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## **Instruction manual for Ocean Optics USB4000 and QE65 Pro spectroradiometers**

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## 1. Table of contents

1. Table of contents.....	2
2. Overview .....	3
3. Measurement instructions .....	4
3.1. Powering up the instrument and warm-up.....	4
4. Calibration instructions .....	5
4.1. Level calibration .....	5
4.1.1. QE65 Pro .....	5
4.1.2. USB4000.....	6
4.1.3. Calibration analysis Excel.....	7
4.2. Wavelength calibration .....	8
References .....	9

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## 2. Overview

Ocean Optics USB4000 and QE65 Pro (Figure 1) are array spectroradiometers that can be used in various photometric, colorimetric and radiometric measurements. The wavelength range for the USB4000 spectroradiometer is 116.59–884.65 nm and the CCD array consists of 3648 elements, leading to a wavelength interval of about 0.2 nm. For the QE65 Pro spectroradiometer, the wavelength range is 301.42–1088.22 nm divided into 1044 pixels leading to a wavelength interval of 0.79 nm. The sensor of the QE65 Pro instrument is Peltier-cooled to improve the signal-to-noise ratio. The sensor of the USB4000 device is not temperature controlled.



Figure 1: Ocean Optics USB4000 and QE65 Pro spectroradiometers.

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### 3. Measurement instructions

Both spectroradiometers, USB4000 and QE65 Pro, are operated using SpectraSuite software. Instrument drivers are installed at the same time with the operating software.

Basic use of SpectraSuite software is straight forward. The attached instrument is recognized by the software at startup. The device starts measuring automatically after starting SpectraSuite. Below is a step-by-step guide to start measuring with the instrument:

1. Turn on the instrument (warm-up time of 20 minutes or more is required).
2. Connect the instrument to the computer.
3. Open SpectraSuite software. The device starts measuring automatically.
4. Choose the integration time, averaging, and the wanted error correction options.
5. The device is measuring continuously; wait for the measurement to be finished.
6. Save the measurement data.

#### 3.1. Powering up the instrument and warm-up

The electronics of the Ocean Optics spectroradiometers are powered through the USB ports of the devices. In addition, QE65 Pro model includes a separate power plug and power supply unit for the TEC cooler of the CCD cell array. Only the dedicated Ocean Optics AC power adapter (model PW160) should be used to power up the instrument.

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## 4. Calibration instructions

The Ocean Optics spectroradiometers are calibrated for irradiance by carrying out the required measurements using SpectraSuite software and making a dedicated calibration Excel file. The calibration Excel file for the QE65 Pro spectroradiometer should be named as *qe\_calib\_yyyymmdd.xlsx*, where yyyy, mm, and dd are the year, month, and day of the calibration, respectively. For the USB4000 spectroradiometer, the calibration Excel file should be named as *usb4000\_calib\_yyyymmdd.xlsx*. The created calibration Excel file is used to correct the raw measurement data.

The device has a factory calibrated wavelength scale and a correction for the non-linearity. This manual do not cover the calibration of the wavelength scale or the non-linearity.

### 4.1. Level calibration

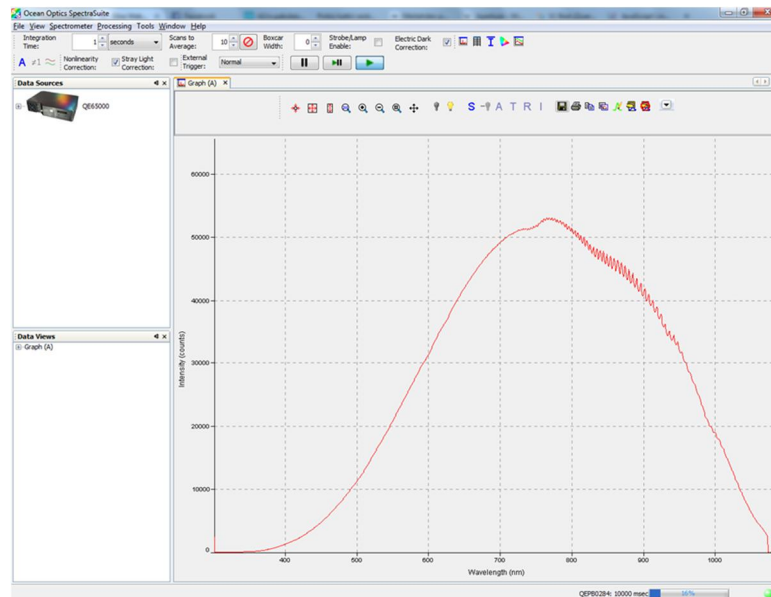
#### 4.1.1. QE65 Pro

The QE65 Pro spectroradiometer is calibrated against a FEL lamp in the optical rail laboratory. The calibration distance is 500 mm and a shutter is used between the lamp and the diffuser head of the spectroradiometer. The diameter of the shutter aperture should be set to 50 mm.

The measurement parameters for calibrating the device are as follows:

- Integration time: 1 s
- Scans to average: 10
- Boxcar width: 0

Several corrections can be applied for the device measurement data; electric dark, nonlinearity, and stray light corrections. The calibration should be carried out for every correction combination separately. For the most convenient and fast way of calibrating and using the device is to use only electric dark and nonlinearity corrections. However, the corrections required depend on your application. Figure 1 shows a screenshot of the SpectraSuite software with the typical calibration measurement settings.



**Figure 2:** Ocean Optics SpectraSuite software is used to control the QE65 Pro spectroradiometer.

The calibration is carried out by first measuring the dark signal of the device with the 50 mm shutter closed. After the dark signal measurement, the shutter is opened and the reference light signal measured. Before saving the data, the spectroradiometer data needs to be allowed to stabilize at least 1 minute.

When saving the data, a tab delimited text file with headers should be chosen as the saving format.

#### 4.1.2. USB4000

The USB4000 spectroradiometer is calibrated against a FEL lamp in the optical rail laboratory. The calibration distance is 500 mm and a shutter is used between the lamp and the diffuser head of the spectroradiometer. The diameter of the shutter aperture is 50 mm.

The measurement parameters for calibrating the device are as follows:

- Integration time: 200 ms
- Scans to average: 10
- Boxcar width: 0

Several corrections can be applied for the device measurement data; electric dark, nonlinearity, and stray light corrections. The calibration should be carried out for every correction combination separately. For the most convenient and fast way of calibrating and using the device is to use only electric dark and nonlinearity corrections. However, the corrections required depend on your application. Figure 3 shows a screenshot of the SpectraSuite software with the typical calibration measurement settings.

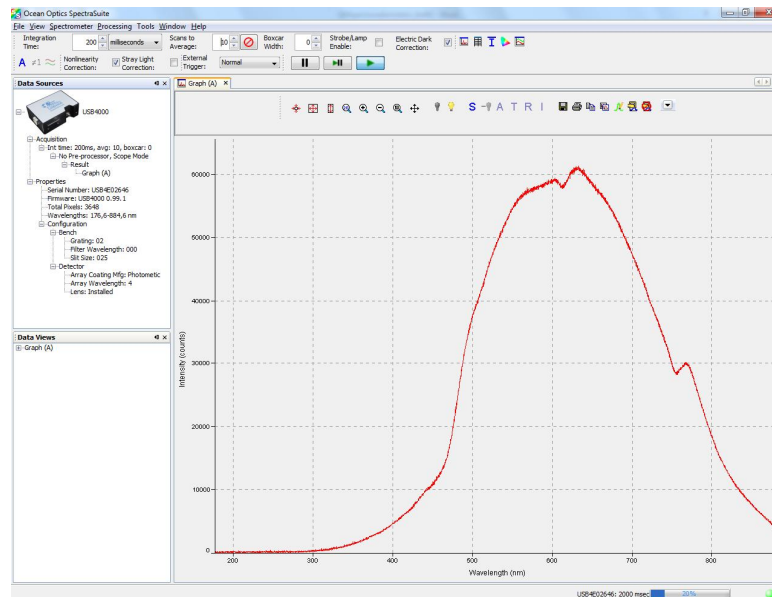


Figure 3: Ocean Optics SpectraSuite software is used to control the USB4000 spectroradiometer.

The calibration is carried out by first measuring the dark signal of the device with the 50 mm shutter closed. After the dark signal measurement, the shutter is opened and the reference light signal measured. Before saving the data, the spectroradiometer data needs to be allowed to stabilize at least 1 minute.

When saving the data, a tab delimited text file with headers should be chosen as the saving format.

#### 4.1.3. Calibration analysis Excel

The calibration measurement files are analyzed using a calibration Excel file. The first sheet of the Excel file includes the calibration data of the FEL lamp used in the calibration measurements. The FEL calibration data can be found from the calibration certificate of the lamp.

The spectroradiometer calibration measurement data will be added to the second sheet of the Excel file, called 'QE calib.' The dark measurement of the FEL lamp will be added to the column named 'Dark.' The lamp spectrum measurement will be added to the column named 'FEL-460 measurement.' The calibration coefficients are calculated to the column 'Calib.'

After calibration, the 'Correction' sheet of the calibration Excel can be used to correct the measured spectrum for absolute irradiance. The sheet named '360-830' interpolates the data of the 'Correction' sheet for the wavelength range between 360 and 830 nanometers using a wavelength interval of 1 nm.

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#### 4.2. Wavelength calibration

The wavelength calibration of the Ocean Optics spectroradiometers has not been tested.



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## References