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Get a Straight Answer

Please note!

Listed below are questions submitted by e-mail to the author of "The Great Magnet, the Earth." Some of them (marked ***) came in response to an earlier site "The Exploration of the Earth's Magnetosphere" and are also found there in the question-and-answer section. Only some of the questions that arrive are listed, **either** because they keep coming up again and again--on the reversal of the Earth's magnetic field, for instance--**or** because the answers add extra details, which might interest other users.

Index of Questions arranged by Subject

Items covered:

If you have a relevant question of your own, you can send it to
earthmag("at" symbol)phy6.org
Before you do, though, please read the instructions

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49. Loss of magnetic energy from Earth

Dr. Stern,

Upon looking at many web sites regarding geomagnetism, I wish to inquire of you about the following

1. Does the earth **radiate energy** because of its magnetic field? In any manner, similar to or dissimilar from pulsars, does the rotating non-axisymmetric field produce any radiating energy? Assuming it does, what rate of production (power output) exists or has existed in the past?

2. Does **magnetic pole reversal dissipate internal energy** from the earth? Does the reversal represent a reduction from a high-energy state (wound up magnetic field lines as in the sun), to a lower-energy state (relaxed in some way)? What amount of energy release accompanies such a change? What form does it take (radiation, temperature increase at depth, something else)?

I am interested in earth's energy budget through geologic time, and the major components of it--additions and subtractions.

REPLY

Dear Mark

Any loss of the Earth's rotational energy to electromagnetic radiation (as a rotating asymmetric dipole) is probably completely negligible. If I recall right, the radiated energy of a Hertzian oscillator goes like the **4th power of the frequency**, which comes to a very small amount, because the Earth rotates so slowly. Furthermore, the dipole is shielded from infinity by electric currents on the magnetopause. I would think that other effects associated with the rotating magnetic field may be more important (but still negligible).

The energy balance of magnetic pole reversal is complicated, and we don't really have all its factors yet. It is not that the Earth has a primordial magnetic field which is gradually being dissipated--in which case one could indeed ask whether the dissipation is affected by reversals. Rather, **that field is constantly being regenerated** by the

dynamo mechanism, driven by convection due to various types of heat release. We are yet uncertain what heat sources contribute--the two main suspects are heating by radioactive elements (although most such elements seem to be in the crust, not the core) and by solidification of molten iron onto the surface of the inner core--but the magnitudes of these processes are uncertain.

In this view, the core maintains a sort of energy balance, between the amount generated as heat and converted to convective flows and then to electric currents (responsible for the magnetic field), and between losses to viscosity, ohmic resistance and conductions out to the mantle and beyond. My suspicion is that reversals are just an incidental facet of the process, and may make relatively little difference.

49. Tesla's patents, and ball lightning

Greetings and thanks for such an informative and enjoyable website. My adventure in the study of 'electric and magnetic energy' has just begun. In my studies I have come across some of the writings of Nikola Tesla and have become intrigued. Tesla seemed to have been able to "tap" into one or more of the levels of the earth's magnetoshpere through several different methods. At this time, I am interested in one of his methods (see copies of Tesla's patents at **http://project-ufo.com/tesla/database_tesla.htm**). Also, in his other research he was able to produce and maintain "Ball lightning (spherical plasmoids, foudre spherique,or kugelblitz)."

My questions are these:

1. What is the radiant energy that Tesla was utilizing?
2. What is ball lightning?

Just a note of interest for those interested, I have come across an 'object of art' from the British artist Richard Box (**http://www.richardbox.com/**) demonstrating transmission of electricity through ambient air [from adjacent high voltage power lines]:

> "A fluorescent tube glows when an electrical voltage is set up across it. The electric field set up inside the tube excites atoms of mercury gas, making them emit ultraviolet light. This invisible light strikes the phosphor coating on the glass tube, making it glow. Because power lines are typically 400,000 volts, and Earth is at an electrical potential voltage of zero volts, pylons create electric fields between the cables they carry and the ground.

REPLY

Dear Don

I am afraid I cannot help you much. Tesla's language is not transparent, but after reading his patent, my guess is that he wrote about some **photo-electric effect**, a novelty in 1901. Consider a satellite in sunlight: the sun's rays eject electrons from its atoms, and cause it to accumulate some positive electric charge. The charge is small, however, because the electrons are ejected with an energy of only a few electron volts. So, once the charging brings the satellite up to (say) 10 volts, no more electrons will leave, they will all be repelled back to the metal skin of the satellite. If somehow one of the floating electron hits the skin and is re-absorbed, another "photoelectron" can take its place, but the total charge stays the same.

Maybe something similar happened in Tesla's apparatus, and if a capacitor is connected ("condenser") it can accumulate charge and slow down the rise of voltage. The amount of energy is however negligible.

Similarly, I suspect the amount of **power extracted by the fluorescent tubes** of Richard Box is small. I remember how in my army service, our barracks had electricity leak into the cinderblock (from private lines soldiers rigged up, using poorly insulated phone wire). Before an officer found out and stopped the practice, you could stick a neon lamp onto the wall (one of those the little circuit-tester lights), hold the other end between two fingers, and it would light up: the voltage was enough for that, but the current was too small to feel. There does exist an electric field near power lines, but air is still a good insulator and allows very little leakage (though the AC field may also excite atoms inside the lamps).

In short, **there's no secret source of energy**.

About **ball lightning** a lot gets written, but no testable evidence exists. "Plasmoids" of glowing plasma can exist in very rarefied gas, for small fractions of a second. In air of atmospheric pressure, though, they would get almost instantly dissipated, as ions and electrons collide and recombine.

I hope you also study the mainline of the science of electricity and magnetism!

51. Can electricity be generated from Earth's magnetic field?

Can electricity be generated from Earth's magnetic field?

I have heard that this could be done, but would like to hear your understanding about it.

REPLY

Dear Tim

Yes, it can be done, but the answer probably isn't the one you want. We can get electricity from the magnetic field, but we need invest energy equal to what we get out, or a little more to take care or electric resistance and friction.

Specifically, you can whirl around a "**search coil**" in the Earth's magnetic field, and extract an induced current due to its motion in a magnetic field. It's a bit like the way an electric generator creates a current from a coil rotating between its pole pieces. Some spinning satellites and space probes have used search coils to observe the ambient magnetic field, or at least its two components perpendicular to the spin axis.

But there ain't no such thing as free power from the Earth's magnetic field.

52. Decay of magnetism in a magnet

I have a question about decrease of strength of magnet with respect of time.

There are three magnets.

(1) First magnet's poles are kept in direction of East and West,
(2) second magnet's poles are kept in direction of North and South poles, and
(3) third magnet's poles are kept opposite to second position.

All three magnets are kept in only Earth's magnetic field. **My question**: among these three which magnet loses maximum strength after a period of long time?

REPLY

I am no expert, but as far as I know, under usual circumstances **magnets stay magnetized**, with no change. After all, lodestones--natural magnets--may be many thousands of years old yet remain strongly magnetic. The spreading basalts of the ocean floor have kept their magnetization (a weak one, true) for millions of years. So I don't expect ordinary steel magnets to grow weaker, although in some substances weakening might perhaps occur.

Heating a magnet above a certain temperature ("Curie Point") will cause it to lose magnetization. Exposure to rapidly alternating magnetic field can erase magnetism, and I think (not completely sure) that intense vibration can also do so. Under ordinary circumstances, however, none of your three magnets is expected to change.

Have you ever heard of a magnetic compass losing its directional ability? In the early days of sailing ships the legend was circulating that the breath of a sailor who had eaten **garlic** can cause this to happen, and sailors who smelled of garlic were (according to the story) punished by flogging if they got too close to a compass. William Gilbert around 1600 checked this and found that garlic had no effect on magnets.

53. Magnetizing glass by a radio wave?

Is it possible to impart magnetic character to a piece of glass from a radio wave? The thought is **similar to rubbing a piece of glass with wool** to place a charge on it. Could a radio wave make a thin, hanging piece of glass magnetic?

REPLY

Dear Chris

I am sorry to disappoint you, but sources of electric and magnetic fields are quite different.

Glass can indeed be electrified by rubbing. I remember as teaching assistant (while in graduate school) I would tell a student that I can erase the picture on the screen of an oscilloscope (which actually had a transparent plastic cover) by rubbing it with a cloth. "No, you cannot!" the student would protest, "you are rubbing on the outside while the picture on the screen is traced by a beam of electrons inside!" But I would pull out a clean handkerchief and wipe off the picture. Of course, it was the electric charge on the plastic cover that did it, by repelling the electrons and diverting them to the sides of the tube. After a while, as the charge leaked away, the picture would creep back

Magnetism on the other hand **needs electric CURRENTS**, steady flows of electric charges, or at the very least ordered atomic magnets (especially electrons, which are miniature magnets by virtue of their "spin"). I know no way of providing either in glass.

Even steel, which CAN be magnetized, would not become magnetized by a radio wave--first, the magnetic field needs exceed a certain (rather large) threshold before it makes steel magnetic. And second, the very fast alternation of the direction of the magnetic field is more than the steel can follow. In fact, I believe an alternating magnetic field (not nearly as fast) is used in devices designed to **erase** messages on magnetic disks, by disorienting magnetic domains.

54. Magnetization of materials

My name is Catrina. I am currently in a geology class and we have

recently studied Earth's magnetic field. I have been trying to find out **why, if you break a magnet in half, one fragment will reverse polarity**. A second part to this question is why do nails become magnetized when placed on a magnet and does this weaken the magnet's magnetism? :)

Also, could Earth's magnetic liquid core slowly **magnetize the solid inner core** over a long period of time until a point when the outer core, because of it's liquidity, becomes unattached and reverses polarity?

Second: Could the fact that, as much new crust is being formed, it has magnetic makeup that forms in agreement with the current polarity, contribute an **additional source of magnetism**? As more crust is created with concurrent polarity to the liquid outer core, the crust as a whole is slowly being magnetized toward that direction because new crust will not form in a polarity opposing Earth's current polarity; and although some rock is eroded, warped and moved; the majority is stable and relatively still. Could it be possible that this continues until the majority of Earth's crust is polarized in agreement with the liquid core to a point when the liquid core flips polarity?

REPLY

Dear Catrina

Like most correspondents, you did not say which of my web pages you have read (clearly, you got my address from one of them). If you have not done so yet, please read all parts of "The Great Magnet, the Earth," where many of your concerns are addressed.

Very briefly now:

(1) Breaking a bar magnet in two **does NOT** produce reverse polarity: If (say) the original magnet had the N pole on the left and the S pole on the right, each of its pieces, after the break, will **also** have N on the left and S on the right.

(2) Nails do not weaken a magnet, but they **channel magnetic field lines**, concentrating them in the iron and spreading them apart (which makes the field weaker) in the space **not** occupied by iron.

(3) The Earth's core is **much too hot** to be permanently magnetized. I am not sure how hot--more than 3000 deg C I think--but permanent magnetism disappears around 500 deg. or lower, depending on the material.

(4) **New crust** is only formed on the ocean floor, and rather slowly. By the time the ocean floor adds 20-40 kilometers, the field usually reverses and the new floor is reversely polarized. Thus sea-floor

magnetization forms alternating strips, containing about equal amount of each polarity. In addition, compared to the "main field" from the core, this is a very weak magnetic source.

55. Induction by non-fluctuating magnetic fields?

Hi, your web site is really awesome, but it doesn't answer the one question that sent me looking for info on the web in the first place. From everything I have ever heard, the only magnetic field that can induce a current is **a fluctuating one**. Per my understanding a **static** magnetic field does NOT cause electrons to flow, only a varying one. The magnetic field of the earth doesn't fluctuate around, so how is that the charged particles started circling around the lines of force. And why would they spiral in towards the N/S magnetic poles? I thought that the current is supposed to run strictly **at right angles** to the magnetic field??

Thanks for your help.

REPLY

Dear Diane

As the poet wrote, "a little knowledge is a dangerous thing." There is so much involved in magnetism, in current and trapped particles, that a short message here won't do it justice! My advice is look up my web sites on the magnetosphere and the Earth's field, and take your time.

Still, some quick answers:

(1) True--a **fluctuating magnetic field** will induce a voltage, which can drive current, while a static magnetic field just sits there. But there exists another situation important in space (and in the dynamo mechanism of sunspots and the Earth's core): a magnetic field in a fluid conducting medium which FLOWS--where part of it moves with respect to the other. See for instance

http://www.phy6.org/earthmag/dynamos.htm

and sections that follow. One such flow is the flow of the solar wind past the Earth, and apparently, this creates currents which flow into the polar ionosphere and out of it, giving us aurora as by-product. The cartoon depicting this in the web page "**The Magnetosphere**" is almost certainly an oversimplification (we really don't completely know the circuit), but that apparently is the source, and the energy comes from the kinetic energy of the solar wind.

(2) Now about those **auroral currents**: they indeed flow **ALONG** magnetic field lines. You write "I thought that the current is supposed to run strictly at right angles to the magnetic field," but that is true only for the magnetic field **generated by the current itself**. The field

lines involved here are created by the earth's core, a much stronger source (50,000 nT at the Earth's surface, whereas the currents near Earth may generate 50 nT). The field of the currents themselves therefore only adds a little twist to those field lines.

About the spiraling, etc.--you will have to read about it in "The Exploration of the Earth's Magnetosphere," home page
http://www.phy6.org/Education/wcurrent.htm
I hope you will find them interesting in their own right.

56. "Good magnetic insulators"

I am a seventh grade student in Denver, Colorado. I am currently working on a science fair project. My project is about what materials make good magnetic insulators. I would greatly appreciate any information you could send me on this topic.

REPLY

Dear Maya

There exist magnetic shields, but they are not made of "magnetic insulators." On the contrary, they are excellent "conductors" of magnetic field, and their role is to **divert** the magnetic field--instead of continuing straight to whatever is being shielded, the field lines are grabbed by the shield and flow through it, around the shielded object.

I do not know the situation nowadays, but it used to be that TV video tubes and cathode ray tubes in oscilloscopes had magnetic shields wrapped around their necks. Both these use a beam of electrons to "paint" a picture on a glowing screen, and the shield was meant to stop any existing magnetic fields from interfering with the beam. High magnetic permeability (denoted by the Greek letter mu) helps here, so one alloy used is called "mumetal."

For a demonstration of the ultimate in magnetic shielding, see 2nd half of my web page **http://www.phy6.org/earthmag/magmeter.htm**

57. Creating magnetic pottery

I am trying to discover a way of inserting magnets into pottery. I understand however that when heat is applied to magnets they lose their properties. I would like to use magnetic filings rather than a lump of metal. Is there any possible way of magnetising the filings perhaps after they have been kilned in the clay?

REPLY

Dear Matthew

The question your are asking goes well beyond my area of expertise, but perhaps I can guide you to a better resource.

Yes, permanent magnets indeed lose their magnetism past a "Curie temperature" which can be somewhere between 250 and 600 deg. C, depending on the substance. See:

http://www.geo.umn.edu/orgs/irm/hg2m/hg2m_b/hg2m_b.html
In principle, you might be able to bake pieces of iron into pottery and then magnetize them, although they do have very different coefficients of expansion.

Instead I would encourage you to look into pottery materials which are naturally magnetic. I don't know how magnetic you want your pottery to be (or your reasons for making it magnetic) but many ceramic materials are naturally magnetic. Some of the strongest magnets made commercially are ceramic--although, admittedly, they have very special compositions.

But even ordinary ceramic materials exhibit some magnetism: I have read, for instance, where brick buildings were found useless for magnetic observatories, because their bricks were too strongly magnetic, having absorbed the Earth's magnetic field when they cooled down from being fired.

Meanwhile, if you have a local university with a geophysics department or with a physics department where some members specialize in solid state physics, you might ask there.

Even if your pottery material can hold permanent magnetism, you still need to magnetize it. You might ask at the university--perhaps they have instruments for magnetizing materials, and that would be the safest way. You may or may not create a sufficient magnetizing field by wrapping around your sample a thick insulated electric wire (e.g. house wiring, no. 14 gauge) and touching its ends briefly to a car battery. It's a short circuit and sparks of hot metal may fly because of the heat (also, it's bad for the battery) so the touch should be VERY brief, with appropriate precautions. Also wear glasses and leather gloves. Even then, the field may or may not be strong enough to magnetize--get some engineering help on this, someone who can calculate the field ahead of time (and you can also experiment first with a small sample).

Anyway, since I have never done anything like that myself, by all means get advice from someone smarter than me!

58. Shielding magnetic fields--(A)

Hey, I'm working on a science project with a buddy of mine. But our magnets are too close together with the same polarity and they push each other away when we don't want them to affect each other. If there were a substance that I could put as a wall between the magnets, that would block their fields, that'd be helpful. I've read some of your info on soft iron. But I don't know what that is in contrast to normal iron or anything. If you could give me some clues to this, I'd appreciate it. Thanks.

REPLY

Shielding is possible, but it won't solve your problem.

Suppose you put a big sheet of thick soft iron (of the appropriate kind) next to a magnet. The magnetic field on the other side will be very weak, but there will exist a strong force between the magnet and the shield itself.

I suspect there will also be strong forces with a sheet of soft iron between two magnets. Sorry.

Shielding magnetic fields--(B)

I was looking for some info regarding a non magnetic material that can block magnetic fields from flowing threw it on the website and came across your e-mail address. I would appreciate it should you be aware of such a material if you can let me know.

REPLY

A superconductor of electricity is the only near-perfect shield I know.

At the temperature of liquid helium, 4 degrees above absolute zero--and in some more recent materials, up to tens of degrees above that--certain materials become ideal conductors of electricity. They have no resistance, and if you induce an electric current in a ring of such material and check it hours later, the current is still flowing. It is a quantum phenomenon, and has been applied where large currents are needed to create strong magnetic fields--in large particle accelerators, magnetic levitation trains and in medicine, in some magnetic resonance imaging (MRI).

An electric conductor exposed to a build-up of magnetic field (e.g. when a magnet approaches it) produces an induced electric current, which tries to prevent the magnetic field from crossing it. It is a shielding effect, and in space surrounded by a superconductor, it is perfect. the induced current diverts all magnetic field lines to go around the superconductor, and none manages to enter it.

59. Conductivity and Transparency

hello,
I would like to know why does glass does not conduct electric current but does pass light, even though both are electromagnetic entities?
regard . . . thankyou

REPLY

You have an interesting connection there, but **the wrong question**. Ideally, insulators are not prevented from transmitting electromagnetic waves (unless the material absorbs them), so what you observe makes sense. **Conductors** are the ones that should block them.

An ideal conductor makes sure the voltage on it is everywhere the same (like, zero). If the voltage is the same, any wave, which involves an oscillating voltage, cannot work its way through it That's why metals block light, and if polished, can reflect it back.

You can try the following experiment: take a small portable battery-operated radio--with no antenna, or with a short one--and tune it on to some station, so that the sound is loud and clear. Then take aluminum foil, the kind used in the kitchen, and wrap everything in it, including antenna. The sound should stop, because the radio signal cannot get through the conducting aluminum. Then unwrap it and you will get the sound back.

The **real question you should ask** is--why is clean salt water a conductor of electricity, but transparent. Or, why is a **chinaware** dish (as is used for food) an insulator but not transparent?

The answer is that (1) conductivity (and therefore transparency) depends on frequency and (2) absorption depends on atomic properties of the material. The ions which turn salt water into a conductor are apparently too massive to follow the fast oscillations of light, unlike the electrons in aluminum metal. The fact that a glass prism separates colors by refracting them at different rates shows that even in the visible range, light transmission varies. And most of ultra-violet is blocked by glass.

60. Heat sources inside the Earth

Hope you are enjoying retirement as I am (also retired 2001, as airline pilot).

A question on radioactive heating of the earth's core - you mention potassium and U238.

I was a tour pilot to Kilauea and Mauna Loa back in the early 80s and came VERY close to the lava fountains and flows. I recall no mention of danger from radioactivity, so am wondering if radioactivity is only occurring at depths way below that of issuing magma.

Can you please clarify

REPLY

You can rest assured, almost all of that radioactivity occurs deep inside the Earth. Those alpha particles and beta particles probably cannot penetrate the thickness of a penny.

The energy release is actually **very diffuse**: the problem is that it is difficult for the heat to escape. Look at it this way. If you are standing on a square foot of ground, imagine a wedge-shaped chunk of the Earth below you, going all the way to the center of the Earth. Assuming a spherical symmetry of materials in the Earth, all the heat generated by radioactivity in that wedge has no other place to escape except that square foot you are standing on! Therefore, even if the rate at which heat is generated (per unit volume) is very, very small (as it is), an appreciable heat flow may be necessary to get rid of it.

Two corrections may be added here. **One**, most of the heat is generated in the upper 100 miles of the Earth, in the crust. And **two**, while this heat flow can be observed by specially designed heat probes almost anywhere on Earth (it is greater in volcanically active regions, where hot springs also exist), there also exist "hot spots" where the heat flow is much larger than average, and comes from greater depth.

Hawaii may be the most notable of those (others are Reunion and Mauritius, Mt. Cameroon, perhaps the central Mediterranean--ask a volcanologist). Hawaii is interesting, because the Pacific "plate" of the Earth's crust above its deeper-seated hot spot slowly migrates eastwards leaving behind the remains of older volcanic flows, which are gradually eroded away. Hawaii is most recent, still active, Oahu etc. are older and worn down, Midway island is almost gone, and if you look at a map of the ocean floor, you will see a long string of seamounts, eroded remains of volcanic islands.

61. Geomancy

I am from traditional Hindu family in Nepal where there is a tradition/superstition (whatever, I am poor in English!) that one should not sleep, mostly at night, having his/her body aligned north-south with head to the north. Generally, sleeping with head towards northward is thought to cause bad dreams and/or luck. Is there any relation of body parts with the geo-magnetism that might have such effects?

REPLY

I am sorry, but I cannot find any scientific phenomenon which will support the belief you describe. My guess is that it came from China, from the ancient beliefs of "**geomancy**" whose practitioners used a magnetic compass to determine "lucky" or "good" directions. You will find more on the web site

http://witcombe.sbc.edu/earthmysteries/EMGeomancy.html

The human body seems unable to sense magnetic forces: to do so it needs to contain either magnetic materials or large electric currents, and we have no evidence for either (certain animals, such as homing pigeons, may have organs sensitive to the field, but not people).

Sometimes doctors need look into the soft organs of our bodies--check for tumors, for instance--and they use "magnetic resonance imaging", in which you lie on a narrow board which is rolled into a huge magnet (X-rays can see bones, but this is soft flesh). I had it done, and while the machine is very noisy, I could not feel any difference when the magnetic field was turned on, though it is much stronger than that of the Earth (you need leave coins, keys and other metal objects outside the room!). So I do not think the weak magnetic field of the Earth has an effect, whichever way you lie down.

62. Are we approaching a polarity reversal?

I am an Earth Science teacher. taking part in an on-line course in science journalism offered through the University of Massachusetts. As part of my online course **I am writing an article** about the Earth's magnetic field, and the possible upcoming reversal. I chose this subject because: 1) I find it interesting, 2) my students find it interesting, and 3) I wanted to update my knowledge on the subject. Your website has been a tremendous help, as has a NOAA website (**http://www.ngdc.noaa.gov/seg/geomag/faqgeom.shtml**)

All of the information I have found reports the weakening of the dipole and a possible reversal date of about 1300 yrs in the future. My questions are:

1) The information on the web sites seems to date from 1993, 1995, and possibly 2001. Is there any current, ongoing research on this subject? Are there any new findings in the last 5 to 10 yrs?

2) Does the weakening of the dipole appear linear, or is the rate changing?

3) The reversal, when it happens, is expected to take 1000 yrs or more. How will we know when it is happening? What indicators would we look for? Could we now be in the early stages of a reversal?

I'm still reading from link to link through your site.

Reply

You ended your message with ".. I'm still reading from link to link through your site." The "questions and answers" collection contains many questions about reversals (there were more, but not all are included), and you might find them interesting, too.

If your patience holds out, look up the review "A Millennium of Geomagnetism" on my web site, which tells more about dynamos and reversals. One article cited there is about the work by Coe, Glatzmeier et al. (1999), who actually simulated reversals on a computer..

To answer your questions:

1. The variation of the Earth's magnetic field is slow, so little changes over one decade. The main advances are in paleomagnetism--tracing of fossil magnetism from congealed lavas (and some deposits)--and in theory. Coe's report suggests a new approach using computer simulations, but please realize, they are currently are just similar to the Earth's, the actual range of parameters for the Earth is different, and to use them would take more computing power than we now have.

   (LI> From 1840 to 1970 the weakening rate seemed to be **5% per century**, but after that it might have speeded up to 7%. The transition ("geomagnetic jerk") was rather abrupt, apparently taking just a few years.

2. As far as I know, the decline of the dipole field is balanced by the growth of other modes of the Earth's central field, with the **total magnetic energy** changing little. (However, the field we observe on the surface weakens, because other modes decline faster with distance from the Earth's core.)

Such balance is not essential. Rather little energy is lost to resistive heating, but some could be absorbed by being converted into kinetic energy, by speeding up some flows. However, if it holds, when the main dipole field "goes to zero" the Earth's field does not vanish, it just gets complex--you may have for a while 4, 6 or more magnetic poles, and a somewhat weaker field.

The present trend, reaching zero in perhaps 1300 years, but it may change. Studies of magnetism in ancient lavas, and also the simulations, show that "excursions" happen where the magnetic field declines and then rises again; I am not sure how fast these events are.

Some people have deduced the density of magnetic field lines emerging from the surface of the Earth's core (that is about the most information we can get--we cannot reconstruct the field inside the core

without ambiguity) and noted that right now, in one area "reversed flux" seems to be growing quite fast. Some have speculated that is the harbinger of a reversal, but what it really means is hard to say. As Yogi Berra supposedly said, "**prediction is difficult, especially about the future**."

63. Magnetic Levitation

Hi there! We are two girls from Australia. We are very interested in finding out if it is possible to use the earths magnetic field to **levitate** an object of approx. 100kg or less. If so, does this technology exist (and if it does, without the use of large or cumbersome components), or could you refer us to any relevant web sites.

Love this site! Really interesting reading. Hope to hear from you soon!

Reply

Depends on what you mean by "levitation." Strong magnets are hung from cranes in scrap-yards and are used to lift scrap iron from pile to pile, or from a pile to a waiting truck, but I do not think that's what you had in mind, Very strong magnets also keep experimental "maglev" trains hovering a tiny distance above a special tack--they exist in Japan and Shanghai, I believe one is in Germany, too.

But if you mean a sort of **anti-gravity**, where objects hover in space, seemingly weightless--**the answer is no**. For more, please look up "**Can Magnetism Propel Spaceships?**" in
http://www.phy6.org/earthmag/magnQ&A1.htm#q7

64. Why does the magnetic field stop particles but not Electromagnetic radiation?

I first wanted to say thank you for your site. I just recently discovered it and I am reading it daily. You explain things very well for someone at my level.

My question is,.... well, I know the earth's magnetic field blocks high energy radiation/protons from the sun, but why does it not block all radiation ie: visible light, UV light, infrared? also, does the ability to block different wavelengths/energy levels depend on the strength of the field?

Reply

The best way to reply to your question is through an analogy. Imagine you sit in an armored vehicle, and an enemy machine gun is firing at you. The bullets never reach you, they are stopped by the

armor, but you can clearly hear the sound of their impact. How come the sound gets through and the bullets don't?

The reason, of course, is that the two are quite different. The bullets are chunks of matter, and to let them through, the matter of the armor has to give way, something it strenuously resists. The sound is a wave: the bullets make the armor oscillate and propagate the wave through it, without breaking its integrity.

Similarly with particles and radiation from the Sun (or from any source outside Earth): they are completely different. Particles carry an electric charge, and a moving electric charge is in somewhat equivalent to an electric current. Electric currents react to magnetic forces--in fact, magnetism may be viewed as interactions between electric currents--so it's no wonder charged particles get deflected, sometimes even trapped.

Light, X-rays, radio etc. are electromagnetic waves, wave-like disturbances propagating in space. They carry no electric charge, and in empty space are not affected by magnetism. (When passing through matter they can be modified--e.g. light is refracted by glass--and that modification may strongly depend on magnetic fields, but that's a different phenomenon). What absorbs those waves is matter, e.g. atoms and molecules. When a wave encounters those, it may suddenly materialize as a compact "photon" and deposit its energy.

65. Earth's rotation and magnetism

Does it make a difference to the earth's magnetic field whether the earth rotates or not? Would the same magnetism be expected in another metallic object that is stationary in space and is in the same rotational orbit around the sun as is the earth?

Reply

The magnetism of the Earth does not arise from the fact that it is "a spinning metallic object", although the rotation has an important role. Nor is it essential that the Earth's core seems to be mostly iron, remembering that iron is the stuff of permanent magnets and electromagnets.

What IS important is that the Earth's core is **metal**, because metals conduct electricity. Also, that the metal is molten, and therefore can flow. Something indeed causes it to flow--some source of energy, still debated, creates heat which flows outwards, to the mantle and ultimately away from Earth. It is THIS flow, which interacts in a complicated way (similar to what was modeled by some computers) and creates the magnetism as a by-product.

Because flows can vary, this also explains why the magnetic field

of Earth is slowly changing (the main north-south "bar magnet" is weakening by 5-7% per century), and has in the past even reversed.

The rotation of the Earth is also important factor, but not in a simple way. The flow of molten iron in the core is in some ways like the flow of the atmosphere, bringing solar heat from the surface to the higher layers, from where it is radiated to space. In the atmosphere, the rotation of the Earth adds to that flow a swirling motion--e.g. in hurricanes and large weather systems. It must do so too with flows in the molten core, and that swirling is important in the "dynamo process" producing the magnetism.

66. A career in geomagnetism?

As I have a general interest in geomagnetism, I was wondering if you might be able to recommend a particular path with regard to the study of geomagnetism. I have been told that I need to study chemistry and/or physics for a starter...

Are there any courses or universities that offer a curriculum that might be preferred? Is it possible, after taking some basic courses, to work with scientists already studying the field?

Reply

Let me warn you, geomagnetism is a small, very narrowly specialized field. Some people model the main field from satellite data, others build instruments for satellites, still others model the dynamo on computers, and there exist geomagnetic observatories, also people who use magnetism to seek oil or for other uses, even detecting submarines below the surface. But each of these usually has only a handful of people involved. Geomagnetic observatories are being automated, and magnetospheric exploration has suffered cutbacks.

In other words: a tough field for making a living.

I gather that you are about to choose your university education. Areas related to the Earth's magnetism can be of interest--and if you are really interested, you may look for summer jobs in them--but in general, you start with broad studies and specialize only gradually. Studying computer applications, applied math, electronics and physics is a reasonable start, and choosing a university with a strong program is important (also, can be expensive), as are good textbooks.

Once you are enrolled, see that you get good grades and a good grasp on the subject. Keep notes--they help you understand (you will not write down what you don't understand, but try to make sense of it first). And ask for advice--from teachers, colleagues, professionals.

Good luck in your quest--you will need it.

67. The movie "The Core"

I just found your website through a search engine when I looked up Earth's magnetic field. My reason for looking up Earth's magnetic field is this.

We were watching the Apocalyptic drama "The Core" in science today. In case you haven't seen it, it's about the Earth's outer core stopping. As a result, all electronics stop working, there are giant electric storms as the magnetic field cuts out, and when the field is gone, the earth is fried. So some scientists drill to the core of the Earth to start a huge explosion to get the outer core moving again.

I was wondering: is any of this possible? Could the outer core stop moving, and if it did, would all our electronic devices shut down? Why? Would there be so many violent static superstorms? And would the earth be completely fried by the solar winds if its magnetic field disappears?

Reply

Disaster movies are a big industry which does not mind bending the rules of nature for the sake of a better spectacle. That is especially true about "The Core."

The Earth's magnetism appears to be due to the slow flow of billions of tons of molten iron in its core, and you cannot change such flows abruptly. Currently the main north-south field is decreasing at 5-7% per century, and even this does not seem to be a real loss of magnetic energy, just a shift of patterns--as the north-south field gets weaker, the less regular parts of the field are growing stronger, the energy is almost unchanged. Magnetic records in ancient lavas, etc., suggest that this rate is typical,

You can read more about all these matters in "The Great Magnet, the Earth," home page http://www.phy6.org/earthmag/demagint.htm .

So what would happen **if the Earth's magnetic field** somehow magically **disappeared overnight?** You probably would not sense any change. Radiation from space (which is not high, except during rare solar outbursts) is anyway stopped by the atmosphere, whose thickness is equivalent to 10 feet of concrete. Storms in the atmosphere would not be affected--the energy involved in them vastly exceeds that of any magnetic phenomena. Electronics would operate as before: the polar regions of Earth have very little magnetic shielding, yet no real interference results. I am not sure about the polar aurora--it might even disappear, since it is produced in the Earth's field and guided by it.

I should add that **sending a capsule with human crew towards the**

core is pure science fiction. The Soviet Union once drilled to a depth of15 kilometers (say, 10 miles) in the Kola peninsula, north of St. Petersburg. Not only did they find temperatures hot enough to boil water, but the pressure was so high that drill pipes were bent from round to oval. The weight of 10 miles of rock piled up on top is enough to make the rock yield like a thick fluid.

All this, I guess, goes to show that Hollywood films are not a good guide, the film industry is not too selective when it produces films around natural phenomena. If only they had the imagination to make a disaster movie about a great hurricane flooding a famous American city *[written shortly after hurricane "Katrina"]*, perhaps people might have been better prepared when it actually happened ... But I guess, that would be asking for too much.

68. Telling the 6th grade about polarity reversals

I found your site on the web as I was searching for more information about the mid ocean ridge and magnetism. My 6th grade students want to know, and so do I, the reason why the magnetic poles of the Earth switch? what causes this, and at which time interval does this happen? Is it an on-going process, like the tilting of our planet? I have been unable to find a concise yet simple explanation about this.

Reply

That is a very difficult thing to explain at 6th grade level!

In "The Great Magnet, the Earth" your students will find many answers, and there is also the outline of a course in 3 parts, starting at
http://www.phy6.org/earthmag/NSTA1A.htm
The 3rd part discusses reversals.

I would recommend for you to read the material of these web pages, to get for yourself a good understanding. After that you might try to explain it to the class, though the full story seems too detailed for 6th graders.

To a 6th grade asking about "the reason why the magnetic poles of the Earth switch" I would say, you are going too far too fast--as if you were trying to build a house starting with the 4th floor. First come the foundations!

1. **What is magnetism ?**
2. **What causes the Earth to be magnetic at all?**
3. **How do we know about past reversals of magnetic polarity?**
   And only then
4. **What is the reason why the magnetic poles of the Earth switch?**

(1) "**What is magnetism?**" Most of our adult population seems to

misunderstand this. They are familiar with iron magnets, and therefore regard magnetism as a mysterious property of iron. They may perhaps know about electromagnets--turning a bar of iron into a magnet by running an electric current through a coil wrapped around it--but iron is always needed.

IT ISN'T SO. Iron has interesting magnetic properties, but basically, magnetism is a force created by electric currents--a force that can act on iron magnets, or on other electric currents.

I recommend three experiments here, described at
http://www.phy6.org/earthmag/MagTeach.htm but in particular the last of them, also described in
http://www.phy6.org/earthmag/oersted.htm
(see the end, on how to perform the experiment in a classtoom)

You may run into a problem here--someone asking "but what is an electric current?" You can just say then "the flow through material of tiny particles known as electrons, carrying an electric charge", and you may compare this to a flow of water in pipes, as I did in the first part of
http://www.phy6.org/Education/welectrc.html

(2) "**What makes the Earth magnetic?**" MUST be electric currents, because careful measurements show the field is constantly but slowly changing. Navigators using the magnetic compass (that was before GPS!) needed to update their magnetic charts every 10-20 years, for that reason.

We know the inside of the Earth is hot (volcanoes, geysers!). We also know from study of earthquake waves--vibrations like sound, spreading world-wide--that a denser core exists, and is liquid. We guess the core is iron (the density fits, and iron is a very common element), too hot to be permanently magnetic but a good conductor of electric current.

The heat (produced perhaps by radioactivity, perhaps by solidification of liquid iron) flows outwards, and can cause swirling motion.

It is like the heat deposited by the Sun on the Earth, which is carried by swirling motions of air to high level, from where it is lost to space (as infra-red light, radiated by warm air). The swirling in the atmosphere goes by the name "weather." Swirling of a fluid conducting electricity CAN produce magnetism. Mathematically, this is a very difficult thing to prove, only achieved recently, but computers have now simulated it, too.

(3) **How do we know about past reversals?** That is the interesting part of the story. See

http://www.phy6.org/earthmag/reversal.htm

(4) "**What is the reason** why the magnetic poles of the Earth switch?" The patterns of swirls changes constantly. Besides the north-south field, irregularities also exist, and at the core these are actually larger than they seem on the surface (because their effect decreases faster with distance than the main north-south field).

There is no physical reason for a preferred North-South polarity, the math suggests either polarity has equal likelihood. As the field changes, sometimes the "main" north-south magnet weakens to become just an irregularity, and some other swirl may become dominant. Sometimes when the new swirl grows, it returns the Earth to the same north-south polarity, but sometimes the new polarity is a reverse of the old one. Computers have simulated reversals, too.

Tidbit: The evidence of magnetization of the seafloor suggests that in the era of dinosaurs, there was a stretch of tens of millions of years, a "superchron", when no reversals occurred at all (usual intervals are bout half a million years). Interesting, but probably unrelated to dinosaurs.

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