Helio-STELLA Heliophysics Spectrometer Operation Guide

Hello and welcome to the Helio-STELLA instrument!

Introduction:

Helio-STELLA measures the spectrum of visible light in 8 channels, from violet to red, plus UVA and total brightness in lux units. Specifically designed for looking upward to measure solar radiation, Helio-STELLA is useful for characterizing sunlight colors and intensities. How does the light change at sunset? Is it different from sunrise? How does the light change as the sun goes behind the moon during an eclipse?

Operation: Startup

Press and release the power button. The red power indicator, on the microcontroller near the USB connector, will light up. Other lights on the microcontroller will flash, and the source lamp on the spectral sensor will flash once.

You'll see a series of startup screens on the display module.

1. Date and time: This should show the current date, and the time at UTC. The data is timestamped in the data file, using the iso8601 standard, and the decimal hour for that day. The decimal hour is there to make it easy to plot data versus time. If you need to set the clock, see line 10 of the Preparation Instructions.
2. UID and Batch: Every individual processor has a unique identification number, set at the factory. We use the last four digits as a unique ID (UID) so that we can keep records of which instrument we are using. The batch number is also logged in the data file. It starts at 0 and increments by 1 every time you start up the instrument. On the change of calendar day, at midnight UTC, the batch number resets to 0. Write this number in your field notes for the measurements you are making, to refer to later when you are reading the datafile. Examples: "Batch 3: direct sunshine, light hazy clouds." or "Batch 15: thick wildfire smoke midday". If the SD card is not in the slot on the back of the microcontroller, this display will show the message "NoSD".
3. Battery charge level: This screen reports the battery charge state, in percent of a full charge. A full charge will allow the instrument to operate for about 24 hours continuously, though if you are taking important data, it's best practice to recharge at a minimum of 25%. If you want to see the amount of charge remaining, restart the instrument and you will see this screen again. See below for instructions on how to charge the battery. If you are reading this screen while the instrument is connected to a power source, the charge state will read near 100%, regardless of the battery state of charge.
4. Sample interval: the HelioSTELLA takes a reading of each of the sensors and records the data, once every sample interval. The default interval is 1.0s. You can change the interval by editing line 10 of the software.

Operation: In use

5. The next screen you see will be the instrument main screen. It shows the shortest and longest wavelengths covered on the graph, with the batch number in the top center. The graph shows relative intensity for each of the 8 colors, versus the wavelength. The color channels, from left to right on the graph, are listed here, with their band center wavelengths, in nm (nanometers) listed below each color:

violet,	indigo,	blue,	cyan,	green,	yellow,	orange,	red.
415	445	480	515	555	590	630	680

The graph autoscales, to show the maximum and minimum values each time it reads the sensor. The data, and thus the display, update every second. If there is no SD card inserted on the back of the microcontroller, the batch message will be replaced with "no SD card". Insert an SD card, and restart the instrument to let the processor know that the card is there.

Each time a datapoint is written to the datafile, the LED at the end of the microcontroller board will flash green. If it flashes orange, that indicates there is a problem writing to the file: Either there is no SD card, or it is full, or it was removed during use.

If you want to turn on the reference light, hold the pushbutton (some are red, and some are green) for 3 seconds. To turn it back off, hold the pushbutton again for 3 seconds. The reference lamp gives you a repeatable source of light, which you can use as a control for data collection. Record some datapoints with the instrument in a dark place with the reference lamp on, and then record some datapoints of the light you are interested in characterizing with the lamp off.

Press and release the pushbutton (some buttons are red, others are green) to change screens. The microcontroller is a low power computer, so it takes some practice to press the button so that the microcontroller detects the press. When it does, it will light up the button a little brighter to let you know the press was detected. The screens will show as follows:

1. GPS latitude and Longitude, if the GPS sensor is connected. If the sensor is connected but doesn't yet have a position fix, the values will show as 0.
2. Magnetic field strength in three axes, x, y, and z, in microTeslas (uT), if the magnetic field sensor is connected. The axes are labelled in white on the top of the sensor, near the SCL pin.
3. Lux and single channel UVA, if the UVA sensor is connected: Centered at 550nm, the total visible light sensor reports the overall brightness of visible light, in lux units, +/- 10 lux. In direct sunlight on a clear day, the lux sensor saturates. The display will show the message "sat". UVA: Centered at 320nm, this sensor reports UVA brightness in uncalibrated units.

4. UV spectrometer, if the sensor is connected. Reports UVC, UVB, and UVA brightnesses in irradiance units (W/m^2.nm).

If the visible spectrometer sensor is connected, the next 8 screens report the optical brightnesses in irradiance units (W/m^2.nm). The calibration is valid for the bare sensor. The ping pong ball diffuser, used to make the sensor less direction-sensitive, will change the values, resulting in uncalibrated readings, though still in irradiance units.

5. Violet: Centered at 415nm, this channel of the spectral sensor reports the intensity of violet light in irradiance units (W/m^2*nm). The units are the same for the remaining channels.
6. Indigo: 445nm
7. Blue: 480nm
8. Cyan: 515nm
9. Green: 555nm
10. Yellow: 590nm
11. Orange: 630nm
12. Red: 680nm

Press the button again to return to the main graph screen.

Operation: Charging

To charge the battery, first turn the instrument on. Then plug it in to a USB-C power source. The amber LED in the center of the microcontroller will come on. When the battery is fully charged, the amber light will go out. If you connect the instrument to power with the battery disconnected, the amber light will show somewhat dimmed. You must turn the instrument on, and leave it running, to charge the battery. Leaving a device running in order to charge it is a bit unusual. This unusual charging method is a side effect of making the instrument using only connectors, without requiring any soldering.

Datafile:

Instrument data recorded to the SD card are stored in a file titled "heliostella_data_YYYYMMDD-B.csv", in the comma separated value (.csv) format, which can be opened by any spreadsheet software, or in a text editor. YYYY is the year, MM is the month, and DD is the day. B is the batch number. The instrument will make a new datafile for each calendar day, and any time it detects, on power up, that a sensor has been added or removed since last use.

The data columns are labeled by the following headers:

1. device_type ["Helio-STELLA"]
2. software_version [current software version number]
3. UID [unique ID for this particular microcontroller]
4. batch [current batch number for the data being recorded]
5. weekday [day of the week]

6. timestamp_iso8601 [yyyymmddThhmmssZ, where Z indicates UTC time]
7. decimal_hour [hours and fractions of hours since midnight UTC]
8. Latitude (if GPS sensor connected)
9. Longitude (if GPS sensor connected)
10. Altitude (if GPS sensor connected)
11. Bx magnetic field intensity in x, (if magnetic field sensor is connected)
12. By magnetic field intensity in y, (if magnetic field sensor is connected)
13. Bz magnetic field intensity in z, (if magnetic field sensor is connected)
14. lux [total light intensity in lux units +/-10. If saturated, the value will show 99999.]
15. uva center wavelength in nm
16. uva [UVA unitless intensity]
17. UVC center wavelength in nm (if UV spectrometer sensor is connected)
18. UVC raw, uncalibrated reading. (if UV spectrometer sensor is connected)
19. UVC irradiance in W/m^2.nm. (if UV spectrometer sensor is connected)
20. UVB center wavelength in nm (if UV spectrometer sensor is connected)
21. UVB raw, uncalibrated reading. (if UV spectrometer sensor is connected)
22. UVB irradiance in W/m^2.nm. (if UV spectrometer sensor is connected)
23. UVA center wavelength in nm (if UV spectrometer sensor is connected)
24. UVA raw, uncalibrated reading. (if UV spectrometer sensor is connected)
25. UVA irradiance in W/m^2.nm. (if UV spectrometer sensor is connected)
26. UV spectrometer sensor temperature in C (if UV spectrometer sensor is connected)
27. violet_center_nm
28. violet_counts [violet intensity as measured in detector counts on the analog to digital converter, 0 to 65535]
29. violet_irradiance_W/(m^2*nm)
30. indigo_center_nm
31. indigo_counts
32. indigo_irradiance_W/(m^2*nm)
33. blue_center_nm
34. blue_counts
35. blue_irradiance_W/(m^2*nm)
36. cyan_center_nm
37. cyan_counts
38. cyan_irradiance_W/(m^2*nm)
39. green_center_nm
40. green_counts
41. green_irradiance_W/(m^2*nm)
42. yellow_center_nm
43. yellow_counts
44. yellow__irradiance_W/(m^2*nm)
45. orange_center_nm
46. orange_counts
47. orange_irradiance_W/(m^2*nm)
48. red_center_nm
49. red_counts
50. red_irradiance_W/(m^2*nm)

51. battery_voltage
52. battery_percent