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[170] Leaflet by Optical Museum, Ernst Abbe Foundation Jena, Germany: *Riskieren Sie einen Blick in die Geschichte der Optik!*

[171] Table of Sellmeier constants in [22] p. 39. In the entry for "pure silica, annealed", the number for λ_1 is given as 0.068043; it must be 0.0684043.

[172] The sampling theorem was first formulated by H. Nyquist in 1928, later C. Shannon gave a mathematical proof. See [137] or [129].

[173] Planck's radiation law is treated in many textbooks on optics or lasers; see, e.g., [135] or [151].

[174] The laser linewidth is treated in most textbooks on lasers; see, e.g., [151]

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Glossary

Amplifier (p. 134): In optics, a device which increases the power of a light wave passing through it. Amplifiers are a central element of any → laser. In optical telecommunications, mostly semiconductor optical amplifiers and doped-fiber amplifiers are used.

Autocorrelator (p. 277): Device to measure the duration of ultrashort pulses down to the few-femtosecond regime. The light beam is split into two; both parts are brought together again with variable delay in a nonlinear medium. The mixing signal is detected; the detector does not have to be very fast. The resulting signal, mathematically the autocorrelation function of the pulse shape, allows conclusiuons about pulse duration and shape.

Avalanche diode (p. 149): Special type of → photodiode, in which a high bias voltage is applied to accelerate charge carriers to the point that they in turn generate new carriers. In an avalanche process, an amplification of the primary photocurrent is obtained.

Bandwidth (p. 213): Frequency interval over which a certain signal contains energy. Usually stated as the difference between highest and lowest signal frequency.

Bending loss (p. 77): When an optical fiber is tightly bent, additional loss occurs. A fiber that carries visible light can be observed to shine brightly at tight bends; here, some of the guided light is lost.

Birefringence (p. 48): Phenomenon in anisotropic materials. Light of different linear → polarization is subject to different → refractive index.

Bragg effect (p. 124): A periodic array of scatterers (a grating, in the widest sense) can reflect a wave when a certain relation between grating constant (grating period) and wavelength is fulfilled; named after William Henry Bragg and William Lawrence Bragg (father and son), who shared a Nobel prize in 1915.

Channel (transmission channel) (p. 224): General term for an arbitrary transmission medium such as a cable and radio link. which provides a certain → bandwidth. This results in a certain → channel capacity.

Channel (frequency channel) (p. 219): A frequency band reserved for a specific signal is also called a channel. Using several channels, different signals can be transmitted simultaneously; this is well known for radio and TV. In fiber optics one such channel may also be called a → WDM channel to clarify this use of the term.

Channel capacity (p. 224): According to a theorem by C. Shannon, there is a maximum rate with which information can be successfully transmitted over a given → channel; this rate is known as channel capacity.

Chirp (p. 162): Term denoting a slide of carrier frequency within a short pulse of light. The product of spectral and temporal width can be equal to or larger than a certain constant; in the presence of chirp it is larger.

Circulator (p. 130): A device to steer light signals between several ports. It lets light beams pass in one direction. Light beams traveling in the the opposite direction are redirected to a third direction.

Cladding (p. 17): The zone in an optical fiber which surrounds the → core. In most commercially available fibers the outside diameter of the cladding is 125 µm.

Core (p. 17): The innermost zone in the structure of an optical fiber. In the case of → single-mode fibers the radius is several micrometers. Most of the light is guided in the core.

Coupler (p. 131): Device for coupling of two fibers, so that signals traveling in them can be split or combined.

Cutoff wavelength (p. 38): The shortest wavelength at which a fiber supports only a single mode. Occasionally also used for the limit of existence range of higher-order → modes.

Dispersion (p. 10, 47): Wavelength dependence of some optical characteristic of a signal. This may be the → refractive index of a glass or the deflection angle of a prism ("angular dispersion"). In fiber optics the term usually refers to the group velocity dispersion.

Fabry–Perot interferometer (p. 122): Arrangement in which light passes back and forth between two mirrors. When the round trip distance equals an integer multiple of the wavelength, a resonance occurs. Fabry–Perot interferometers are often used to select specific wavelengths, e.g., in laser resonators. The name derives from Charles Fabry and Alfred Pérot (Marseille, ca. 1890).

Fiber (p. 6): Spelled *fibre* in Great Britain. Here the term refers to optical fibers, thin flexible strands of glass which can conduct light.

Fiber laser (p. 145): A type of → laser, in which the → amplifier (gain medium) is formed by a fiber which is doped with active substances. In optical telecommunications, it is particularly the Erbium-doped fiber which finds widespread use.

Fused silica (p. 92): Chemically, silicon dioxide, but in glassy rather than crystalline form. The corresponding crystal is called quartz.

Gaussian beam (p. 269): Light beam which contains a single spatial → mode. It is characterized by a transverse power profile which takes the form of a Gaussian. Gaussian beams are diffraction-limited, i.e., their spread is minimal. They are typically generated in lasers. In fibers, the fundamental → mode is only approximately Guassian.

Gradient index profile (p. 22): In some fibers the → refractive index in the → core is not constant but varies continuously in the radial direction, typically in a parabolic way. In → multimode fibers, such a profile reduces → modal dispersion.

Holey fiber (p. 68): The → cladding of this type of fiber contains voids, i.e., cylindrical hollows which run the entire length of the fiber. This lowers the effective → refractive index of the cladding and enables the guiding of light.

Isolator (p. 128): In optics, an arrangement which allows light to pass in one direction, but blocks it in the opposite direction.

Kerr effect (p. 155): Also known as "quadratic electro-optic effect," named after John Kerr (1875). By the Kerr effect the → refractive index of a material is modified in proportion to the square of the amplitude of an applied electric field. In fibers the "optical Kerr effect" occurs in which the light field takes the role of the applied field. Then the refractive index is modified in proportion to the intensity of the light.

Laser (p. 5): The acronym stands for "light amplification through stimulated emission of radiation." A light source capable of producing coherent light. The laser principle relies on stimulated emission in a material which is used as an optical → amplifier. Energy must be supplied for the amplification; in the example of → diode lasers, this is done by running a current through the device.

Laser diode (p. 140): Type of laser, in which the → amplifier (gain medium) is formed by a semiconductor device of diode structure. Energy is supplied by an operating current.

LED (p. 140): Acronym for *light-emitting diode*, also known as luminescent diode. A semiconductor device producing light when an operating current passes through. Simpler in structure than a → diode laser; also, the light is not coherent. Often used for indicator or pilot lights in electronic equipment of all kinds. Increasingly used for general illumination as LED technology proceeds because LEDs are much more power-efficient than light bulbs.

Material dispersion (p. 47): Phenomenon based on the frequency dependence of the → refractive index. It lets short pulses of light widen as they propagate through a fiber. It also causes chromatic abberations in lens-based imaging and enables prisms to spread white light into colors.

Modal dispersion (p. 20): In → multimode fibers different → modes propagate at different speed. This causes a scatter in the arrival time at the receiving end. This spreading of a signal pulse is called modal dispersion and is typically measured in ps/km.

Mode (p. 32): Throughout physics there is an important concept of elementary oscillations known as modes. Resonators of a given geometry support specific modes which can be obtained from the geometric constraints. For example, a violin string has a fundamental oscillation and harmonics, each with its own characteristic frequency and oscillation pattern. In optical fibers, the constraints select certain field distributions and propagation constants known as the modes of the fiber. Fibers can be designed to be → single-mode or → multi-mode fibers.

Mode coupling (p. 23): Energy can be exchanged between the → modes of a fiber at perturbations of the geometry, like in tight bends.

Mode locking (p. 141): The phases of longitudinal modes of a laser can be locked together to generate very short pulses of light.

Modulation (p. 212): In optics, the controlled modification of amplitude, phase, frequency, or polarization of a light wave in order to impress information on it which is then carried along.

Modulational instability (p. 165): Phenomenon in some materials exhibiting → nonlinearity, in which a continuous wave becomes unstable and forms a more or less periodic modulation. In fibers this can happen by the interplay of → Kerr effect and anomalous → dispersion.

Multimode fiber (p. 7): Type of fiber which supports several → modes. Due to → modal dispersion this is useful only for moderate data rates and short distances. Plastic optical fibers are almost always multimode fibers. The total power of the light signal is distributed over all participating → modes. This distribution may fluctuate; then *mode partition noise* is generated which can be a nuisance in many contexts including fiber-optic → sensor applications. The safest fix is the use of → single-mode fiber.

Nonlinearity (p. 153): The phenomenon that a property of a device or material which has an influence on the signal may not be constant but affected by the signal. In fiber optics the most relevant nonlinearity is that the → refractive index of the fiber depends on the light intensity by way of the → Kerr effect.

Normalized index step (p. 19): A metric for the difference of → refractive index between → core and → cladding of a fiber. In most fibers this difference is in the range from 0.001 to 0.01. Bend loss tends to be lower for fibers with large values.

NRZ (p. 220): Acronym for *no return to zero*: A binary coding format in which the light power stays constant throughout the entire clock period. In a succession of several logical "1"s, the light power stays on for several clock cycles, without returning to zero in between. Compare → RZ.

Numerical aperture (p. 19): A metric for the acceptance angle of a fiber, i.e., the angle of the cone within which light can be coupled into a fiber. The same cone also appears for light leaving the fiber.

OTDR (p. 114): Acronym for *optical time domain reflectometry*: Procedure to measure the time after which a light pulse returns from the fiber and to evaluate for the position of loss from bends, splices, damage, etc.

Photo diode (p. 146): Semiconductor device for the detection of light. The photoeffect creates free charge carriers inside the photodiode; these give rise to a current which can be measured.

Photonic crystal fiber (p. 68): Similar to → holey fiber, voids run the entire length of the fiber in the → cladding zone. Here the holes are located precisely in a periodic pattern so that by a → Bragg effect it acts as a reflector. This generates a strong guiding of light so that the → core can even have a *lower* → refractive index than the → cladding, without compromising the guiding.

PMD (p. 64): Acronym for *polarization mode dispersion*. In → birefringent fibers, parts of the signal with different → polarization propagate at different speed; this causes a distortion of the signal.

Polarization (of matter) (p. 26): Under the action of an external electrical field as provided by a light wave, electrons in a material experience Coulomb interaction forces. This distorts the atomic orbitals. Do not confuse with → polarization of light.

Polarization (of light) (p. 48): Orientation of the oscillation in a wave. The oscillation can take place longitudinally (e.g., in sound waves in air) or transversally (in light waves). If it is transversal, there are several choices for the direction: The oscillation can be linear (two orthogonal directions, and their linear combinations) or circular (two directions of rotation, and their linear combinations). Ordinary lamp light or sunlight is often called "nonpolarized"; here the state of polarization changes extremely rapidly so that over time all possibilities are represented with equal probability. Do not confuse with → polarization of matter.

Polarization-maintaining fiber (p. 66): A type of fiber in which by design the → birefringence has been made large. To maintain polarization requires that the light be linearly polarized along one of the birefringent axes.

Polarizer (p. 127): Device which selects the component of a desired polarization from a light beam with arbitrary → polarization.

Preform (p. 93): Intermediate state in the production of optical fibers.

Refractive index (p. 48): Also index of refraction: An important quantity in optics to characterize a material. The refractive index is a complex function of wavelength. The real part indicates how much the speed of light is reduced in comparison to vacuum. It also governs the angle of refraction when light passes through an interface between different media and is therefore responsible for the function of prisms and lenses, among other things. Its frequency dependence gives rise to → material dispersion. The imaginary part describes the attenuation of the light wave. Since attenuation can often be neglected in typical materials encountered in optics (air, glass, etc.), the term "refractive index" is often used for the real part alone.

RZ (p. 220): Acronym for *return to zero*: A binary coding format in which a light pulse signals a logical "1," and its absence a logical "0." The pulse duration is shorter than the clock period so that at the beginning and end of each clock period the intensity is zero in any event. Compare → NRZ.

Self phase modulation (p. 162): Process in optical fibers in which → nonlinearity (→ Kerr effect in particular) generates a → chirp in light pulses.

Sensor (p. 247): Device which assesses some physical (or chemical, etc.) quantity and transfers the value to some easily evaluated format, such as an electrical voltage. Fiber-optic sensors gain acceptance and sometimes can do things which other sensors cannot.

Single-mode fiber (p. 7): Fiber which supports only a single → mode. Speaking strictly, this mode is doubly degenerate (and may therefore be counted as two) due to polarization effects. Single-mode fibers are indispensible for the transmission of very high data rates over long distances.

Soliton (p. 164): A light pulse which maintains its shape during propagation in the presence of both → dispersion and → Kerr effect.

Splice (p. 123): Low-loss joint between two fibers. Most often, fusion splices are used: The cleaved surfaces of two fibers are put together, heated, and melted together.

Step index fiber (p. 17): Optical fiber consisting of → core and → cladding; either zone has a fixed → refractive index. This results in a radial step in the index profile.

TDM (p. 218): Acronym for *time division multiplex.* Format for the simultaneous transmission of several signals which are interleaved into each other so that one falls into the pauses of the other.

Total internal reflection (p. 15): Phenomenon at the interface between two materials with different → refractive index. The medium with the higher index is often called "optically more dense." If a light ray inside the more dense medium ($n = n_a$) hits the interface with the "thinner" medium ($n = n_b$) under a sufficiently flat angle, it gets totally reflected. The limiting angle is given by $\alpha_{\text{crit}} = \arcsin(n_b/n_a)$.

Waveguide dispersion (p. 47): Contribution to a fiber's total → dispersion which is specific to the geometry of a waveguide.

WDM (p. 218): Acronym for *wavelength division multiplex.* Format for the simultaneous transmission of several signals by spreading them out over the available → bandwidth of the → transmission channel.

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