Attenuation

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Attenuation is the reduction in amplitude and intensity of a signal with respect to distance traveled through a medium. Attenuation can also be understood to be the opposite of amplification. Attenuation is an important property in fibre optics
and ultrasound applications because of its importance in determining signal strength as a function of distance. Attenuation is usually measured in units of decibels
per centimetre of medium (dB/cm) and is represented by the attenuation coefficient of the medium in question. [1]

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One area of research in which attenuation figures strongly is in ultrasound physics. Attenuation in ultrasound is the reduction in amplitude of the ultrasound beam as a function of distance through the imaging medium. Accounting for attenuation effects in ultrasound is important because a reduced signal amplitude can affect the quality of the image produced. By knowing the attenuation that an ultrasound beam experiences travelling through a medium, one can adjust the input signal amplitude to compensate for any loss of energy at the desired imaging depth.[2]

Attenuation coefficient

Attenuation coefficients are used to quantify different mediums according to how strongly the input ultrasound amplitude decreases as a function of dB/cm. The attenuation coefficient (α) can be used to determine total attenuation in the medium using the following formula:

$$\mathrm{Attenuation(dB)} = \alpha(\mathrm{dB/MHz} * \mathrm{cm}) \times l(\mathrm{cm}) \times \mathrm{f(MHz)}$$

As this equation shows, besides the medium length and attenuation coefficient, attenuation is also linearly dependent on the frequency
of the incident ultrasound beam. Attenuation coefficients vary widely for different mediums. In biomedical ultrasound imaging however, biological materials and water are the most commonly used mediums. The attenuation coefficients of common biological materials at a frequency of 1 MHz are listed below:[2]

Material	**α(dB / MHz * cm)**
Lung	41
Bone	20
Kidney	1.0
Liver	0.94
Fat	0.63

Blood	0.18
Brain	0.85
Water	0.0022

Attenuation and fibre optics

Another area of research that deals with attenuation is fibre optics physics. Attenuation in fibre optics, also known as transmission loss, is the reduction in intensity of the light beam with respect to distance travelled through a transparent medium. Attenuation coefficients in fibre optics usually use units of dB/km through the medium due to the much faster speed of light as compared to sound. The medium is usually a fibre of silica glass that confines the incident light beam to the inside. Attenuation is an important factor limiting the transmission of a light pulse across far distances, and as a result much research has gone into both limiting the attenuation and maximizing the amplification of the fibre optic light beam.[3]

Attenuation in fibre optics can be quantified using the following equation:[4]

$$\mathrm{Attenuation(dB)} = 10\times\log_{10}\left(\frac{\mathrm{Output\ Intensity(W)}}{\mathrm{Input\ Intensity(W)}}\right)$$

See also

- Attenuator (genetics)
- Attenuator (electronics)
- Cross section (physics)
- Mean free path
- Radiography

External links

- NIST's XAAMDI: X-Ray Attenuation and Absorption for Materials of Dosimetric Interest Database (http://physics.nist.gov/PhysRefData/XrayMassCoef/cover.html)
- NIST's XCOM: Photon Cross Sections Database (http://physics.nist.gov/PhysRefData/Xcom/Text/XCOM.html)
- NIST's FAST: Attenuation and Scattering Tables (http://physics.nist.gov/PhysRefData/FFast/Text/cover.html)

References

1. ^ Essentials of Ultrasound Physics, James A. Zagzebski, Mosby Inc., 1996.
2. ^ ***a b*** Diagnostic Ultrasound, Stewart C. Bushong and Benjamin R. Archer, Mosby Inc., 1991.
3. ^ Telecommunications: A Boost for Fibre Optics, Z. Valy Vardeny, Nature 416, 489–491, 2002.
4. ^ "Fibre Optics (http://floti.bell.ac.uk/MathsPhysics/5attenua.htm) ", *Bell College*.