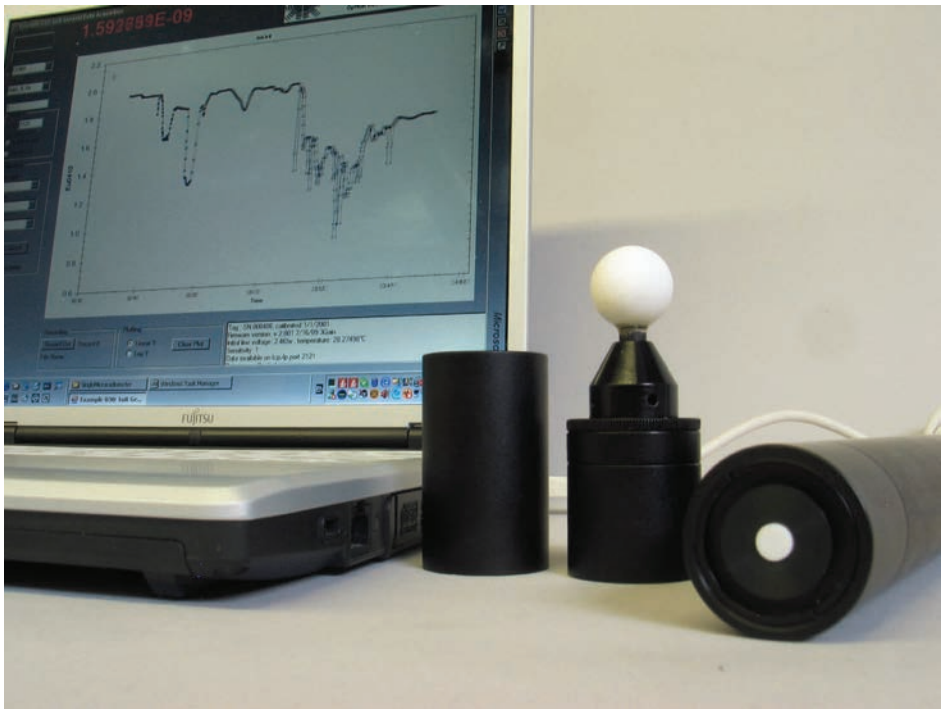
Biospherical Instruments Inc.

Your Source for Optical Sensing and Aquatic Profiling Technologies

# Advanced Multi-purpOse Usb Radiometer: AMOUR



High-speed versatile USB Radiometer for research and engineering

**Applications:**

- Algal growth chambers/ photosynthetron illumination
- Fluorescence detection
- Illumination studies
- LED testing
- Optical hazard detection
- Solar irradiance (insolation)
- … and more

**Measurement geometries**

- Irradiance
- Scalar Irradiance
- Radiance
- Coupling to optical fibers

**Spectral responses**

- Narrow band
- UV
- Blue-Light Hazard
- High-energy visible light
- PAR

## What is the AMOUR?

The AMOUR is a versatile single-channel USB-powered filter radiometer intended for use in the laboratory or field. It can be equipped with several inter-changeable fore-optics for different measurement geometries. The instrument's spectral response can be tailored to support many applications. The dynamic range of the instrument covers more than 10 orders of magnitude. It incorporates Biospherical Instruments' microradiometer technology, which was developed under a contract to NASA.

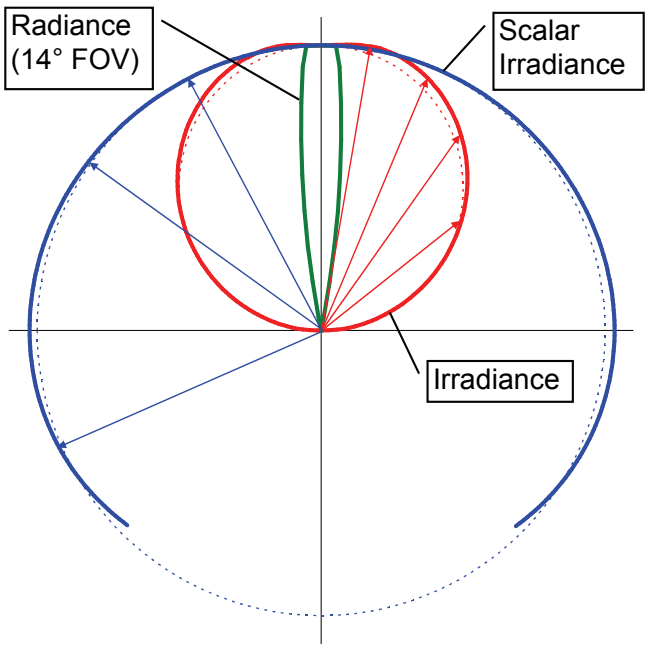
## Measurement Geometries

The user can select from the following measurement geometries. Calibration data for every type is available.

- **Irradiance**
  Measurement of radiation incident on a flat surface. This geometry is used for most radiometric applications, including illumination and solar energy studies. The AMOUR collector deviates from the ideal cosine response by less than ±5% for incidence angles up to 85°.

- **Scalar irradiance**
  The scalar response is independent of the direction of the incident radiation. This geometry is commonly used for oceanographic and limnological studies involving algae or microorganisms as effects caused in cells are do not depend on the direction of light. Scalar collectors measure as much as 3.7π steradians out of 4π steradians, depending on the length of the shaft used.

- **Radiance**
  Measurement of radiance allow to quantify how bright an object is. Objects may include the ocean viewed from above, the sky, or an indoor object. More formally, radiance describes the radiative power per area and solid angle subtended by the observation. AMOUR's radiance fore-optics have field of views ranging from 2.5° to 20°.




Polar diagram of directional response of various fore-optics offered for AMOUR radiometers. The ideal response is indicated by a dotted line. Solid lines show measurements of the actual devices.

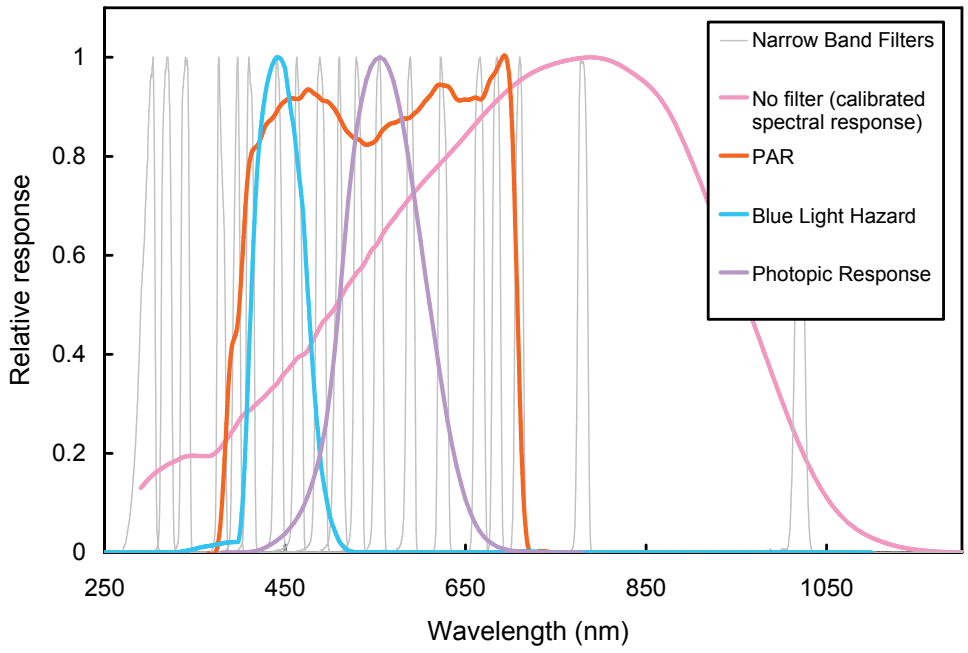
- **Fiber Optics**
  AMOUR radiometer can be ordered with a SMA connector for coupling to optical fibers. This configuration allows measurements in difficult-to-reach locations such as algae mats. Fibers and also be coupled to an integrating sphere or other components on an optical bench.

## Spectral Response

By default, AMOUR radiometers measure with the spectral response of a silicon photodiode (wide-band response between 250 and 1100 nm). If the wavelength distribution of the source being measured is known, and the instrument is ordered with a response function calibration, the optical flux can be measured.

The instruments can also be ordered with a large selection of filters, including narrow-band and filters that mimic some physiological response function. These include:

- **Narrow Band filters (~10 nm bandwidth)** are normally used when the source distribution is known and typically confined to a small region, such as an Laser, or where it is combined in an ensemble of radiometers spaced through the spectral region of interest, such that the entire spectrum can be reconstructed.
- **PAR** (Photosynthetically Active Radiation), which is confined to the 400-700nm spectral region and is weighted with a quantum response as opposed to most weighted spectral responses. Calibration units include moles/($cm^2$ s), einsteins/($cm^2$ s), and quanta or photons/($cm^2$ s), and their MKS variants.
- **Blue Light Hazard**, which is defined as the potential for a photochemical induced retinal injury resulting from radiation exposure at wavelengths primarily between 400 nm and 500 nm.
- **Photometric** Response, which describes the perceived brightness to the human eye.
- **Erythema**, which describes the wavelength-dependent sensitivity of the human skin to sunburn
- **Additional response functions,** tailored to customer needs.




Standard spectral response functions of filters offered for AMOUR radiometers.

## Specifications

**AMOUR Specifications**

**Fore Optics:** Selection of

- **Irradiance:** Cosine error < ± 3% for zenith angles smaller than 85°
- **Scalar irradiance:** Directional error < ± 5% for incidence angles < ± 135° with some fall-off occurring approaching ±165° due to intrusion of the stainless steel casing.
- **Radiance: Standard** field-of-view 6°, 14°; optional field-of-view from 2.5° to 20°
- **Fiber coupling:** SMA connector

**Spectral response:** Depending on filter - see ordering options

**Detection limit:** Depending on configuration, see Table.

**Dynamic range:** $6x10^{10}$, defined as saturation signal divided by minimum resolvable signal.

**Sampling rate:** 4 - 125 Hz (native); 1/60 - 125 Hz (with internal averaging)

**Electronics interface:** USB (standard). Optionally available with RS232 or RS485.

**Physical dimensions:**

- **Diameter**: 1.2"
- **Length:** Depending on Fore optics: 5" (Irradiance); 8"-?? (scalar irradiance); 7" (radiance with 14° field-of-view, longer for smaller field-of-view)

**Microradiometer Specifications (The heart of AMOUR)**

**Detectors:** Si (13 $mm^2$), InGaAs (7 $mm^2$), or GaAsP (7 $mm^2$)

**Photocurrent-to-Voltage Conversion:** Electrometer amplifier with three gain stages—1, 200, and 40,000.

**ADC:** 24-bit bipolar: 4–125 Hz data rates.

**Dynamic Range:** 10 decades

**Linearity:** Measured on all microradiometers over a signal current range of $1 \times 10^{-12}$ to $1 \times 10^{-5}$ A using a programmable light source. Typically, errors are < 1% compared to a reference system electrometer. Gain ratios are individually measured using a computer controlled optical source and programmed into each microradiometer.

**Response Time:** Exponential change with a time constant of < 0.01 s. Time required for gain change is < 0.1 s.

**Electronic Sensitivity:** ADC resolution is 0.5 µV with a current resolution of < $10^{-15}$ A. The saturation current is 160 µA. The 3-gain signal-range is $1.6 \times 10^{11}$, defined as the saturation signal divided by minimum resolvable signal.

**Dark Offsets:** Dark offsets are measured and set at the time of calibration for each gain level.

**Microradiometer Power:** ± 5 VDC at 4 mA total.

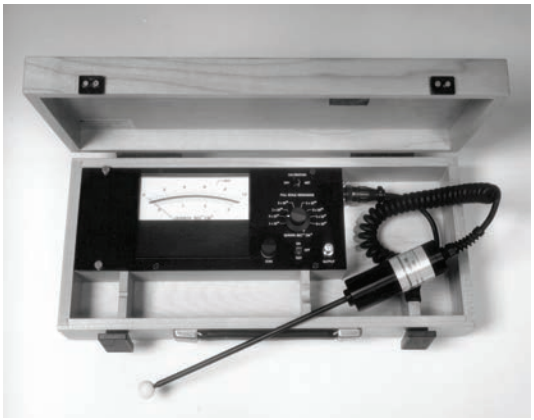
**Spectral Range:** 250–1650 nm. (Range of 1100–1650 nm requires InGaAs detectors.)

**Detection Limit and Saturation**

| | Detection limit | Saturation | Unit | Dynamic range |
|---|---|---|---|---|
| Irradiance, 313 nm | 6.9E-06 | 3.6E+05 | µW/(cm² nm) | 5.2E+10 |
| Irradiance, 490 nm | 1.2E-06 | 6.8E+04 | µW/(cm² nm) | 5.9E+10 |
| Irradiance, PAR nm | 1.1E-10 | 5.7 | µE/(cm² s) | 5.2E+10 |
| | | | | |
| Scalar, 313 nm | 6.3E-02 | 4.1E+09 | µW/(cm² nm) | 6.6E+10 |
| Scalar, 490 nm | 2.0E-05 | 1.0E+06 | µW/(cm² nm) | 5.2E+10 |
| Scalar, PAR nm | 1.1E-09 | 58.5 | µE/(cm² s) | 5.2E+10 |
| | | | | |
| Radiance, 313 nm | 4.9E-07 | 3.0E+04 | µW/(cm² nm sr) | 6.0E+10 |
| Radiance, 490 nm | 1.4E-07 | 8.5E+03 | µW/(cm² nm sr) | 6.0E+10 |
| Radiance, PAR nm | 1.3E-11 | 0.79 | µE/(cm² s sr) | 6.0E+10 |

## Legacy of Biospherical Instrument's single-channel radiometers

Since 1978, Biospherical Instruments has been making a variety of optical instruments to serve the scientific community. The AMOUR radiometer line incorporates the fourth generation of PAR sensors we have built, and significantly extends the functionality, dynamic range and sensitivity of prior generations, directly connects to USB for signal and power, and can be configured with several measurement and spectral geometries.



Introduced in 1978, the QSL-100 is still found in many labs through the world. Light striking the Teflon ® irradiance sphere is integrated from all directions, much as a algal cell would collect light for photosynthesis. This irradiance-collecting sphere is still the basis for our scalar irradiance collectors.

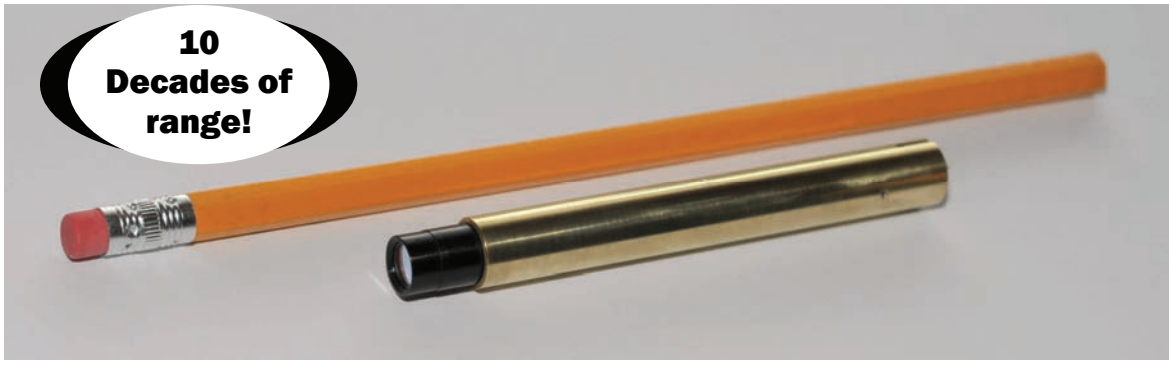
The AMOUR, Biospherical Instruments' latest generation of single-channel radiometers features different fore-optics, which can be screwed on the device. The instrument combines BSI's microradiometer technology with a USB interface card, which provides power derived from the USB port to the microradiometer, and conditions the signals to be received via USB. For applications that require longer signal length than accommodated by USB, an extender to operate over 100 meters can be provided. The instrument is built into a 1-inch cylindrical housing.

## Inside the AMOUR

The heart of the AMOUR, is the microradiometer—a novel approach to photodetector integration on one small circuit board assembly the size of a pen. The consists of a photo-diode, a current-to-voltage electrometer with a three-stage programmable gain amplifier, a 24-bit analog-to-digital converter, and a low-power microprocessor that can automatically select the correct gain, conduct internal data averaging, and offset correction. An outer sleeve made of brass provides support and isolation from electronic noise.

The 24 bit analog-to-digital converter (ADC) covers a range of -30 mV to 4.096 V. Counts at full scale are $2^{24}$ = 16777215, and the resolution is 0.596 µvolts/count. The ADC converts at user-selectable rates ranging from 4 to 125 Hz. Internal averaging and autoranging allows data to be reported at rates from greater than 50 Hz down to one sample per minute.

Several data reporting options are available, including ASCII and binary floating point. The instrument can also report internal temperature and power supply state. Optionally, up to 200 instruments can be aggregated into a synchronized sampling systems, providing a single data stream. Multi-channel microradiometer systems have been utilized in underwater spectroradiometers (C-OPS), atmospheric radiometers, transmissometers, fluorometers, and many other light measuring applications.




Example of a 19-channel microradiometer system for measuring radiance under water. The system uses the same technology as AMOUR radiometers.

## Ordering Options

The basic AMOUR radiometer consists of an uncalibrated USB radiometer mounted in a water-resistant housing using a silicon photodiode with a sensitivity from 190 nm to beyond 1100 nm as detector. Depending on application, the customer can choose from a large variety of fore-optics, filters, detectors and other accessories. The resulting combination is then calibrated in our calibration laboratory.
*Part number:*

**Fore optics**

**Scalar irradiance collector**
1.9 cm diameter ultra pure Teflon® collector on 2 cm sealed stainless steel shaft
*Part number:*
*Price:*

**Cosine-corrected irradiance diffuser**
Teflon® irradiance diffuser
*Part number:*
*Price:*

**Fiber optic adaptor**
Allows connection of a SMA optical fiber to the microradiometer. Consult factory for availability of other adaptor types.
*Part number:*
*Price:*

**Radiance adaptor**
Allows measurement of radiance with a 2.5 to 20° field-of-view. Standard options are 6° and 13.7°
Consult factory for details

**Long shaft scalar collector 1.9 cm**
1.9 cm diameter Teflon® collector mounted on a long (25 cm) shaft. Stainless steel construction allows immersion in most media.
Part number:
Price:

**Long shaft scalar collector 1.3 cm**
1.3 cm diameter Teflon® collector mounted on a long (25 cm) shaft. Stainless steel construction allows immersion in most media.
Part number:
Price:

**Detectors**

**InGaAs detector**
For near infrared (NIR) applications beyond 1100 nm the standard silicon detector can be switched to a InGaAs photodiode covering 900-1700nm.
*Part number:*
*Price:*

**GaAsP detector**
Not sure what that detector is used for
*Part number:*
*Price:*

**Filters**

| | |
|---|---|
| **Bare Photodiode Response Function**<br>Calibration of the spectral response function<br>*Part number:*<br>*Price:* | **10nm Narrowband Filter Response**<br>Installation of a 10nm FWHM interference filter and calibration of the assembled sensor. Stocked filters include the wavelengths: 305, 313, 320, 330, 340, 380, 395, 412, 443, 465, 490, 510, 520, 532, 555, 560, 565, 589, 625, 665, 670, 683, 694, 710, 765, 780 and 875, 1020, 1245, and 1640 nm. The last two wavelengths require the InGaAs detector option.<br>*Part number:*<br>*Price:* |
| **PAR Spectral Response**<br>Includes calibration with 1 set of collection optics.<br>*Part number:*<br>*Price:* | **Photometric Spectral Response**<br>Includes calibration with 1 set of collection optics.<br>*Part number:*<br>*Price:* |
| **Erythemal response**<br>Wavelength dependence of the human skin to sunburn as defined by the International Commission on Illumination (CIE)<br>*Part number:*<br>*Price:* | **Custom Response Function**<br>Examples of custom function include Blue Light Hazard function, and other functions mimicking biological action functions. Describe the product, service, or event here. Include a brief description and any features. |

**Other**

| | |
|---|---|
| **USB extender system**<br>Allows connection over up to 100 m using a CAT5 cable between PC and probe.<br>*Part number:*<br>*Price:* | |

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