Nature's Sacred Undercurrent

Lawrence W. Fagg [*]

Resumo

Entre as forças físicas da natureza, é o electromagnetismo, essencialmente independente das outras três, que activa toda a química e biologia, portanto tem sido vital na evolução de toda a natureza terrestre, desde as rochas às plantas e aos animais, incluindo os humanos e os seus cérebros. As interacções e radiações electromagnéticas (luz) são o principal meio pelo qual são obtidos os conhecimentos, tanto dos mundos microscópicos como cosmológicos. Durante milénios, a luz era universalmente algo de essencial para os rituais religiosos e inspirou as obras de místicos e filósofos religiosos de todo o mundo. A luz, juntamente com míriades de processos electromagnéticos não visiveis, fornece a base física para a emanência na natureza sentida pelos místicos, desde S. Francisco de Assis, no Ocidente, a Lao Tzu, no oriente.

In Romans 1:20 of the Christian Bible St. Paul tells us: "Ever since the creation of the world His invisible nature, namely, His eternal power and deity, has been clearly perceived in the things that have been made." Among the multitude of things that have been made, Paul was undoubtedly affected by the cornucopia of plant and animal life that graces this planet: butterflies, sunflowers, rabbits, palm trees, and deer all testify to the fecundity and rich diversity of this life.

Several years ago it struck me, as a physicist, how beneath this prolific diversity is a myriad of electromagnetic phenomena (Fagg 1996). These underlying phenomena received their first mathematical description in 1864 by James Clerk Maxwell. With a set of equations of elegant simplicity and symmetry he showed that electricity and magnetism were simply aspects of one force, electromagnetism.

[*] Catholic University of America, Washington, DC 20064, USA.
Email: lfagg@shentel.net

One of the most important results of Maxwell's work was that the electromagnetic radiation predicted by the theory turned out to propagate at a speed about equal to the speed of light as experimentally measured at that time. It was soon realized that the whole spectrum of radiations from radio waves to x-rays and gamma rays were all electromagnetic radiations moving at the speed of light. Thus the word "light" has now become a common generic label for all electromagnetic radiations, especially among physicists. The sweeping range of these radiations is obvious when their frequency or wavelength spectrum is seen on a scale of powers of ten.

However, just how intimately light can be seen as part of electromagnetism and how universal it is was revealed in the completing refinement of electromagnetic theory in terms of the theory of quantum electrodynamics. This theory reconciles Maxwell's theory with the universally basic theories of relativity and the quantum (Feynman 1961). Quantum electrodynamics, or QED, is the most accurate theory in all of physics, agreeing with experiment with precisions of one part in a billion.

QED showed that the electromagnetic force is transmitted by unobservable quantum particles known as virtual photons. This is in contrast to the real photons, quantum particles of electromagnetic energy, which constitute visible light. The virtual label may seem to imply that virtual photons do not exist but this is not so. Though they cannot be directly observed there existence is certified by the fact that, without including them, QED calculations could not yield results that are in such incredible agreement with experiment (Feynman 1961, Feynman 1985).

In part because of the accuracy of QED but also because of the wide technological application of electromagnetic theory, the electromagnetic force is known far better than the other three physical forces of nature. Its effect and presence in all aspects of our life and relation to the world is ubiquitous. Electrons are constrained to orbit around the nucleus of an atom by the electromagnetic force via its virtual photons.

It is the same interactive "glue" that holds atoms together in a molecule so that all of chemistry and biology operate fundamentally by means of electromagnetic interactions, thus making it possible for bacteria, which are the smallest living cells, to exhibit the purposeful mobility, coherent collective action, and remarkable sophistication they do in their growth and survival. At the other end of the biological hierarchy we ourselves and all our organs are run by this mechanism, from the interactions of blood cells to the activity of neurons in the brain.

It is this same force that governs the incessant interplay of the molecules in air and water that collectively unite to give us sound and ocean waves. While it is gravity that keeps us, all earthly objects, and the atmosphere attached to the earth, it is the electromagnetic force with its mediating photons binding atoms and molecules tightly together that yields the vibrant stasis of solid objects. So that it is a prime factor, along with certain quantum effects, in keeping the table lamp from falling trough the table, and the table from falling through the floor.

It is this force that makes possible all of modern communication: telephone, radio, TV, satellite, etc. Virtually all of modern technology depends on electromagnetic interactions for its operation. This is so from the precisely focused laser beams for eye surgery to the massive motor generators furnishing electric power for our homes. Indeed our increasingly intimate interaction with our technology (cell phones, computers, robotic devices, organ implants, etc.) suggests that it will be a vital adjunct to our future evolution. In effect, we are already beginning to be co-creators of it.

Furthermore, whether we are examining the quantum realm of elementary particles with gigantic particle accelerators or probing the heavens with giant telescopes, the knowledge we gain is mediated by the electromagnetic force. Virtually all experimental studies of the other three forces of nature are conducted through an electromagnetic sensor of some kind. In the performance of such studies we find that there is no quantum observation that does not use some electromagnetic phenomenon to accomplish the result (Fagg 2002).

Certainly one of the most relevant features of electromagnetism is the host of very low energy electromagnetic events that make possible the life of humans and their consciousness. The extreme subtlety of these events is quantified in experiments in microbiology, which show that voltage gradients as low as one ten millionth of a volt per centimeter and frequencies between 0 and 100 cycles per second are involved in the interaction between cells in living creatures. All plant and animal life is bathed in, and interacts with, a sea of such very low frequency radiation that envelopes the earth. This is *independent* of the radiation superimposed by technology (Adey 1993).

These subtle electromagnetic phenomena have been used in life's entire evolutionary process from the assembly of molecules to form first, bacteria cells, then the host of plant and animal species, and finally humans and their consciousness. Each breakthrough to a higher level of complexity was carried out as the result of incessant probing and testing by a multitude

of these phenomena, restlessly and unremittingly experimenting in search of a higher level of complexity or organization.

An equally impressive manifestation of electromagnetism's pervasive universality is the role that its radiation, light, and its speed play in our understanding of the cosmos. Although the 300 million meter per second speed of light is extremely fast, it is not infinite. Light's finite speed sets the pace at which we learn about the behavior of the cosmos. Some of the farthest galaxies are observed to be some 13 billion light years away. (A light year is the distance traveled by light in one year.) Thus light arriving at the astronomer's telescopes today allows them to see the galaxies as they were 13 billion years ago. So the farther away a galaxy is, the further back in time is our observation. The history of the entire physical universe is spread out before our eyes, and it is electromagnetic radiation that tells the story.

The universality of this radiation and the electrodynamic interactions that are involved in its generation elicits what for me, as a physicist, is the most the wonder-provoking question. How is it that four simple properties of electromagnetic radiation can combine with such minute sensitivity to make physically possible the presence of everything on earth, animate and inanimate, including us and our consciousness? These properties characterize not only the photons of visible or detectable radiation, but also the unobservable photons that quantum electrodynamics tells us transmits the electromagnetic force. Each of these properties displays inexhaustible variety due to its capacity to vary through a continuous range.

Specifically, they are intensity (or strength), wavelength or frequency, phase, and polarization. Intensity can vary by any tiny amount from the most subtle, animating the neural system of a fruit fly, to that energizing a huge power transformer. Wavelengths can be fine-tuned with incredible precision over a virtually infinite spectrum extending from the longest of radio waves to the shortest of astonishingly energetic gamma rays from outer space. Two waves can be in or out of phase so that they mutually reinforce or cancel, respectively, with all possible relative phases in between, no matter how incrementally different. Finally, a wave can be polarized like the light waves that have filtered through your sunglasses and can be varied in polarization by an infinitesimal amount over the entire range of possible angles.

How these four basic properties can be orchestrated to provide the physical basis for the incredible richness of nature and of human life and

interaction on this earth is to me the most awesome and profound question (Fagg 2002).

Clearly one could continue indefinitely giving examples of how universal electromagnetism and its radiation are in our internal and external experience. For no other phenomenon of physical nature so totally and intimately permeates and affects our lives and our world, providing the means by which we can in turn sense the sacred in all of earthly nature.

One of the principal features of nature by which this sacredness is sensed is light, which again is electromagnetic radiation. Light has served as a primary medium for the spirituality of men and women since the dawn of human consciousness. It has been an essential component in the creation myths of cultures worldwide. It has been the principal focus for the spirituality expressed in rituals of religions throughout the world for millennia.

Scriptures of religions worldwide are replete with the use of light to symbolize God's inhering presence. As is well known, the Bible uses this symbol frequently, in particular in Isaiah, the Psalms, and the Gospel of St. John. In Sura 57 of the Koran light proceeds ahead for believers, provided by God so they may walk straight. In the Bhagavad Gita, the scriptural jewel of Hinduism we read: "I behold thee…as a mass of light shining everywhere with the radiance of flaming fire and the sun."

In many of the spiritual paths traveled by the Christian mystics light has been a major feature in the visions they have experienced. St. Theresa of Avila speaks of "A light that knows no night" and Mechtilde of Magdeburg "The flowing light of the Godhead." St. Paul's conversion on the road to Damascus was accompanied by a blinding light.

Furthermore, the reference to light as a symbol or metaphor is voluminous in the writings of theologians and religious scholars around the world. Major among these are St. Augustine, Joannes Philoponus, and Robert Grosseteste. But all of them, among many others, saw a clear distinction between the worldly light that God created and the uncreated Light of God.

So whatever God there may be has provided the photon of electromagnetic radiation as a very early feature of creation, as an indispensable ingredient of our daily lives, as a means of communication for all humankind, and as an intimation of divine presence.

However, complementing the role that light plays, is that played by the non-visible properties of electromagnetism. It is this invisible, muted

dynamism that those with a reverence for nature see as having an indwelling and sacred quality. Literature world- wide abounds with rich descriptions of the spiritual sense of a divine presence in surrounding nature. This sense has been cogently described by such Christian mystics as Jacob Boehme, St. Francis of Assisi, and St. Rose of Lima, as well as the Muslim, Jalal adin Rumi. For example, St. Rose saw in the sway of the flowers, rustling of the trees, the trill of the birds, and the hum of the insects, a symphony that joined her in the praise of God.

In the East the vibrant presence that inheres in nature especially characterizes the Taoist, Shinto, and some Buddhist traditions. For example, in Taoism the Tao is the mysterious quiet that pervades the natural world; and in Shinto anything from a specially located rock to a tree can possess a spirit, called Kami.

In this century there are religious thinkers whose philosophic approach to the phenomena of nature implies a spiritual indwelling and the influence of God. Leading among these are Alfred North Whitehead and Pierre Teilhard de Chardin. Whitehead saw the world proceeding by means of irreducible events or elements of experience that he called "actual occasions," which can be influenced, but not determined by God. Teilhard speaks of "the within of things" in all of nature.

But the immanence in nature expressed by all of these sources, East or West, finds its most proximate physical undergirding in the electromagnetic field. This is essentially the reason I see this field as a meaningful physical analogy to God's, or some divinity's, indwelling. Analogy has been a vital tool for theologies for millennia, because it is one powerful means to help us understand something about God. It helps give us a properly realistic perspective with respect to God as the ideal, but also linked to god as derivative creatures bearing some marks of the creator.

It is true that the dictionary definition of analogy tells us that it can involve any mix of similarities and differences and is thus by its nature an incomplete comparison. However, I reason that one of the most complete of the "incompletes" is again the electromagnetic field, specifically with respect to the immanence of God.

This hypothesis is based essentially on HOW this field can be seen to be analogous to divine immanence. First, they both share in the property of ubiquity, both are all pervasive in our world. Second, they have analogous ranges of intensity from the most subtle and sensitive natural phenomena

and human experiences to the most powerful and awesome. Third, they are analogous because light is so often used as a sign or symbol of God's inner presence. But light is electromagnetic radiation. Just as God's light is far beyond our ability to see, so analogously the electromagnetic spectrum extends far beyond what is visible. Fourth, just as there is beauty in a spiritual experience or insight, so also there is beauty in physical nature and in the elegance of the electromagnetic equations that describe that nature (Fagg 1999).

However, in all that I have said I must emphasize that God is not light or electromagnetism and electromagnetism is not God's immanence. But it is the primal physical mechanism giving us an analogical view of what that immanence might be like, a provident means by which we can gain some perspective of its nature. I hold that it should be considered as such by any theology that seeks to interpret nature (Fagg 1999).

In forwarding this view I readily acknowledge that the other three physical forces, the weak, nuclear, and gravitational, can arguably also be considered as reasonable analogs for divine immanence. For example, it is the nuclear force that provides the vast majority of mass to all of matter and hence affords us a sense of substance and tangibility and so could be considered as a metaphor for divine inherence. Even more convincing is the gravitational force that provides the mutual attraction between every mass in the universe, however infinitesimal.

Nevertheless, although each has a vital function in making possible our existence, none of these three forces can compare with the versatility, diversity, and scope of the electromagnetic force in providing the physical basis for the awesome plethora of creations on this earth, including us. Throughout evolution it is has played this special role virtually independent of the relatively passive and inanimate background role played by the other forces.

Some who are more physics-oriented may wonder about the fact there is what is known as the electroweak theory that received its first strong experimental support about twenty years ago. This theory jointly describes the electromagnetic and weak forces from about one billionth of a second after the big bang, when they were indistinguishable, to today, when they behave quite differently. So today the weak part of the electroweak force cannot do any of the wondrous things the electromagnetic part can do that I describe here.

These wondrous things, these indispensable undergirding phenomena, do not seem to be considered very much in the science-religion dialogue in recent years. Most of this dialogue has understandably drawn on the biological sciences: evolutionary biology, zoology, anthropology, neurology, and studies of the brain and consciousness etc. But in our passionate search for a deeper understanding of the wonders of complexity, perhaps it might worthwhile to take a backward glance at the physical instruments that are used in achieving this complexity. Should we entirely take for granted the *necessary* in our devout quest for the *sufficient*?

These physical instruments, these electrodynamic phenomena, place limits on, and help define the nature of, the complexity we seek to comprehend. They provide the prerequisite physical grounding for all living complexity. To understand more clearly the nature of this grounding, let us reflect on the fact that we, and all living nature, are carbon-based species. So let us consider the carbon atom. 99.97% of its mass is concentrated in the nucleus at its center and occupies some one trillionth of its volume; the rest of the volume consists of six electrons of very small mass and trillions of force-carrying photons that keep the electrons in their orbits.

Therefore there is a vast array of electrodynamic phenomena that fills the overwhelming majority of the world's space, so that we ourselves are immersed in an ocean of electromagnetic events; in fact we are part of the ocean. This helps me see these electromagnetic phenomena as constituting the furthest frontier of the physical realm probing with its sensitive tendrils into the unknown gap between that realm and the realm of the conscious and spiritual. Thus, it plays a unique role in our unending search for a fuller cohesion of the whole continuum of existence from the material to the spiritual (Fagg 2002).

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