus in order to avoid prolonged exposure to the high intensity UV irradiance from the 1000W lamp.

12. Move the cosine arm to the zero degree position and lock it by tightening the 5/8" bolt and wing nut.

13. Adjust the cosine arm assembly so that the axis of rotation of the cosine arm is aligned with and level to the Brewer's full sky UV diffuser. The idea is that as the arm is rotated it will sweep out a cosine with the origin defined at the center of the Brewer's diffuser.

14. Align the laser so that it is incident on the center of the Brewer full sky UV diffuser.

15. Set an adjustable optics bench mirror on top of the Brewer case near the UV dome so that the mirror is facing approximately toward the laser source.

16. Level the mirror with respect to the Brewer case by placing a bubble level on the mirror and adjusting the mirror mount appropriately.

17. Adjust the aligning laser using the translational stages so that the laser beam reflects off the mirror and back to the source.

18. Insert the lamp alignment jig into the lamp mount on the cosine arm.

19. The laser should now be incident on both the crosshairs of the lamp alignment jig and the center of the diffuser. If this is not the case then further adjustments to the system are required.

20. Once the alignment is properly made, remove the alignment mirror from the Brewer case.

Procedure-1000W Lamp Wiring and Operation

1. Connect the current leads of the lamp wiring harness to the posts on the lamp mount. The current leads should be of appropriate rating in order to safely handle the 8.2 Amp current from the power supply to the lamp.

2. Connect the other end of the current leads to the *Xantrex* power supply. The positive lead from the *Xantrex* should pass through the shunt so that the current to the lamp can be monitored.

3. Connect the voltage leads of the lamp wiring harness to the posts on the lamp mount.

4. Plug the voltage leads from the 1000W lamp mount into the back panel of the DMM to monitor the voltage across the lamp.

5. Plug the voltage leads from the shunt into the front panel on the DMM to monitor the voltage across the shunt.

6. Remove the lamp alignment jig and insert a 1000 Watt FEL lamp.

7. Clean the lamp with methanol and lens tissue.

8. Set the *Xantrex* power supply to constant current mode by turning the voltage knob to the maximum position and the current knob to the minimum position before engaging the power to the unit.

9. Provide 8.2 Amps current to the 1000W lamp by turning the current adjustment knob in the clock wise direction until the voltage drop across the shunt reads 82.000 mV (assuming a 10 mili Ohm resistor is being used). The

output of the lamp should be closely maintained during the cosine test although the absolute intensity of the lamp is not critical. Allow the lamp to warm up for at least 30 minutes prior to taking any measurements.

Procedure-Cosine Measurement

1. Move the cosine arm into the -80 degree position by loosening the 5/8" bolt with wing nut on the cosine arm assembly and rotating the arm to the desired position. The negative sign of the angular position is standardized by the NUVMC to indicate the position counter clock wise from the zero degree position when facing the cosine arm.

2. Begin the cosine test by giving the command "LZ" at the Brewer Home screen. Note that the "LZ.rtn" is a routine created by staff at the NUVMC and is therefore not standard Brewer software.

3. When prompted, enter the input angle of the lamp. The scan takes about one minute and will beep when finished.

4. Put on safety goggles and protective clothing and enter the room with the cosine apparatus. Move the cosine arm into the next ten degree increment position by loosening the 5/8" bolt and wing nut and swiveling the cosine arm. Tighten the bolt and nut firmly when the desired position is reached.

5. Continue to take measurements for the input angles -80 to +80 degrees in ten degree increments for a total of 17 scans.

6. When the last scan is completed power down the lamp by rotating the current adjust knob on the *Xantrex* power supply in the counter clock wise direction.

7. Turn off power to the *Xantrex* and DMM.

8. Allow the lamp to cool before removing it for storage in a clean, protected environment.

9. Rotate the Brewer, tracker and tripod so that the instrument is oriented 90 degrees from the previous direction. If the first measurement was made along the "short" optical axis of the instrument the second should be made along the "long" optical axis.

10. Repeat the measurement procedure for the second optical axis of the instrument.

Procedure-Data Analysis

1. Copy the data files from the Brewer computer to a machine with MS Excel or similar data analysis program. The naming convention of the files is "LZdddyy.###", where "ddd" is the Julian day, "yy" is the two digit year and "###" is the Brewer number.

2. The first column in the file are the angle headers that were input by the user. The second through sixth columns are photon counts at the ozone calculating wavelengths, i.e. 306.3, 310.1, 313.5, 316.8 and 320.1 nm. The seventh column is the dark count.

3. Use the spreadsheet to sum the counts at the five operational wavelengths and subtract the dark count from this number.

4. Calculate the experimental cosine of each angle by dividing the photon counts at each measured angle by the photon counts at the zero input angle. Use the header "experimental cosine" to label this new column.

5. Create a new column with the calculated cosine of the input angles. For MS Excel the formula is "cos(A*pi/180)" where "A" is the input angle. Use the header "theoretical cosine" to label this new column.

6. Calculate the deviation in the experimental value from the theoretical value for each input angle by calculating the ratio of the two values in a new column.

7. Create a chart with plots of the experimental, theoretical and ratio values as a function of input angle. Typically the agreement between experimental and theoretical is within 10% for the angles less than 50 degrees and within 20% for angles larger than 50 degrees.

8. The algorithm used to calculate the cosine correction for the Brewer UV data will not be discussed in this procedure. The user is referred to the paper "Cosine corrections for ultraviolet radiation data from the USEPA/UGA Brewer Network" by J. Sabburg and R.S. Meltzer.

For further information or advice concerning this SOP please contact the NUVMC at the University of Georgia at http://oz.physast.uga.edu