# INTERACTIONS BETWEEN ELECTROMAGNETIC FIELDS AND MATTER. pdf

## 1: :: International Commission for Electromagnetic Safety ::

*Interactions between Electromagnetic Fields and Matter deals with the principles and methods that can amplify electromagnetic fields from very low levels of signals. This book discusses how electromagnetic fields can be produced, amplified, modulated, or rectified from very low levels to enable these for application in communication systems.*

Although modern quantum optics tells us that there also is a semi-classical explanation of the photoelectric effect â€”the emission of electrons from metallic surfaces subjected to electromagnetic radiation â€”the photon was historically although not strictly necessarily used to explain certain observations. It is found that increasing the intensity of the incident radiation so long as one remains in the linear regime increases only the number of electrons ejected, and has almost no effect on the energy distribution of their ejection. Only the frequency of the radiation is relevant to the energy of the ejected electrons. This quantum picture of the electromagnetic field which treats it as analogous to harmonic oscillators has proven very successful, giving rise to quantum electrodynamics , a quantum field theory describing the interaction of electromagnetic radiation with charged matter. It also gives rise to quantum optics , which is different from quantum electrodynamics in that the matter itself is modelled using quantum mechanics rather than quantum field theory. Dynamics[ edit ] In the past, electrically charged objects were thought to produce two different, unrelated types of field associated with their charge property. An electric field is produced when the charge is stationary with respect to an observer measuring the properties of the charge, and a magnetic field as well as an electric field is produced when the charge moves, creating an electric current with respect to this observer. Over time, it was realized that the electric and magnetic fields are better thought of as two parts of a greater whole â€" the electromagnetic field. Until , when the Danish physicist H. In , Michael Faraday , one of the great thinkers of his time, made the seminal observation that time-varying magnetic fields could induce electric currents and then, in , James Clerk Maxwell published his famous paper A Dynamical Theory of the Electromagnetic Field. If these other charges and currents are comparable in size to the sources producing the above electromagnetic field, then a new net electromagnetic field will be produced. Thus, the electromagnetic field may be viewed as a dynamic entity that causes other charges and currents to move, and which is also affected by them. This discussion ignores the radiation reaction force. Feedback loop[ edit ] The behavior of the electromagnetic field can be divided into four different parts of a loop: A common misunderstanding is that a the quanta of the fields act in the same manner as b the charged particles that generate the fields. In our everyday world, charged particles, such as electrons, move slowly through matter with a drift velocity of a fraction of a centimeter or inch per second, but fields propagate at the speed of light - approximately thousand kilometers or thousand miles a second. The mundane speed difference between charged particles and field quanta is on the order of one to a million, more or less. Those fields can then affect the force on, and can then move other slowly moving charged particles. Charged particles can move at relativistic speeds nearing field propagation speeds, but, as Einstein showed[ citation needed ], this requires enormous field energies, which are not present in our everyday experiences with electricity, magnetism, matter, and time and space. The feedback loop can be summarized in a list, including phenomena belonging to each part of the loop: Mathematical descriptions of the electromagnetic field There are different mathematical ways of representing the electromagnetic field. The first one views the electric and magnetic fields as three-dimensional vector fields. These vector fields each have a value defined at every point of space and time and are thus often regarded as functions of the space and time coordinates. As such, they are often written as E x, y, z, t electric field and B x, y, z, t magnetic field. If only the electric field E is non-zero, and is constant in time, the field is said to be an electrostatic field. Similarly, if only the magnetic field B is non-zero and is constant in time, the field is said to be a magnetostatic field. In the vector field formalism, these are:

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## 2: Interactions Between Electromagnetic Fields And Matter | Download eBook PDF/EPUB

*The interactions that can be studied between electromagnetic fields and living matter are divided into two main groups. The interactions that produce thermal effects and the ones that do not produce thermal effects.*

These interactions can occur locally as well as on very large scales between objects such as galaxies, stars, and planets. They can be loosely classified into electromagnetic interactions, flow-object interactions, plasma-neutral interactions, and radiation-plasma interactions. Magnetic field lines connecting different plasma populations act as channels for the transport of plasmas, currents, electric fields, and waves between the two environments. In this way, the two plasmas become coupled electromagnetically to one another. When a flowing magnetized plasma strikes a solid object, an atmosphere, or a magnetosphere, strong interactions of various types can occur. Flow-object interactions range from the simple sputtering of ions from solid surfaces like the Moon to the production of flux ropes around unmagnetized planets with atmospheres like Venus , to magnetic reconnection and the resulting production of large-scale disturbances like magnetic storms at planets with magnetospheres. Throughout the solar system and universe, plasmas are generally embedded in a background neutral gas with which they interact. Radiation-plasma interactions are important in solar and stellar atmospheres, which respond to and mediate radiation in the form of magnetohydrodynamic waves and shocks emanating from the stellar surfaces and more energetic ultraviolet and x-ray photons propagating downward from the stellar coronas. These interactions will determine, for example, how ultraviolet emissions observed from stellar atmospheres are best interpreted in terms of their vertical structure. Finally, the interactions described here take place over tremendous ranges of temporal and spatial scales. The spatial scales are often classified in terms of microscales at which individual particle motions Page 47 Share Cite Suggested Citation: Plasma Physics of the Local Cosmos. The National Academies Press. Often the mesoscale and macroscale dynamics are produced by microscale phenomena as magnetic reconnection leads to coronal mass ejections and magnetospheric substorms , while macroscale phenomena can drive dynamics at the smaller scales as the Kelvin-Helmholtz instability is generated by large-scale flows of plasma along a boundary layer. As discussed in the preceding chapter, it is a fundamental property of space and astrophysical plasmas that efficient communication can occur across the various spatial scales. In the following sections, the various plasma coupling phenomena are described briefly and some of their universal aspects are noted. Throughout there are close connections to material addressed, for example, in Chapters 2 , 3 , and 5. At Earth, the most important manifestation of this process is the strong electromagnetic coupling that occurs between the magnetosphere and the ionosphere. This coupling includes plasma circulation, plasma escape along field lines, field-aligned particle acceleration, and parallel to B currents. The current density along magnetic field lines is provided by electrons from the ionosphere the downward currents and the much more tenuous magnetosphere the upward currents. Since the magnetospheric densities are low a few per cubic centimeter at most at Earth , intense upward currents require field-aligned electric fields, which accelerate magnetospheric electrons down into the atmosphere to produce the required current and, in the process, create bright auroral forms. The aurora consists of two components: The processes that drive field-aligned currents into ionospheric plasmas also generate electric fields transverse to the magnetic field, the strength and location of which are strongly influenced by the properties of the ionospheric plasma. A two-way coupling between such regimes is set up in response to the driving field-aligned currents. These transverse electric fields drive ionospheric circulation and, through ion-neutral collisions, the motion of the neutral atmospheric gas. Similarly, the ionospheric feedback electric fields map upward along the magnetic fields, affecting processes in the overlying regions. In the terrestrial environs, the development of a disturbance ring current drives strong electric fields in regions of low ionospheric conductivity. Auroral emissions can be seen extending to high latitudes on the nightside. Also evident are the terminator the boundary between the dayside and the nightside and, at the right of the image, bright ultraviolet dayglow emissions from the sunlit hemisphere. Page 49 Share

Cite Suggested Citation: The image shows the main auroral oval, diffuse polar cap emissions, and auroral emissions at the magnetic footprints of Io I , Ganymede G , and Europa E. Image courtesy of J. Reprinted, with permission, from J. Copyright , Macmillan Publishers Ltd. The electrodynamical interaction between Jupiter and Io has been known for some time and is evidenced by radio emissions and auroral emissions at the foot of the flux tube linking the planet to the satellite. Recent Hubble Space Telescope observations of similar localized emissions at the magnetic footpoints of Ganymede and Europa are evidence that these moons, too, are electrically coupled by field-aligned currents with the jovian ionosphere Figure 4. In the case of the supersonic solar wind encountering a planetary obstacle, the outermost boundary is a bow shock discussed in Chapter 3 , which heats and slows down the solar wind so that it can flow around the obstacle. If the planet is strongly magnetized, the solar wind is separated from the planetary plasma environment by a boundary known as a magnetopause. A magnetopause also exists at the jovian moon Ganymede, whose intrinsic magnetic field was discovered in ; in this case, however, the ambient plasma is that of the jovian magnetosphere rather than the solar wind. The separation of solar wind and magnetospheric plasmas is not perfect, owing to a dissipation of the magnetopause current, allowing plasma and electric fields to penetrate the magnetopause. At Earth, this interaction produces a dynamic response that depends to a certain extent on the properties of the upper atmosphere, producing heat and auroral light emissions. Since Mercury, the only other terrestrial planet with a significant global magnetic field, has no atmosphere, but only a tenuous exosphere of sodium and Page 50 Share Cite Suggested Citation: The process of stellar collapse can be summarized through the following paradigm: This disk transfers mass onto the central protostar while angular momentum is transferred outward. In general, it appears that the formation of a jet combined with an accretion disk is a crucial element of angular momentum shedding. These processes in particular for high-mass stars are poorly understood, since an adequate description of viscosity in hydromagnetic disks is still lacking. Nevertheless, the presence of a disk, as well as jets, has been observed and provides a mechanism for the formation of planetary bodies. Many such mysteries surround the early phases of the formation of stellar and planetary systems. Among these are the following see figure, p. What processes control the collapse of molecular cloud cores during the earliest phases of stellar system formation? Strong coupling between the neutral gas and dust components and the magnetized plasma components is thought to play a major role. The process of ambipolar diffusion that allows these components to separate is not well understood. That process has close analogues with the plasma-neutral interactions see discussion in this chapter occurring near the heliospheric boundaries, the plasma-neutral coupling occurring in planetary upper atmospheres, and the plasma-netural-dust interactions occurring in the neighborhood of comets. Solar system plasma physics has much to contribute to this topic. A related question is, What role does hydromagnetic turbulence play in the initial cloud-core collapse? Similar issues of turbulent transport processes surround the solar-system analogues to this problem already mentioned in Chapter 3. How are bipolar jets created and maintained? The solar wind most certainly breaches, by magnetic reconnection, the magnetopauses of Jupiter and the other gas giants as well, but the extent of the contribution of the resulting energy transfer to magnetospheric dynamics at these planets is not known. The boundary that separates the solar wind plasma from the ionospheric plasma is called the ionopause Figure 4. In addition to the thermal pressure of the ionosphere against the solar wind, the solar wind is also opposed by a magnetic barrier that Page 51 Share Cite Suggested Citation: Magnetic field forcing also plays a central role in some theories of bipolar jet formation, which further aids the shedding of angular momentum. The physics involved in all of these applications is fundamentally similar to the physics in processes ongoing in solar system plasmas. Bipolar outflows and the shedding of angular momentum during star formation. Panel a is reprinted by permission from F. Observation and theory, Annual Review of Astronomy and Astrophysics 25, , Copyright , Annual Reviews www. Panel b is courtesy of C. Panel c is reprinted, with permission, from J. Shu, Magnetocentrifugally driven flows from young stars and disks. Copyright by the American Astronomical Society. As in the case of magnetized bodies, the separation of the solar wind plasma and the planetary or cometary plasma is not perfect, and at times of high solar wind dynamic pressure, the solar wind magnetic field may penetrate into the ionosphere. Once inside the magnetosphere, this solar wind energy powers high-latitude ionospheric convection, generates field-aligned currents into and out of the ionosphere, initiates geomagnetic storms and substorms, produces the ring current, and drives auroral displays. All of these phenomena intensify during periods of southward interplanetary magnetic field IMF orientation. Many mechanisms, including diffusion, impulsive penetration, and the Kelvin-Helmholtz instability, have been proposed to account for the interaction of the solar wind with the terrestrial magnetosphere. Reprinted, with permission, from T. Cravens, The solar wind interaction with non-magnetic bodies and the role of small-scale structures, pp. Copyright , American Geophysical Union. Some models propose that merging always occurs in the vicinity of the subsolar point on the magnetopause, others that its location depends on the IMF orientation. Some models propose that it occurs steadily, others that it takes place in bursts. Some models suggest that bursty merging occurs in response to varying solar wind conditions, others that it occurs in response to intrinsic magnetopause instabilities. Some models require that it occurs along an extended line, others that it takes place in patches. Because almost all of these studies were based on single-point measurements during transient magnetopause crossings, they could not determine the extent of merging, its duration, whether it was more rapid in the subsolar region or elsewhere, or whether it was triggered by varying solar wind conditions. Recent imaging of the proton aurora by the NASA IMAGE satellite, which can identify protons accelerated by the reconnection electric field as they bombard the dayside upper atmosphere, has shown that magnetic reconnection occurs continuously at the magnetopause, changing location in response to variations in the direction of the solar-wind magnetic field. In situ measurements by the four-spacecraft Cluster II mission have confirmed that the reconnection regions connect to the proton aurora emission regions. Such energetic neutral atoms, which retain the energy and velocity of the parent ions, can be detected remotely to produce global images of the magnetospheric ion populations. Near ionopauses, the relatively hot solar wind ions can exchange charge with planetary neutrals, thereby affecting the plasma populations there. Exchange of charge with solar wind protons is one of the mechanisms by which inflowing interstellar neutrals are converted to ions within the heliosphere. The other mechanism is photoionization by solar ultraviolet radiation. The ions newly created by charge exchange and photoionization are picked up by the solar wind and transported outward, toward the termination shock, where some of them are accelerated to extremely high energies. These return to the inner heliosphere as anomalous cosmic rays. The resulting energetic neutral oxygen atom is no longer trapped and can travel in a line-of-sight path away from the source population B. The detection of such energetic neutral atoms by a remote imager allows global images to be made of magnetospheric plasmas, which are invisible to standard astronomical observing techniques. Page 54 Share Cite Suggested Citation: It is, for example, responsible for the neutral hydrogen wall between the termination shock and the heliopause. In addition to charge exchange, other ion-neutral collisional processes can affect the momentum and energy transfer between different spatial domains, such as between ionospheres and magnetospheres. In the upper atmosphere of planets or comets where significant neutrals exist, plasma dynamics both drives and responds to the neutral circulation, leading to coupling and feedback between these regions. When the reconnection rate at the dayside magnetopause is significantly reducedâ€”for example, when the IMF suddenly turns from southward to northwardâ€"the magnetospheric driver of the ion motion is quickly reduced, whereas the neutrals tend to maintain their original inertial motion, forming a so-called fly-wheel effect. Under such circumstances, neutrals transfer energy and momentum to the ions, thus providing a mechanical and electromagnetic coupling from the thermosphere to the ionosphere and the magnetosphere. While radiative transfer in dynamic gaseous media is a well-developed discipline, the importance of the interaction between electromagnetic radiation and matter in the plasma state has only recently been recognized and analyzed.

## 3: Electromagnetism - Wikipedia

*Evidence for the interactions between external electromagnetic fields, diffusion and deformation mechanisms have been gathered over the years, a global yet detailed understanding of the interactions between electromagnetic fields and solid-state matter transport is far from being reached.*

History of electromagnetic theory Originally, electricity and magnetism were considered to be two separate forces. There are four main effects resulting from these interactions, all of which have been clearly demonstrated by experiments: Electric charges attract or repel one another with a force inversely proportional to the square of the distance between them: Magnetic poles or states of polarization at individual points attract or repel one another in a manner similar to positive and negative charges and always exist as pairs: An electric current inside a wire creates a corresponding circumferential magnetic field outside the wire. Its direction clockwise or counter-clockwise depends on the direction of the current in the wire. A current is induced in a loop of wire when it is moved toward or away from a magnetic field, or a magnet is moved towards or away from it; the direction of current depends on that of the movement. As he was setting up his materials, he noticed a compass needle deflected away from magnetic north when the electric current from the battery he was using was switched on and off. This deflection convinced him that magnetic fields radiate from all sides of a wire carrying an electric current, just as light and heat do, and that it confirmed a direct relationship between electricity and magnetism. However, three months later he began more intensive investigations. Soon thereafter he published his findings, proving that an electric current produces a magnetic field as it flows through a wire. The CGS unit of magnetic induction oersted is named in honor of his contributions to the field of electromagnetism. James Clerk Maxwell His findings resulted in intensive research throughout the scientific community in electrodynamics. This unification, which was observed by Michael Faraday , extended by James Clerk Maxwell , and partially reformulated by Oliver Heaviside and Heinrich Hertz , is one of the key accomplishments of 19th century mathematical physics. It has had far-reaching consequences, one of which was the understanding of the nature of light. Unlike what was proposed by the electromagnetic theory of that time, light and other electromagnetic waves are at present seen as taking the form of quantized , self-propagating oscillatory electromagnetic field disturbances called photons. Different frequencies of oscillation give rise to the different forms of electromagnetic radiation , from radio waves at the lowest frequencies, to visible light at intermediate frequencies, to gamma rays at the highest frequencies. In , Gian Domenico Romagnosi , an Italian legal scholar, deflected a magnetic needle using a Voltaic pile. The factual setup of the experiment is not completely clear, so if current flew across the needle or not. An account of the discovery was published in in an Italian newspaper, but it was largely overlooked by the contemporary scientific community, because Romagnosi seemingly did not belong to this community. The owner emptying the box on a counter where some nails lay, the persons who took up the knives, that lay on the nails, observed that the knives took up the nails. On this the whole number was tried, and found to do the same, and that, to such a degree as to take up large nails, packing needles, and other iron things of considerable weight Whittaker suggested in that this particular event was responsible for lightning to be "credited with the power of magnetizing steel; and it was doubtless this which led Franklin in to attempt to magnetize a sewing-needle by means of the discharge of Leyden jars. The electromagnetic force is one of the four known fundamental forces. The other fundamental forces are: In particle physics though, the electroweak interaction is the unified description of two of the four known fundamental interactions of nature: All other forces e. Roughly speaking, all the forces involved in interactions between atoms can be explained by the electromagnetic force acting between the electrically charged atomic nuclei and electrons of the atoms. Electromagnetic forces also explain how these particles carry momentum by their movement. This includes the forces we experience in "pushing" or "pulling" ordinary material objects, which result from the intermolecular forces that act between the individual molecules in our bodies and those in the objects. The electromagnetic force is also involved in all forms of chemical phenomena. As a collection of electrons becomes more confined, their minimum momentum necessarily increases due to the Pauli exclusion principle. The behaviour of matter at the molecular scale including its density is determined by the balance between the electromagnetic force and the force generated by the exchange of momentum carried by the electrons themselves. Classical electrodynamics In , William Gilbert proposed, in his De Magnete , that electricity and magnetism, while both capable of causing attraction and repulsion of objects, were distinct effects. Mariners had noticed that lightning strikes had the ability to disturb a compass needle. One of the first to discover and publish a link between man-made electric current and magnetism was Romagnosi , who in noticed that connecting a wire across a voltaic pile deflected a nearby compass needle. A theory of electromagnetism, known as classical electromagnetism , was developed by various physicists during the period between and when it culminated in the publication of a treatise by James Clerk Maxwell , which unified the preceding developments into a single theory and discovered the electromagnetic nature of light. This violates Galilean invariance , a long-standing cornerstone of classical mechanics. One way to reconcile the two theories electromagnetism and classical mechanics is to assume the existence of a luminiferous aether through which the light propagates. However, subsequent experimental efforts failed to detect the presence of the aether. For more information, see History of special relativity. In addition, relativity theory implies that in moving frames of reference, a magnetic field transforms to a field with a nonzero electric component and conversely, a moving electric field transforms to a nonzero magnetic component, thus firmly showing that the phenomena are two sides of the same coin. Hence the term "electromagnetism". For more information, see Classical electromagnetism and special relativity and Covariant formulation of classical electromagnetism. Extension to nonlinear phenomena[ edit ] Magnetic reconnection in the solar plasma gives rise to solar flares , a complex magnetohydrodynamical phenomenon. The Maxwell equations are linear, in that a change in the sources the charges and currents results in a proportional change of the fields. Nonlinear dynamics can occur when electromagnetic fields couple to matter that follows nonlinear dynamical laws. This is studied, for example, in the subject of magnetohydrodynamics , which combines Maxwell theory with the Navierâ€”Stokes equations. Quantities and units[ edit ].

# INTERACTIONS BETWEEN ELECTROMAGNETIC FIELDS AND MATTER. pdf

## 4: Electromagnetic radiation - Wikipedia

*Quantum mechanics and Maxwell's theory can then account for the precise description of the interactions between the electromagnetic fields and matter. This book then describes special processes such as 1) the static and quasistatic interactions and 2) dynamic processes, particularly the resonance process.*

Theory[ edit ] Shows the relative wavelengths of the electromagnetic waves of three different colours of light blue, green, and red with a distance scale in micrometers along the x-axis. Because the speed of EM waves predicted by the wave equation coincided with the measured speed of light , Maxwell concluded that light itself is an EM wave. In an electromagnetic wave, the changes in the electric field are always accompanied by a wave in the magnetic field in one direction, and vice versa. This relationship between the two occurs without either type field causing the other; rather, they occur together in the same way that time and space changes occur together and are interlinked in special relativity. Together, these fields form a propagating electromagnetic wave, which moves out into space and need never again affect the source. The distant EM field formed in this way by the acceleration of a charge carries energy with it that "radiates" away through space, hence the term. Near and far fields[ edit ] Main articles: Electromagnetic radiation thus includes the far field part of the electromagnetic field around a transmitter. A part of the "near-field" close to the transmitter, forms part of the changing electromagnetic field , but does not count as electromagnetic radiation. Currents directly produce a magnetic field, but it is of a magnetic dipole type that dies out with distance from the current. In a similar manner, moving charges pushed apart in a conductor by a changing electrical potential such as in an antenna produce an electric dipole type electrical field, but this also declines with distance. These fields make up the near-field near the EMR source. Neither of these behaviours are responsible for EM radiation. Instead, they cause electromagnetic field behaviour that only efficiently transfers power to a receiver very close to the source, such as the magnetic induction inside a transformer , or the feedback behaviour that happens close to the coil of a metal detector. This distant part of the electromagnetic field is "electromagnetic radiation" also called the far-field. The far-fields propagate radiate without allowing the transmitter to affect them. This causes them to be independent in the sense that their existence and their energy, after they have left the transmitter, is completely independent of both transmitter and receiver. Due to conservation of energy , the amount of power passing through any spherical surface drawn around the source is the same. Because such a surface has an area proportional to the square of its distance from the source, the power density of EM radiation always decreases with the inverse square of distance from the source; this is called the inverse-square law. This is in contrast to dipole parts of the EM field close to the source the near-field , which varies in power according to an inverse cube power law, and thus does not transport a conserved amount of energy over distances, but instead fades with distance, with its energy as noted rapidly returning to the transmitter or absorbed by a nearby receiver such as a transformer secondary coil. Whereas the magnetic part of the near-field is due to currents in the source, the magnetic field in EMR is due only to the local change in the electric field. In a similar way, while the electric field in the near-field is due directly to the charges and charge-separation in the source, the electric field in EMR is due to a change in the local magnetic field. Both processes for producing electric and magnetic EMR fields have a different dependence on distance than do near-field dipole electric and magnetic fields. Now independent of the source charges, the EM field, as it moves farther away, is dependent only upon the accelerations of the charges that produced it. It no longer has a strong connection to the direct fields of the charges, or to the velocity of the charges currents. This 3D animation shows a plane linearly polarized wave propagating from left to right. Note that the electric and magnetic fields in such a wave are in-phase with each other, reaching minima and maxima together. Electrodynamics is the physics of electromagnetic radiation, and electromagnetism is the physical phenomenon associated with the theory of electrodynamics. Electric and magnetic fields obey the properties of superposition. Thus, a field due to any particular particle or time-varying electric or magnetic field contributes to the fields present in the same space due to other causes. Further, as they are vector fields, all magnetic and electric field vectors add together according to vector addition. However, in nonlinear media, such as some crystals , interactions can occur between light and static electric and magnetic fields â€” these interactions include the Faraday effect and the Kerr effect. Light of composite wavelengths natural sunlight disperses into a visible spectrum passing through a prism, because of the wavelength-dependent refractive index of the prism material dispersion ; that is, each component wave within the composite light is bent a different amount. Both wave and particle characteristics have been confirmed in many experiments. Wave characteristics are more apparent when EM radiation is measured over relatively large timescales and over large distances while particle characteristics are more evident when measuring small timescales and distances. For example, when electromagnetic radiation is absorbed by matter, particle-like properties will be more obvious when the average number of photons in the cube of the relevant wavelength is much smaller than 1. It is not too difficult to experimentally observe non-uniform deposition of energy when light is absorbed, however this alone is not evidence of "particulate" behavior. Rather, it reflects the quantum nature of matter. Some experiments display both the wave and particle natures of electromagnetic waves, such as the self-interference of a single photon. A quantum theory of the interaction between electromagnetic radiation and matter such as electrons is described by the theory of quantum electrodynamics. Electromagnetic waves can be polarized , reflected, refracted, diffracted or interfere with each other. In homogeneous, isotropic media, electromagnetic radiation is a transverse wave , [20] meaning that its oscillations are perpendicular to the direction of energy transfer and travel. In dissipation less lossless media, these E and B fields are also in phase, with both reaching maxima and minima at the same points in space see illustrations. A common misconception is that the E and B fields in electromagnetic radiation are out of phase because a change in one produces the other, and this would produce a phase difference between them as sinusoidal functions as indeed happens in electromagnetic induction , and in the near-field close to antennas. However, in the far-field EM radiation which is described by the two source-free Maxwell curl operator equations, a more correct description is that a time-change in one type of field is proportional to a space-change in the other. The frequency of a wave is its rate of oscillation and is measured in hertz , the SI unit of frequency, where one hertz is equal to one oscillation per second. Light usually has multiple frequencies that sum to form the resultant wave. Different frequencies undergo different angles of refraction, a phenomenon known as dispersion. A wave consists of successive troughs and crests, and the distance between two adjacent crests or troughs is called the wavelength. Waves of the electromagnetic spectrum vary in size, from very long radio waves the size of buildings to very short gamma rays smaller than atom nuclei. Frequency is inversely proportional to wavelength, according to the equation:

# INTERACTIONS BETWEEN ELECTROMAGNETIC FIELDS AND MATTER. pdf

## 5: Electromagnetic field - Wikipedia

*Electromagnetism is a branch of physics involving the study of the electromagnetic force, a type of physical interaction that occurs between electrically charged particles. The electromagnetic force usually exhibits electromagnetic fields such as electric fields, magnetic fields and light, and is one of the four fundamental interactions.*

Radio waves are one form of EMF. So is ordinary light. Electromagnetic fields are produced by every electrical or electronic device. This includes electrical wiring and power lines, computers, televisions, wireless devices such as cell phones and WiFi devices, microwave ovens, all forms of broadcasting including AM, FM, and TV, etc. Visible light as well as invisible forms such as infrared, and ultraviolet, X-Rays, and gamma rays are also forms of EMF. By causing this gradient of ions, which is a natural occurrence if the cell itself is receiving membrane damage, it causes initially the cell to heal the tissue, providing a small growth in the tissue. However, like all effects of EMF on living tissue, if exposed for too long, these healing mechanisms are surpassed and the tissue itself will start to malfunction and radiation hormesis an hypothesis that states that although short expositions to weak EMF are beneficial, long term exposition is hazardous occours. This results in hypothyroidism and subsequently an increase in the general obesity of the population. This lack of attention can, in case of children, cause autism and other nervous system disorders. Both of these factors can cause mutations in the DNA by changing its structure and atoms, resulting in higher chance of producing cancerogenic cells. Another content of lysosomes that can be leaked and reach the matrix of the nucleous is the enzyme DNAase. This enzyme has the function to destroy DNA, and if in contact with DNA, it will destroy the hydrogen bond and result in a change of information in the DNA that can result in cancer, hyper or hypo trophy. ELF extremely low frequency currents that flow throughout the tissue due to EMFs intervention on these have a preference to cause the removal of calcium ions from the membrane. This reaction, described as inward calcium ion leakage, may cause the problems listed above. In normal circumstances, this ELF current do have a beneficial intervention, stimulating the growth of the tissue in a small quantity, but if in constant exposition to the EMF, one may suffer from inhibition of this growth and repair of tissue, due to the excess of energy needed to repair the tissue. In this cases, permanent damage to the tissue may occur. Other similar experience is done and repeated many times since when it was first noticed. If neoplastic HeLa cells are stimulated with the power of 0. After a while their necrosis will happen, leading to a conclusion that the low EMFs cause a change in the cell membrane that stimulates aggregation and fusion of cells, followed by their necrosis. This research has proved to be a step forward in new ways of eliminating cancerogenic cells if used in long term expositions. The intracellular changes verified in these cells were the following: Increase in the alteration level of cytoskeleton fiber in relation to the control cells, demonstrating a higher change in orientation; Change in the mitochondrial matrix, showing leck of homogeny compared to the control cells; Presence of autophages in many cells; Furthermore, it could be observed Chromatin degeneration, thickening of the chromatin at the nuclear membrane level, nucleus vacuolization and mitochondrial degeneration. It relies on the usage of Pulses of the EMF, by using the magnetic field to pulse electric signals into the tissue and cell. This pulses simulate the find of feedback a tissue would receive to start tissue healing.

## 6: FieldsMatter - FieldsMatter SPP

*The study of the interactions between electromagnetic fields and living matter has become a fertile field for research in the last century, even though these phenomena have been empirically observed by various civilisations since ancient times (1, 2).*

## 7: Interaction in the Steady State between Electromagnetic Waves and Matter

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*"Non-Thermal Effects and Mechanisms of Interaction Between Electromagnetic Fields and Living Matter", a monograph edited by Livio Giuliani and Morando Soffritti for the "European Journal of Oncology" - Library Vol. 5 of the National Institute for the Study and Control of Cancer and Environmental Diseases "Bernardo Ramazzini", Bologna, Italy, , Part I and Part II.*

## 8: Interactions of electromagnetic fields with living matter - WikiLectures

*An electromagnetic field (also EMF or EM field) is a physical field produced by electrically charged objects. It affects the behavior of charged objects in the vicinity of the field. The electromagnetic field extends indefinitely throughout space and describes the electromagnetic interaction.*

## 9: 4 Plasma Interactions | Plasma Physics of the Local Cosmos | The National Academies Press

*whereas the electromagnetic field HL and its interaction with the matter HLM are time-dependent. A quantum mechanical treatment of the light would describe the light in terms of photons for different modes of electromagnetic radiation, which we will describe later.*

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*Cinnamon shops, and other stories. 142 Linear versus Logarithmic Scales Mass Communications History Center, Wisconsin Center for Film and Theater Research, collections Ihsaa baseball rules book Neil gaiman the sandman series The family tree of painting Techniques for the classification and prediction of corporate financial distress and their applications Lipoprotein structure A time for tigers Refutation of the Misstatements and Calumnies contained in Mr. Lockharts Life of Sir Walter Scott, Bart. Dreams and secrets DiAnn Mills How To Mesmerize Animals Pamphlet Philological Studies Cartridge Details The care and feeding of the gen-x soul John R. Mabry My Name is Michele Understanding children through observation The nine discourse bridge Negotiate like the big guys Oversight of veterans health care program in Florida Evidence-based clinical supervision I. Before Communion, 64 The clinical practice of chinese medicine Natural microporous materials in environmental technology Fitkini body challenge Shadow of the Badger DAMRON Womens Traveller (The Best Lesbian Guide to the USA, Canada, European Cities More On the other side of reality Silicon Carbide Ceramics No time-limit for these crimes! Responding to crises in the 1980s Describing the universe Cell and molecular biology ebook. In situ and laboratory experiments on electoral law reform 12. Linguistic etiquette in Japanese society Florian Coulmas V. 2. The house of Lancaster (cont. Piedmontese, a tale. 4 Introduction to Whitehall, 1952-1955 Depression relapse prevention plan Madame, a life of Henrietta Total quality management principles and practices*