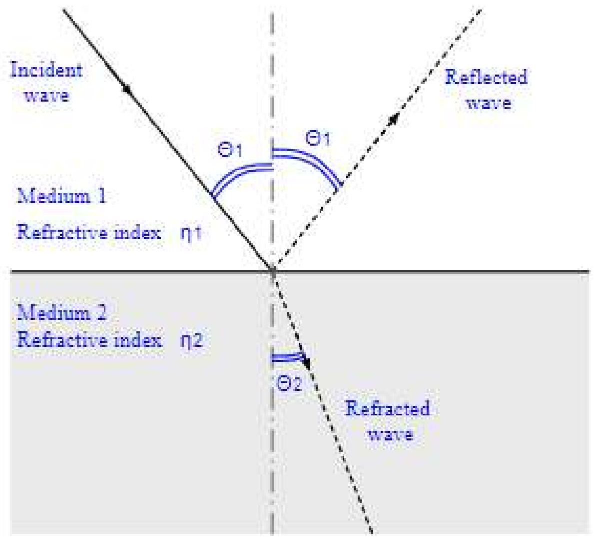
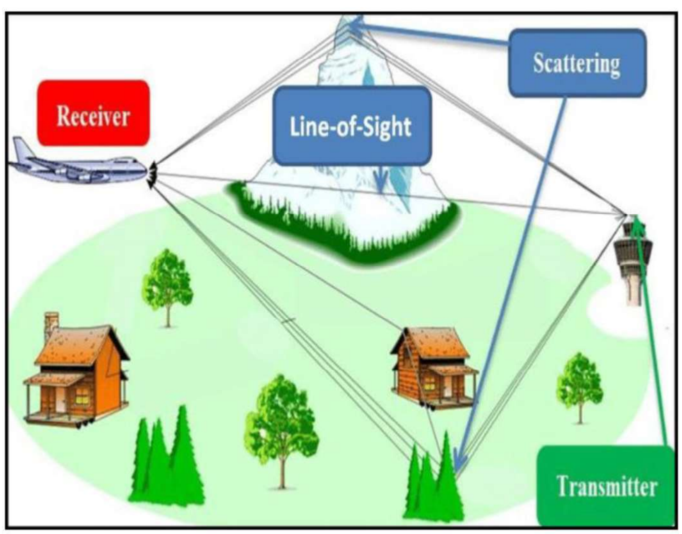
External Environment- change how you interact with the surrounding environment:

- Mirrors/reflective surfaces (glitter/cds/stainless steel/etc) for signal reflection/refraction



Propagation of reflected & refracted waves



  - Outdoor to Indoor Wireless Propagation Simulation Model for 5G Band Frequencies
    - https://www.researchgate.net/publication/340084245_Outdoor_to_Indoor_Wireless_Propagation_Simulation_Model_for_5G_Band_Frequencies

$$\text{Refractivity (N)} = (n-1) \times 10^{6} = \frac{77.6\,p}{T} + \frac{3.75 \times 10^{5} e}{T^{2}}$$

n = index of refraction   e = partial pressure of water vapor
p = barometric pressure   T = absolute temperature (degrees K)

- Fundamentals of RF Propagation in Electronic Warfare
  - https://www.iqpc.com/media/7050/1972.pdf
- Tutorial: An introduction to terahertz time domain spectroscopy (THz-TDS)
  - https://thz.yale.edu/sites/default/files/tutorial.pdf
  - One way to generate THz radiation is to induce a short current pulse in a medium, which then emits THz radiation as described in detail below. The other commonly used method is via a nonlinear optical rectification process which is primarily used in amplifier based systems.
- An Overview of Signal Processing Techniques for Terahertz Communications
  - https://arxiv.org/pdf/2005.13176.pdf
- Electrically reconfigurable terahertz signal processing devices using liquid metal components
  - https://www.nature.com/articles/s41467-018-06463-z
  - However, such devices actuate the liquid metal using pneumatics or strong acids, which remove the native oxide that otherwise stabilizes the shape of the metal. Recently, we have demonstrated voltage-actuated reconfigurability achieved by applying a small voltage (<4 V) across an electrolyte surrounding the liquid metal. The use of voltage alleviates the need for bulky pneumatic pumps while the electrolyte creates a "slip layer" that prevents the metal from adhering to surfaces. Since the length scale of movement of the liquid metal ranges from millimeter to centimeter scale, these are ideal for reconfigurable RF and THz devices

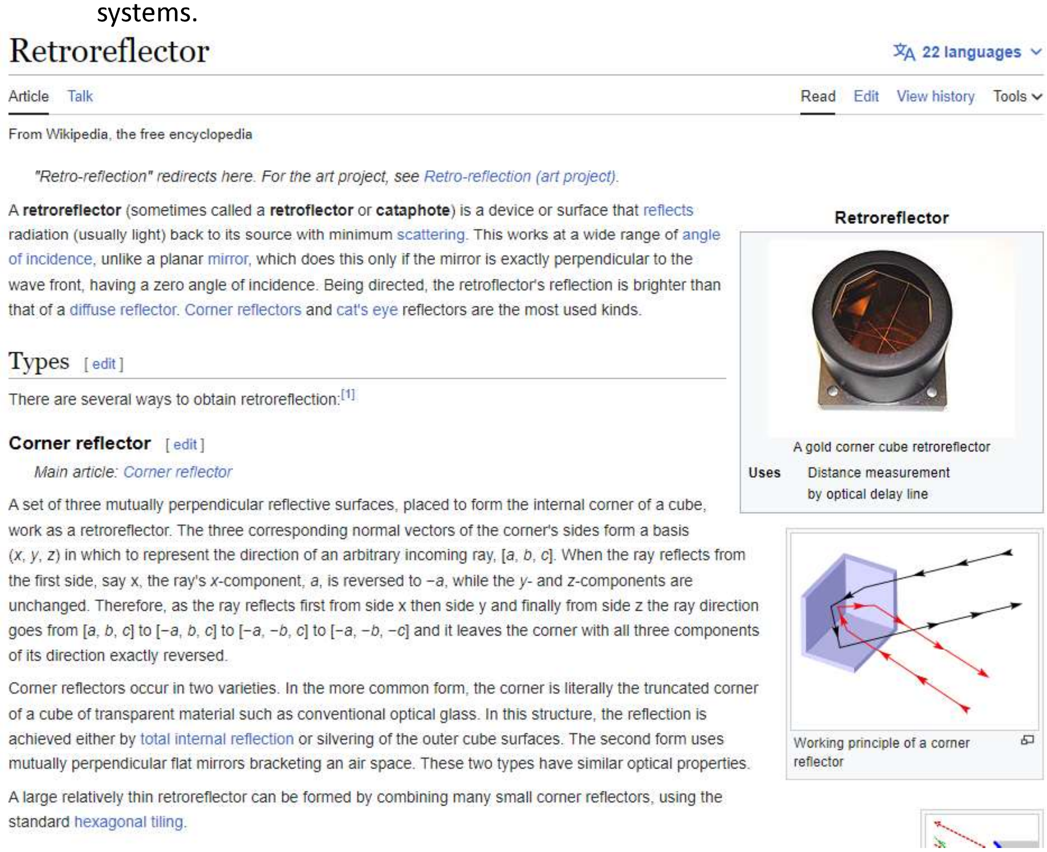
Table 1 Summary of Dielectric Constant and Tangent Loss for Various Materials at 0.5 and 1 THz Reported in Literatures. (Note: Some of the Data Are From Graphs in the Literature)

material	0.5 THz		1 THz		ref	note
	ε_r	tan δ	ε_r	tan δ		
InP			12.33	0.009	[65], Hejase 2011	
			12.39	0.006	[66], Dorney2001	
	12.7	0.009			own data	
GaAs	12.9	0.024	12.91	0.013	[15], Grischkowsky 1990	
Si (doped)	11.85	0.025	11.85	0.01	[65], Hejase 2011	doped wafer (concentration: unclear)
	9.91	0.001	9.91	0.001	[15], Grischkowsky 1990	high resistivity (>10Kohm CM)
Sapphire (A-plane)	9.41	0.01	9.43	0.031	[15], Grischkowsky 1990	C-axis ⊥ pol
	11.61	0.008	11.66	0.032	[15], Grischkowsky 1990	C-axis // pol
Al2O3			9.3	0.003	[65], Hejase 2011	
			9.28	0.004	[60], Bolivar2003	
LTCC #1 (5.53@)	5.43	0.053			own data	0.1mm 10 layers
LTCC #2 (7.1)	6.71	0.072			own data	0.1mm 10 layers
Quartz			3.84	0.004	[65], Hejase 2011	
			3.84	0.0037	[67], naftaly 2007	
	4.44	0.002	4.45	0.005	[15], Grischkowsky 1990	A-plane, C-axis ⊥ pol
	4.64	0.004	4.64	0.003	[15], Grischkowsky 1990	A-plane, C-axis // pol
Pyrex Glass			4.48 @ 0.8THz	0.052@0.8THz	[65], Hejase 2011	
			4.45	0.05	[67], naftaly 2007	
RO3010	12.5	0.025	14	>0.15	[65], Hejase 2011	graph read
RO3006	8	0.015	9	>0.15	[65], Hejase 2011	graph read
RO3003	3.2	0.01	3.2	0.02	[65], Hejase 2011	graph read
polytetrafluoroethylene (PTFE)			2.06	0.0004	[65], Hejase 2011	
			2.08	0.008	[62], Jin2006	
liquid crystal polymer (LCP)	3.5	0.02	3.51	0.05	[65], Hejase 2011	graph read
polyimide (dry)			3.27	0.021	[65], Hejase 2011	
polyimide (air)			3.37	0.037	[65], Hejase 2011	
	3.28	0.098	3.24	0.11	[62], Jin2006	graph read
	3.42	0.001				
Polycarbonate (PC)			2.61	0.027	[65], Hejase 2011	
			2.67	0.028	[67], naftaly 2007	
Zeonor			2.35	0.001	[65], Hejase 2011	
			2.28	0.001	[68], Podzorov2008	
high-density polyethylene (HDPE)			2.36	0.002	[65], Hejase 2011	
			2.37	0.002	[67], naftaly 2007	
	2.36	0.013	2.35	0.009	[62] Jin2007	
PET			2.98	0.031	[65], Hejase 2011	
	2.95	0.054	2.93	0.063	[62], Jin2006	
benzocyclobutene (BCB)			2.41-2.53	0.0042-0.039	[63], Perret2008	membrine structure
photopolymer resin (acrylic-based)			2.89-2.56	0.06	[64] Younus2009	commercial 3D printing material, FullCUreMaterials ®

- Packages for Terahertz Electronics
  - https://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=7819502
- Heterodyne terahertz detection through electronic and optoelectronic mixers
  - https://pubmed.ncbi.nlm.nih.gov/32208378/
  - The high sensitivity detection of terahertz radiation is crucial for many chemical sensing, biomedical imaging, security screening, nondestructive quality control, high-data-rate communication, atmospheric, and astrophysics sensing applications. Among various terahertz detection techniques, heterodyne detection is of great interest for applications that require high spectral resolution. Heterodyne detection involves mixing the received terahertz radiation with a reference terahertz signal provided by a local oscillator and then down-converting it to an intermediate frequency for detection. In this article, we present a broad overview of various types of heterodyne terahertz receivers, which utilize different electronic and optoelectronic techniques to down-convert the received terahertz signal to a radio frequency signal. We describe how the inherent nonlinearity of a Schottky diode, superconductor-insulator-superconductor junction, hot electron bolometer, and field-effect transistor can be utilized to mix the received terahertz radiation with a reference local oscillator signal from a gas laser, quantum cascade laser, photomixer, Gunn diode, IMPATT diode, and frequency multiplier and then down-convert it to a radio frequency signal. The down-converted radio frequency signal can be subsequently detected and analyzed by various backend spectrometers, including filter bank, acousto-optical, autocorrelator, fast Fourier transform, and chirp transform spectrometers. We also discuss how a photomixer pumped by a heterodyning optical beam can be used to down-convert the received terahertz radiation to a radio frequency signal with far fewer bandwidth constraints than conventional techniques.
- Broadband Terahertz Metal-Wire Signal Processors: A Review
  - https://www.mdpi.com/2304-6732/10/1/48
  - Among various terahertz waveguides, metal-wire waveguides have attracted particular attention due to their distinct characteristics, such as structural simplicity, broad operating bandwidths, low transmission losses, and low dispersion, in turn making them promising candidates for signal processing. However, because of the tight confinement of modal energy within the wavelength-scale space, manipulating the propagating terahertz signals in-between the metal-wires is challenging.
- Broadband Spintronic Terahertz Source with Peak Electric Fields Exceeding 1.5 MV/cm
  - https://journals.aps.org/prapplied/pdf/10.1103/PhysRevApplied.19.034018
  - The optimized STE inherits all attractive features of the standard STE design, for example, ease of use and the straightforward rotation of the terahertz polarization plane, without the typical 75% power loss found in LiNbO3 setups. It, thus, opens up a promising pathway to nonlinear terahertz spectroscopy. Using low-energy laser pulses (2 nJ, 0.2 mJ/cm2, 800 nm, 10 fs), the emitted

terahertz pulse has a focal peak electric field of 100 V/cm, which corresponds to a 2-fold improvement, and covers the spectrum 0.3–30 THz.

- Terahertz wave interaction with metallic nanostructures
  - https://www.degruyter.com/document/doi/10.1515/nanoph-2017-0093/html
- Flexible Metamaterial Quarter-Wave Plate and Its Application in Blocking the Backward Reflection of Terahertz Waves
  - https://www.mdpi.com/2079-4991/13/7/1279
  - A terahertz flexible metamaterial quarter-wave plate (QWP) is designed and fabricated using polyimide as the substrate in this paper, with a 3 dB axial ratio bandwidth of 0.51 THz and high polarization conversion efficiency and transmittance. The effect of the incidence angle on the polarization conversion performance of the QWP is discussed by measuring the transmissions at multiple incidence angles. The blocking effect of this QWP combined with a polarizer on the backward reflection of terahertz waves is investigated by terahertz time-domain spectral transmission experiments. Flexible terahertz metamaterial QWPs and polarizers can effectively block harmful reflected waves in terahertz communication and other systems. They have the advantages of a simple structure, ultra-thinness and flexibility, easy integration, no external magnetic field, and no low-temperature and other environmental requirements, thus having broad application prospects for terahertz on-chip integrated systems.



Retroreflector

22 languages

Article Talk — Read Edit View history Tools

From Wikipedia, the free encyclopedia

"Retro-reflection" redirects here. For the art project, see Retro-reflection (art project).

A **retroreflector** (sometimes called a **retroflector** or **cataphote**) is a device or surface that reflects radiation (usually light) back to its source with minimum scattering. This works at a wide range of angle of incidence, unlike a planar mirror, which does this only if the mirror is exactly perpendicular to the wave front, having a zero angle of incidence. Being directed, the retroflector's reflection is brighter than that of a diffuse reflector. Corner reflectors and cat's eye reflectors are the most used kinds.

Retroreflector

A gold corner cube retroreflector

Uses Distance measurement by optical delay line

Types [edit]

There are several ways to obtain retroreflection:[1]

Corner reflector [edit]

Main article: Corner reflector

A set of three mutually perpendicular reflective surfaces, placed to form the internal corner of a cube, work as a retroreflector. The three corresponding normal vectors of the corner's sides form a basis (x, y, z) in which to represent the direction of an arbitrary incoming ray, [a, b, c]. When the ray reflects from the first side, say x, the ray's x-component, a, is reversed to $-a$, while the y- and z-components are unchanged. Therefore, as the ray reflects first from side x then side y and finally from side z the ray direction goes from [a, b, c] to [$-a$, b, c] to [$-a$, $-b$, c] to [$-a$, $-b$, $-c$] and it leaves the corner with all three components of its direction exactly reversed.

Working principle of a corner reflector

Corner reflectors occur in two varieties. In the more common form, the corner is literally the truncated corner of a cube of transparent material such as conventional optical glass. In this structure, the reflection is achieved either by total internal reflection or silvering of the outer cube surfaces. The second form uses mutually perpendicular flat mirrors bracketing an air space. These two types have similar optical properties.

A large relatively thin retroreflector can be formed by combining many small corner reflectors, using the standard hexagonal tiling.

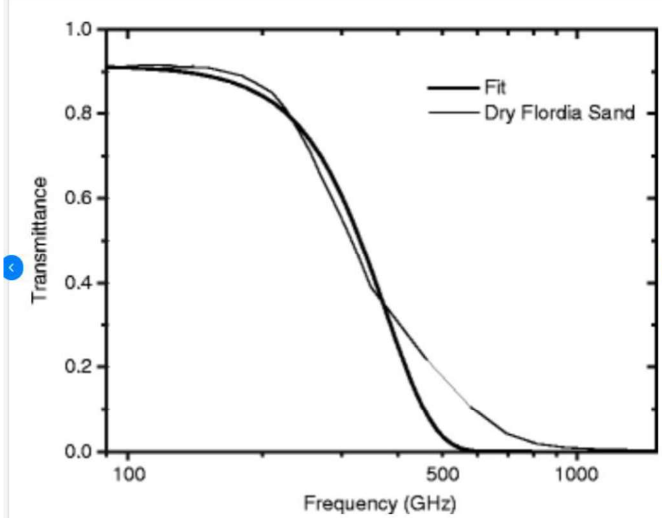
- MilliMirror: 3D Printed Reflecting Surface for Millimeter-Wave Coverage Expansion
  - http://xyzhang.ucsd.edu/papers/Kun.Qian_MobiCom22_MilliMirror.pdf

- Terahertz Van Atta Retroreflecting Arrays
    - https://link.springer.com/article/10.1007/s10762-020-00721-2
- Tunable perfect magnetic mirrors and retroreflectors in terahertz band
    - https://opg.optica.org/directpdfaccess/7f43a959-d228-472b-afbd2cb57e8934cf_425614/oe-28-1-753.pdf?da=1&id=425614&seq=0&mobile=no
- Planar, wide-band omnidirectional retroreflector using metal-only transmit array structure for TE and TM polarizations
    - https://www.nature.com/articles/s41598-022-15540-9
    - In military field, the retroreflector structures can be used for stealth and deception applications. In the field of stealth applications, sometimes there are small vehicles that have a small RCS and it is desirable that it can be detected by friendly radars but not by hostile radars. In these cases, it is desirable to use frequency-limited retroreflector structures mounted on small vehicles.
- Intelligent Reflecting Surfaces: Physics, Propagation, and Pathloss Modeling
    - https://arxiv.org/pdf/1911.03359.pdf
    - In this letter, we derive the far-field pathloss using physical optics techniques and explain why the surface consists of many elements that individually act as diffuse scatterers but can jointly beamform the signal in a desired direction with a certain beamwidth. We disprove one of the previously conjectured pathloss models.

- Sand

A wall made up of bags loaded with sand (ie, sand bags) should do it.

In the case of my stereo system, I built a room inside of a room. The inner room does not touch the outer room, so when the inner room vibrates, the air gap between them is a poor transmitter so one hardly hears anything outside the second room even when playing inside at rock concert levels.



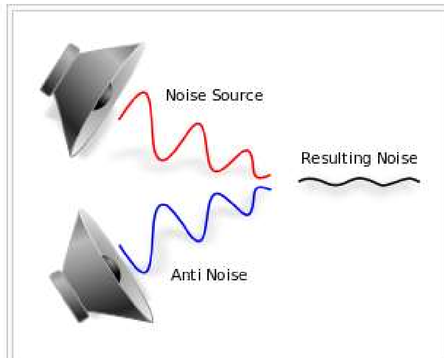
Transmittance of terahertz radiation in dry sand as a function of frequency and a theoretical model based on Rayleigh scattering [7]

    - Invited Review Terahertz Transmission, Scattering, Reflection, and Absorption—the Interaction of THz Radiation with Soils
        - https://www.researchgate.net/publication/316354934_Invited_Review_Terahertz_Transmission_Scattering_Reflection_and_Absorption-the_Interaction_of_THz_Radiation_with_Soils
- Colored lightbulbs/colored eye glasses
    - Short-Wavelength Light-Blocking Eyeglasses Attenuate Symptoms of Eye Fatigue
        - https://pubmed.ncbi.nlm.nih.gov/28118668/
        - Our results support the hypothesis that short-wavelength light-blocking eyeglasses may reduce eye strain associated with computer use based on a physiologic correlate of eye fatigue and on subjects' reporting of symptoms typically associated with eye strain.
    - Violet and blue light blocking intraocular lenses: photoprotection versus photoreception
        - https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1860240/
        - Action spectra for most retinal photosensitisers increase or peak in the violet part of the spectrum. Melanopsin, melatonin suppression, and rhodopsin sensitivities are all maximal in the blue part of the spectrum. Scotopic sensitivity and circadian photoentrainment decline with ageing. UV blocking IOLs provide older adults with the best possible rhodopsin and melanopsin sensitivity. Blue and violet blocking IOLs provide less photoprotection than middle aged crystalline lenses, which do not prevent age related macular degeneration (AMD). Thus, pseudophakes should wear sunglasses in bright environments if the unproved phototoxicity-AMD hypothesis is valid.
    - Do green-blocking glasses enhance the nonvisual effects of white polychromatic light?
        - https://pubmed.ncbi.nlm.nih.gov/30563575/
    - The Neurobiology Of Photophobia
        - https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6383812/
        - Photophobia is commonly associated with migraine, meningitis, concussion, and a variety of ocular diseases. Advances in our ability to trace multiple brain pathways through which light information is processed have paved the way to a better understanding of the neurobiology of photophobia and the complexity of the symptoms triggered by light.
    - Migraine photophobia originating in cone-driven retinal pathways
        - https://pubmed.ncbi.nlm.nih.gov/27190022/
        - Migraine headache is uniquely exacerbated by light. Using psychophysical assessments in patients with normal eyesight we found that green light exacerbates migraine headache significantly less than white, blue, amber or red lights. To delineate mechanisms, we used electroretinography and visual evoked potential recording in patients, and multi-unit recording of dura- and light-sensitive thalamic neurons in rats to show that green activates cone-driven retinal pathways to a lesser extent than white, blue and red; that thalamic neurons are most responsive to blue and least responsive to green; and that cortical responses to green are significantly smaller than those generated by blue, amber and red lights. These findings suggest that patients' experience with

colour and migraine photophobia could originate in cone-driven retinal pathways, fine-tuned in relay thalamic neurons outside the main visual pathway, and preserved by the cortex.

- Surrounding frequencies
  - Windchimes
  - Music/tones and specific frequencies

Active noise control (**ANC**), also known as **noise cancellation** (**NC**), or **active noise reduction** (**ANR**), is a method for reducing unwanted sound by the addition of a second sound specifically designed to cancel the first. The concept was first developed in the late 1930s; later developmental work that began in the 1950s eventually resulted in commercial airline headsets with the technology becoming available in the late 1980s. The technology is also used in road vehicles, mobile telephones, earbuds, and headphones.



Graphical depiction of active noise reduction

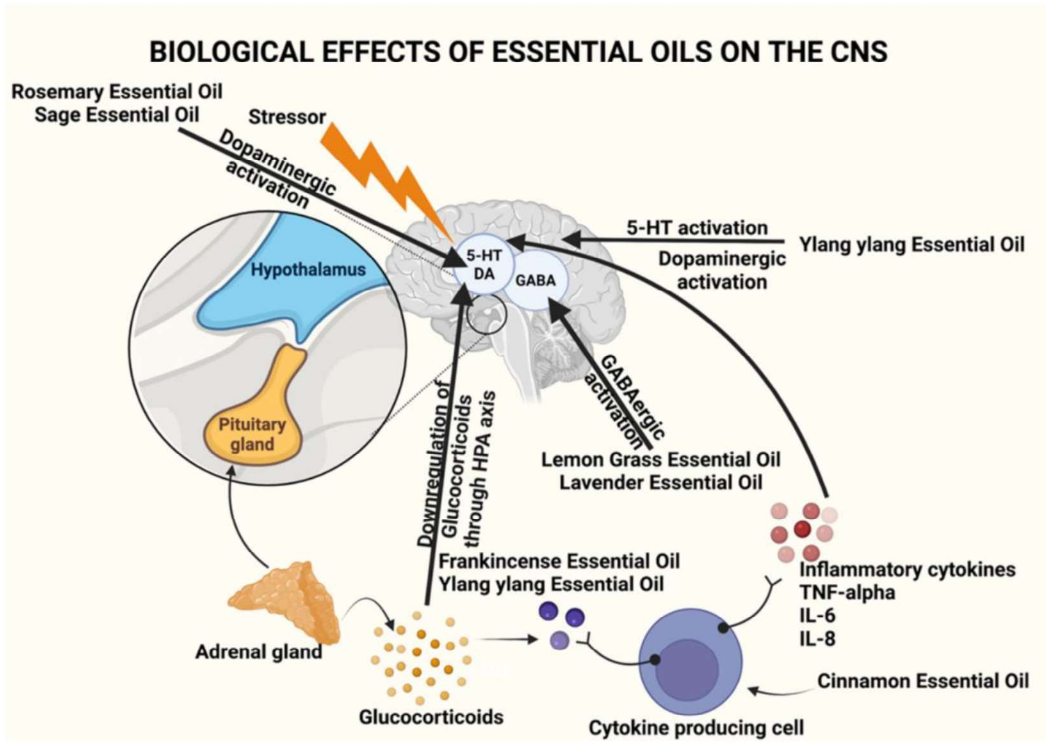
Explanation [edit]

Sound is a pressure wave, which consists of alternating periods of compression and rarefaction. A noise-cancellation speaker emits a sound wave with the same amplitude but with inverted phase (also known as antiphase) relative to the original sound. The waves combine to form a new wave, in a process called interference, and effectively cancel each other out – an effect which is called destructive interference.

  - Wide-band CMOS low-noise amplifier exploiting thermal noise canceling
    - https://ieeexplore.ieee.org/abstract/document/1263653
  - Laser Frequency Noise Cancelation in a Phase-Shifted Fiber Bragg Grating Ultrasonic Sensor System Using a Reference Grating Channel
    - https://ieeexplore.ieee.org/abstract/document/7400917
  - Design of UWB low noise amplifier using noise-canceling and current-reused techniques
    - https://www.sciencedirect.com/science/article/abs/pii/S0167926017302213
  - Recent trends in low-frequency noise reduction techniques for integrated circuits
    - https://ieeexplore.ieee.org/abstract/document/7288622
- Surrounding air
  - Ideal gas law = pV = nRT (pressure x volume = concentration of molecules x temperature)
  - Air filters
    - Reduce the quantity of exogenous air particulates from the outside atmosphere (chemicals in the sky that get inside)
  - Humidity
    - Terahertz refractive phenotype of living cells
      - https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9871359/
      - Compared with the visible region, the refractive index in the terahertz (THz) region is non-linear and reveals the reorientation dynamics of water that hydrates the biomolecules , which contains rich information closely related to the cellular activity and physiological status. Wang et al. (2019) found that various cells in nervous system had different refractive indices, which would increase after cancerization. However, due to the aqueous medium required for living cells measurement easily produces strong background signal interference (Peng et al., 2020),

there remains a big technical challenge for obtaining the refractive index of cells in a viable state.

- Temperature
- Essential oils/aroma therapy/clearing spray
  - Adding beneficial molecules back into the environment to change local resonance and concentration of atoms



  - Exploring Pharmacological Mechanisms of Essential Oils on the Central Nervous System
    - https://www.mdpi.com/2223-7747/11/1/21

Figure 1 Brain topographical map of the distribution of beta brainwave activity

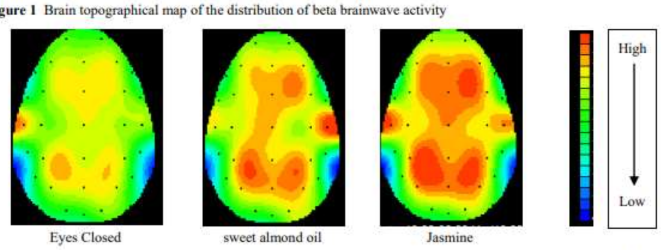


Figure 1 shows the brain topographical map of the distribution of beta brainwave activity. The red areas indicate a significant increase in power.

  - The effects of jasmine Oil inhalation on brain wave activies and emotions
    - https://www.researchgate.net/profile/Tapanee-Hongratanaworakit/publication/236235613_The_effects_of_jasmine_Oil_inhalation_on_brain_wave_activies_and_emotions/links/0deec5174d3e1133a5000000/The-effects-of-jasmine-Oil-inhalation-on-brain-wave-activies-and-emotions.pdf

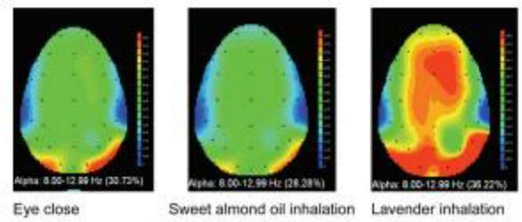


Fig. 2 Brain Topographical map of the distribution of alpha brainwave activity. The red areas indicate a significantly increase of power in bilateral temporal and central area during inhalation of lavender

        - The Effects of Lavender Oil Inhalation on Emotional States, Autonomic Nervous System, and Brain Electrical Activity
            - https://www.thaiscience.info/journals/Article/JMAT/10971475.pdf
        - Physiological effects in aromatherapy
            - https://files.achs.edu/mediabank/files/physiologicaleffectsofaromatherapy.pdf
        - Effects of Inhaled Rosemary Oil on Subjective Feelings and Activities of the Nervous System
            - https://www.mdpi.com/2218-0532/81/2/531
    - Candles
        - Method of evaluating human subconscious response to smell
            - https://patents.google.com/patent/US7871377B2/en
        - Smell and Stress Response in the Brain: Review of the Connection between Chemistry and Neuropharmacology
            - https://www.mdpi.com/1420-3049/26/9/2571
- Crystals
    - Shungite
        - Electromagnetic shielding effectiveness of lightweight and flexible ultrathin shungite plates
            - https://www.sciencedirect.com/science/article/abs/pii/S1567173921001577
        - EPR and magnetism of the nanostructured natural carbonaceous material shungite
            - https://link.springer.com/article/10.1007/s00269-009-0328-9
        - Static and dynamic conductivity of nanostructured carbonaceous shungite geomaterials
            - https://www.sciencedirect.com/science/article/abs/pii/S0254058419300379
    - Quartz/Amethyst/Citrine
        - Electroacoustic properties of quartz minerals in a finely dispersed state
            - http://real-j.mtak.hu/22066/5/EPA_2020_72_5_.pdf#page=30
        - Optical and Chemical Study of Quartz from Granitic Pegmatites
            - https://www.researchgate.net/profile/Delia-Androne-2/publication/327690375_-

_Optical_and_Chemical_Study_of_Quartz_from_Granitic_Pegmatites_-_Revista_de_Chimie_Bucuresti_vol_69_nr_7_1846-1850/links/5b9f69c7299bf13e603807cf/Optical-and-Chemical-Study-of-Quartz-from-Granitic-Pegmatites-Revista-de-Chimie-Bucuresti-vol-69-nr-7-1846-1850.pdf

- Method and apparatus for reducing physiological stress
  - https://patents.google.com/patent/US5562597A/en
- Quartz as a natural luminescence dosimeter
  - https://www.sciencedirect.com/science/article/abs/pii/S0012825209001500
  - The phenomenon of luminescence is related to the interaction of natural radiation with mineral grains, by the activation of and subsequent trapping of electrons at defects within the quartz lattice. The latent luminescence signal (i.e. the trapped electrons) is released when the grains are exposed to stimulation energy in the form of light or heat.
- Raman Spectroscopic Applications to Gemmology
  - https://books.google.com/books?hl=en&lr=&id=E9peWTnT9TgC&oi=fnd&pg=PA469&dq=electromagnetic+signals+quartz+citrine+amethyst&ots=YV__32Q50m&sig=z44FmzWMvLKfwKok4eb-5oaGpwc#v=onepage&q&f=false
- Electromagnetic Emissions from Quartz Subjected to Shear Stress: Spectral Signatures and Geophysical Implications
  - https://www.mdpi.com/2076-3263/10/4/140
  - For the first time, a characteristic migration of peak frequencies was observed, proportional to the evolution of the fracturing process. In particular, the continuous recording of the radio emission spectra shows a migration of the peaks toward higher frequencies, as stress continues over time and smaller and larger fractures form. This migration could be used to distinguish possible natural signals emitted by quartz in tectonically active environments from possible signals of other geophysical and possibly anthropogenic origin.
- New way to absorb electromagnetic radiation demonstrated -Scientists show that it is possible to fully absorb electromagnetic radiation using an anisotropic crystal
  - https://www.sciencedaily.com/releases/2016/01/160114113524.htm
  - It is possible to fully absorb electromagnetic radiation using an anisotropic crystal, report scientists. Electromagnetic energy harvesting in the visible spectrum is very important for photovoltaics -- the conversion of solar energy into direct current electricity. Absorbing materials in the microwave range of frequencies have an application that is equally as important, say scientists who are now able to reduce the radar visibility of an aircraft.

1.9.1 Isometric

The isometric crystal system is correspondingly identified as the cubic system (Figure 1.9). The crystallographic axes exploited in this system are of equivalent length and are jointly perpendicular, striking at right angles to one another. In these regards, entire crystals of the isometric system have four 3-fold axes of symmetry, each of which continues diagonally from corner to corner across the cubic's central unit cell. Crystals of the isometric system, therefore, may also reveal up to three separate 4-fold symmetry axes. These axes, subsequently, if exist, continue from the middle of every face across the origin to the middle of the opposite face and correspond to the crystallographic axes. Besides, crystals of the isometric system perhaps have six 2-fold axes of symmetry, which develop from the middle of every edge of the crystal across the origin to the middle of the contradictory edge. According to this view, minerals of this system perhaps reveal up to nine different mirror planes. For instance, halite, magnetite, and garnet are crystallized in the isometric system. Minerals of this system, therefore, tend to generate crystals of equidimensional or equant habit [11, 14].

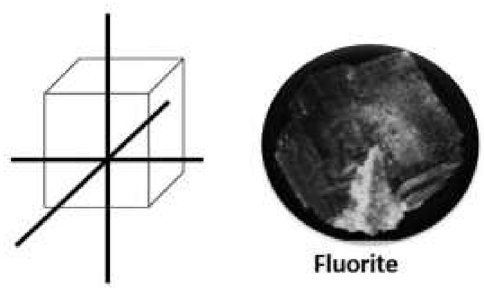


Figure 1.9. Isometric crystal system.

1.9.2 Hexagonal

Minerals of the hexagonal crystal system are denoted by three crystallographic axes, which crisscross at 120° and a fourth, which is upright to the other three (Figure 1.10). Therefore, this fourth axis is regularly depicted perpendicularly. In this sense, the hexagonal crystal system is alienated into the hexagonal and rhombohedral or trigonal partitions. Under this view, entire crystals of the hexagonal partition have a single 6-fold axis of rotation. Also, the crystals of the hexagonal partition perhaps have up to six 2-fold axes of rotation. In this regard, they perhaps reveal a middle of inversion symmetry and equal to seven mirror planes. Crystals of the trigonal division, moreover, entirely have a single 3-fold axis of revolution rather than the 6-fold axis of the hexagonal partition. Therefore, crystals of this division perhaps have up to three 2-fold axes of revolution and perhaps reveal a middle of inversion and up to three mirror planes. Apatite, beryl, and high quartz are such mineral species, which crystallize in the hexagonal division. Moreover, these minerals tend to form hexagonal prisms and pyramids. On the other hand, calcite, dolomite, low quartz, and tourmaline are the mineral species, which crystallize in the rhombohedral division and tend to create rhombohedra and triangular prisms [10, 13, 15].

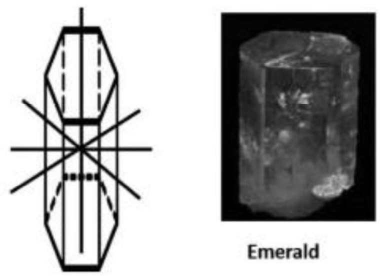


Figure 1.10. Hexagonal crystal system.

1.9.3 Tetragonal

Minerals of the tetragonal crystal system are represented by three jointly perpendicular axes (Figure 1.11). In this regard, the dual horizontal axes are of equivalent length, while the upright axis is of dissimilar length and can perhaps be either shorter

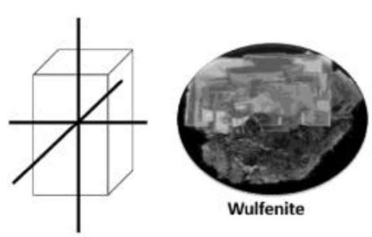


Figure 1.11. Tetragonal crystal system.

or longer than the other two. Minerals of this system would have a single 4-fold symmetry axis. In this view, they perhaps have up to four 2-fold axes of rotation, a middle of inversion, and up to five mirror planes. For instance, zircon and cassiterite are mineral species, which crystallize in the tetragonal crystal system and are inclined to generate the short crystals of prismatic habit [10, 12, 14].

1.9.4 Orthorhombic

Olivine and barite are mineral spices, which belong to the orthorhombic system (Figure 1.12) and tend to be of prismatic, tabular, or acicular habit. In this regard, these orthorhombic crystal systems are shown in three jointly upright axes, every one of which is of a dissimilar length than the others. Moreover, orthorhombic systems uniformly have three 2-fold rotation axes and/or three mirror planes. Therefore, the holomorphic category reveals three 2-fold symmetry axes and three mirror planes besides a middle of inversion. Subsequently, other categories perhaps display three 2-fold axes of rotation or one 2-fold rotation axis and dual mirror planes [12–15].

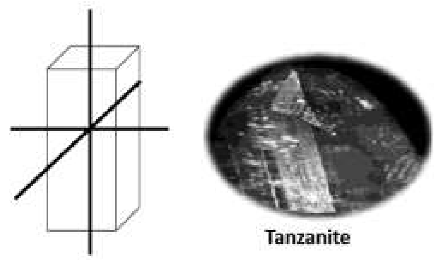


Figure 1.12. Orthorhombic crystal system.

1.9.5 Monoclinic

Minerals such as pyroxene, amphibole, orthoclase, azurite, and malachite, adhere to the monoclinic crystal system and tend to form long prisms. Therefore, the monoclinic crystal system is signified with three unequal axes (Figure 1.13). Dual of these axes are leant toward each other at an oblique angle; these are regularly represented steeply. In this view, the third axis is upright to the other two. The dual upright axes, consequently, do not interconnect one another at perpendicular angles,

Figure 1.13. Monoclinic crystal system.

even though both are upright to the horizontal axis. A single 2-fold rotation axis and/ or a single mirror plane, therefore, can be shown through monoclinic crystals. The holomorphic categories, consequently, have the single 2-fold rotation axis, a mirror plane, and the middle of symmetry. Moreover, different categories demonstrate an appropriate 2-fold rotation axis or proper mirror plane [13–16].

1.9.6 Triclinic

Plagioclase and axinite are the minerals species devoted to the triclinic category and tend to be of tabular habit. In this regard, triclinic crystals are referred to as three unequal axes (Figure 1.14), all of which crisscross at oblique angles. However, none of the axes is upright to any other axis. Perhaps this sort of crystal has only a 1-fold symmetry axis, which is equal to having no symmetry at all. In other words, the triclinic category has no mirror planes. Therefore, the holomorphic category reveals a middle of inversion symmetry [1, 8, 10, 16].

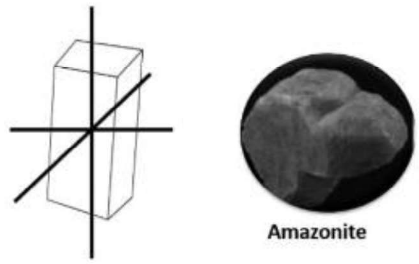


Figure 1.14. Triclinic crystal system.

1.9.7 Trigonal or Rhombohedral

A geometric system of trigonal or rhombohedral is based on a diagonally-stretched cube. For instance, Rhodochrosite crystallizes in the trigonal system (Figure 1.15). In this view, Rhodochrosite is the tendency of crystalline materials to split along definite crystallographic structural planes. These planes of relative weakness are a result of the regular locations of atoms and ions in the crystal, which create smooth repeating surfaces that are visible both in the microscope and to the naked eye [14–17].

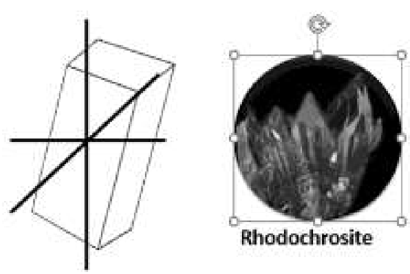


Figure 1.15. Trigonal or Rhombohedral crystal system.

- Rearranging items in your house frequently to make it more difficult for AI machine learning/algorithms