Beam transmissometer:

Why do we measure beam transmission?

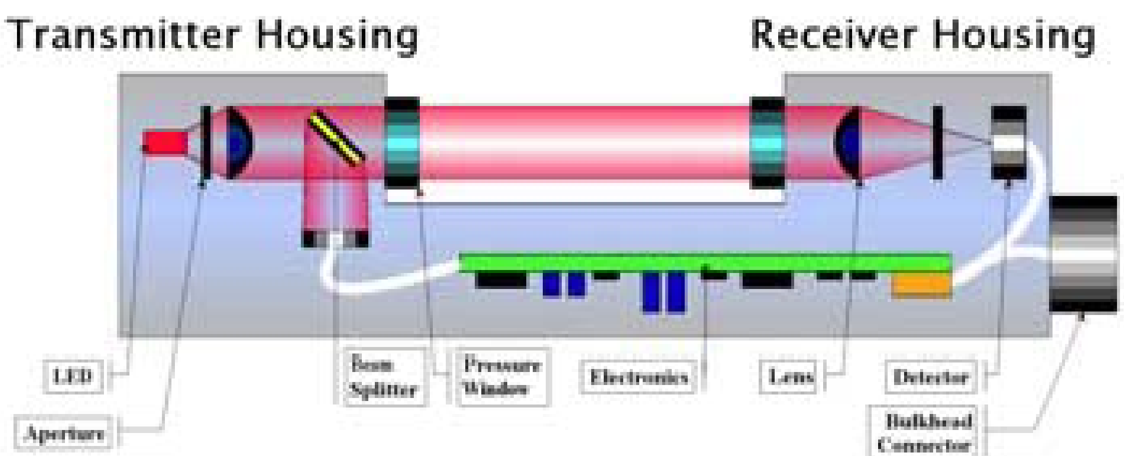
- "Turbidity", "water clarity".
- "Particle concentration".
- POC.

Issues that may affect relationship to concentration:

- Effect of the particle's composition.
- Particle size distribution and aggregation.
- Possible effects of dissolved materials.

From c-star manual:

An LED light source provides light that is focused and collimated by an aperture and lens. The light passes through a beam splitter so that a portion of light can be monitored and used in a feedback circuit to account for variations in the LED source. The light enters the sample volume after passing through the first pressure window, transits the sample volume and enters the receiver optics after passing through the other pressure window. The light passes through additional focusing optics and finally strikes a silicon photodiode detector which converts the amount of received light to a corresponding 0–5-volt analog output signal which represents the amount of light received.



Measurement protocol

$Tr = e^{-cx}$ (1)

$Tr = (Vsig - Vdark) / (Vref - Vdark)$ (2)

$c = - 1/x * \ln (Tr)$

$= - 1/x * \ln ((V_{sig} - V_{dark}) / (V_{ref} - V_{dark}))$ (3)

- Reference voltage (V_{ref}) is voltage in a reference material (e.g. cleanest water).

- Dark voltage (V_{dark}) is voltage when no radiant flux reaches the receiver.

Some important issues:

•Beam-c is defined for an infinite plane (collimated) light beam; as long as the
beam>>particles this is what we measure with a finite beam.

•All of our instrument measurement a radiant flux. We convert this radiant flux to the optical properties of the medium.

•Finite size of receiver+receiver geometry define the acceptance angle of the light rays. For WetLab C-star the acceptance angle is 1.2 °. This means that all light scattered within the acceptance angle does not count as scattered. Issues of Signal-to-Noise ratio and scattering by turbulence are important for the specification of the acceptance angle.

Glass-water vs. Glass air interface issues (or why an air cal. is not the same as a water cal.).

The ratio of reflected to incident irradiance is (Bohren and Hufmann, 1983):

2.7 REFLECTION AND TRANSMISSION AT A PLANE BOUNDARY 31

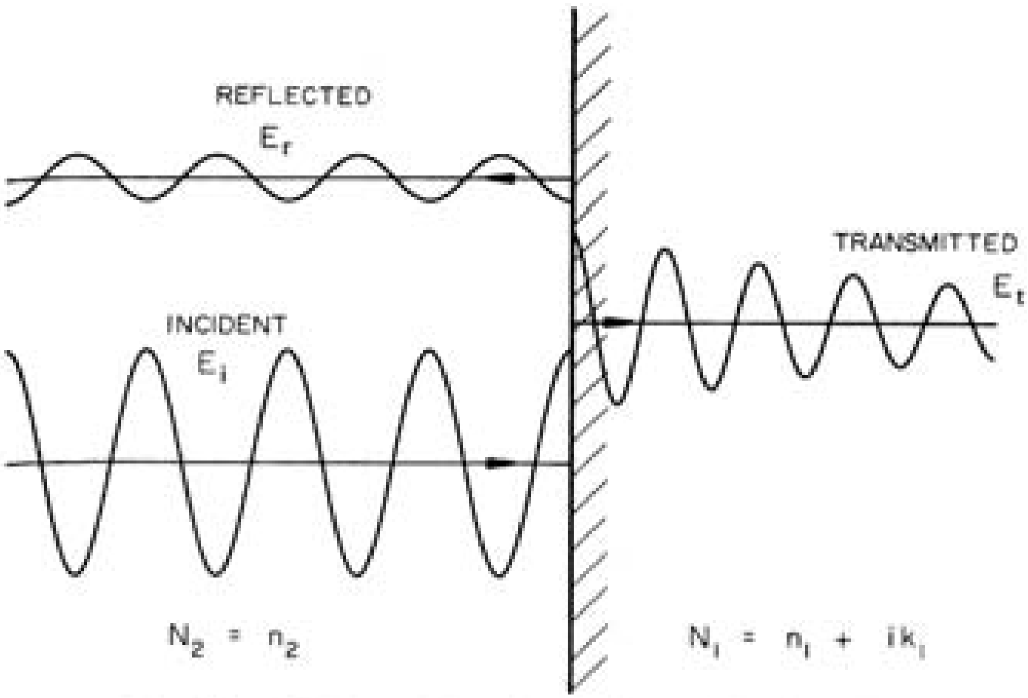


Figure 2.4 Reflection and transmission of normally incident light.

$$R = \left| \frac{1 - {n_1}/{n_2}}{1 + {n_1}/{n_2}} \right|^2$$

Glass-water vs. Glass air interface issues (continued):

$$R_{air-glass} = \left| \frac{1 - \frac{1}{1.5}}{1 + \frac{1}{1.5}} \right|^2 = 0.04$$

$$R_{water-glass} = \left| \frac{1 - \frac{1.33}{1.5}}{1 + \frac{1.33}{1.5}} \right|^2 = 0.003$$

Notice that the changing the order (A->G vs G->A) does not change the reflectance.

In a transmissometer we have two interfaces that are different between an air and water calibration (8% loss vs. 0.6% loss).

References:

Voss K.J. and R. W. Austin, 1993. Beam-attenuation measurement error due to small angle scattering acceptance, J. Atmos. Ocean. Tech., 10, 113- 121, 1993.

Pegau, W. S. , J. R. V. Zanveld and K. J. Voss, 1995. Toward closure of the inherent optical properties in natural waters, J. Geophys. Res., 100, 13,193-13,199, 1995.

Boss, E., W.H. Slade, M. Behrenfeld, and G. Dall'Olmo, 2009. Acceptance angle effects on the beam attenuation in the ocean. Optics Express, Vol. 17, No. 3, pp. 1535-1550.