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Chapter 1

Introduction

> *Each generation of scientists gives too much credence to its own paradigms. By his education, and by participation in 'normal' science, the average research worker is heavily indoctrinated and finds great difficulty in facing the possibility that his world picture might be wrong (Ziman 1991, 90).*

1.1 A Grave Crisis of Ideas

How should we decide on the aim of physics? Is it merely a mathematical model for making predictions about our experience, without any visualizable mechanism? Or does it have a deeper value in trying to replicate through imaginative visualization the world external to us responsible for our experience? It is a question physics cannot answer in isolation by reference to its own partial successes or failures. If we are to find a guide as to the form our theories should take, we need to spend time examining the development of the human understanding, to discover its vector of evolution. As we shall see, as the passing millennia have provided us with an increasing sensory capacity; the human mind has produced maps of the environment that have had increasing utility. The identification and anticipation of predators, and the extraction of responses from the external world favorable to its survival, seem to have determined the direction of this development.

In his later years, one of the founders of quantum mechanics Erwin Schrödinger (1953, 52) was brought to confess that "physics stands at a grave crisis of ideas". It is a stark admission from a man who had been at the very center of twentieth century physics.

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However, the difficulties facing the progress of theoretical physics did not begin with quantum mechanics but instead can be traced back to the electro-dynamical theories of the nineteenth century. George Francis FitzGerald, Oliver Lodge, and James Clerk Maxwell all attempted to construct geometrical models of the electric and magnetic fields, but all were left disappointed with their attempts.[1] Carl Anton Bjerknes subsequently saw it as an abandoned problem:

> We have theories relating to these [E-M] fields, but we have no idea whatever of what they are intrinsically, nor even the slightest idea of the path to follow in order to discover their true nature. (Bjerknes 1906, 1)

Oliver Lodge concurred:

> The problem of the constitution of the Ether, and of the way in which portions of it are modified to form the atoms or other constituent units of ordinary matter, has not yet been solved. (Lodge 1909, xix)

However, Henrik A. Lorentz had no conscience about sweeping the difficulties under the carpet, declaring that “we need by no means go far in attempting to form an image of it [the field]” and even confessed that “on account of the difficulties into which they lead us, there has been a tendency of late to avoid them altogether” (Lorentz 1916, 2).

In 1887, the Michelson–Morley experiment had failed to detect an ether wind. However, Oliver Lodge’s later search for the ether was no demonstration of denial. At the turn of the twentieth century, physicists were looking for an alternative to a particle-like ether, and were trying to imagine the basic unit out of which matter might be constructed. In 1875, the English mathematician William Clifford had suggested that “matter differs from ether only in being another state or mode of motion of the same stuff” (Clifford 2011, 237).

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[1] Maxwell adopted a model of rotating vortices, each smaller than a molecule, with intervening idler wheels, but confessed that “I do not bring it forward as a mode of connexion existing in nature” (Maxwell 1890, 486, Figure opp. 488). For details of the models by Lodge and FitzGerald, see Hunt (1991, 81, 89).

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Joseph Larmor went even further suggesting that "matter may be likely a structure in the ether, but certainly ether is not a structure made of matter" (Larmor 1900, footnote vi).[2] As to the form this structure might take, Oliver Lodge suggested that electric potential energy "must be due to rotational motion [...] circulation in closed curves" and that "the speed of this internal motion [...] must be carried on with a velocity of the same order of magnitude as the velocity of light" (Lodge 1909, 102–103).

The present work develops this idea and posits a traveling screw thread (which generates circularly polarized rotation) running around the surface of a torus at the speed of light c. The rotation around the toroidal axis at speed αc is taken to be electric momentum and that around the tube axis at speed $c(1-\alpha^2)^{1/2}$ is the magnetic momentum.[3] The magnetic field is to be in the direction of the former, while the electric field runs along the axis of the torus. This is a brief sketch of the form of a mass vortex ring (MVR) and will serve as the structure of both the proton and electron.[4]

1.2 Rejection of Geometrical Theories

In 1925, Werner Heisenberg invented a quantum-theoretical mechanics in which "only relationships between observable quantities occur" (1925, 168–169). His theory was based on a flawed logical positivist philosophy that gave no consideration as to how the human brain processes data, and took the view that unless quantities (such as the period of rotation of an electron in an atom) submitted themselves to direct observation, then they should have no place in a theory. Heisenberg held this to be a rigid requirement even if a theoretical model using an unobservable value correctly predicted a directly observable quantity. Schrödinger (1953, 52) thought it was "a philosophical extravagance born of despair". From that time on, the search for the geometrical structure of an underlying

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[2] It follows from this that the idea that the quark is the ultimate building block of nature is an illusion.

[3] Here, α is the fine-structure constant.

[4] Perhaps it is the structure of all 'particles' but this idea will not be claimed here.

reality was completely abandoned, and Paul Dirac subsequently led physics toward a program of mathematical simplicity in theoretical constructs with the declaration that "the main object of science is not the provision of pictures but it is the formulation of laws governing phenomena" (Dirac 2000, 10).

As we shall see below in our discourse on the evolution of human understanding, we need to be clear as to the aim of physics. If it is the mere description of phenomena, then, since it contains unconscious prejudices connected with the way our human sensory apparatus works, it is actually the most primitive form of theorizing possible. However, if it is an attempt to mirror the unobservable structures causing the phenomena, then the adherence to sensory concepts can yield no progress. Of course, there can be no direct comparison between our conjectured model and the external structure it purports to represent. The model's justification rests instead on its inner consistency and its success in producing consequences that correspond to observed phenomena. As our visual model ascends to greater success, we can entertain increasing confidence that this is the form of the world beyond our senses causing our experience.

Before discussing the type of theory that should be pursued for the best chance of theoretical success, there are a number of basic problems in physics that are far from having a satisfactory solution. For example, recent experiments on electron vortices suggest that an electron can adopt energy levels even in the absence of an external potential (Uchida and Tonomura 2010; Verbeeck *et al.* 2010). McMorran *et al.* (2011, 194) have concluded that "electrons can be prepared in quantized orbital states with large OAM, in free space devoid of any central potential, or medium that confines the orbits". However, if the external potential function arising from the proton is removed from the Hamiltonian function in the quantum mechanical treatment of the hydrogen atom, it is completely deprived of its energy levels. The new MVR model presented here seeks to remedy this by positing a self-potential for the OAM mass ring.

As far as the theory of electrodynamics is concerned, it is surprising that confidence is still placed in a theory that was

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conceived over 30 years before evidence for the electron was first secured (Thomson 1897),[5] and over 70 years before light rays were demonstrated to possess spin angular momentum (SAM) (Beth 1936).[6] Maxwell's equations are ill-equipped to accommodate either of these concepts. In addition, there is a lack of explanation in these equations. For example, all we have in Ampère's law is a law of association between a current and a surrounding magnetic field. It makes no attempt to describe a mechanism for the phenomenon. All it claims is that when a current is activated, a magnetic force circulates around it and when it is deactivated it vanishes.

On the basis of this law of association, Richard Feynman has given an argument as to why a mechanism cannot be found for the magnetic field associated with a moving charge (Feynman *et al.* 2006, II.1–10). Let us first set out two premises as follows:

(a) A moving charge *creates* a magnetic field in virtue of its motion, and it is a field that has no existence when the charge is stationary.
(b) The magnetic field has an underlying mechanism.

Feynman gives the example of two identical free charges moving parallel to each other at the same speed. He considers an observer A stationary in some reference frame who sees the two charges moving and therefore observes that each charge is surrounded by a magnetic field. A second observer B who is moving with the charges views them both as stationary and so detects no magnetic field.

Feynman argues that given the truth of (a), then (b) can be true for A but not for B. If the existence or non-existence of a mechanism depends on the state of motion of a charge, then this is unrealistic. So, Feynman rejects (b) for *all* observers while retaining (a).

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[5] Thomson measured the charge-to-mass ratio of cathode rays in an evacuated tube.

[6] Beth used a suspended half-wave plate to reverse the rotation sense of circularly polarized light and create a measurable rotational reaction in the plate.

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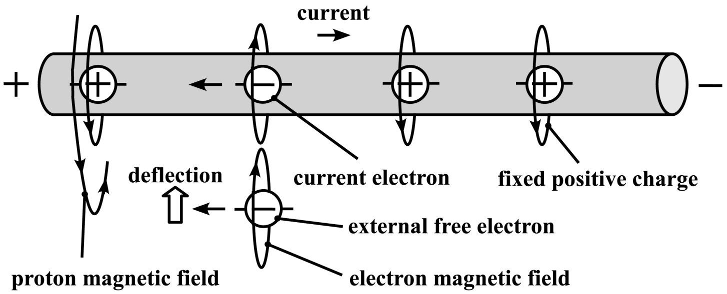

Figure 1.1 The MVR theory explanation of a magnetic field. A potential difference across the wire ends aligns the proton and electron ring axes and their oppositely rotating spin-3 magnetic fields. The electron is deflected toward the wire by a Lorentz force.

Now Ampère's law refers to charges in a wire, so let us place Feynman's argument in this context before returning to his example; see Figure 1.1. Let one of the two electrons be part of the current in a wire and let the other electron be free and external to the wire yet moving parallel and at the same speed as the first one. Allow observer A to be stationary with respect to the wire, while B is moving with the two electrons.

Now, according to the MVR model presented here, we intend to suggest that (b) is true but (a) is false, and that (a) should instead be modified to the following:

(a′) A charge has a magnetic field surrounding it both at rest and in a state of motion.

In fact, this will be a property of our OAM mass ring. In that case, one is now permitted to posit a magnetic field mechanism for all observers. With this in view, we shall proceed to explain the deflection of the external electron toward the wire as a Lorentz force effect.[7] It is a deflection that must exist for both A and B.

However, first we must ask the following: Why does the magnetic field vanish when there is no current? In a wire with no potential

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[7] The magnetic vortex field and the Lorentz force effect in Ampère's law are developed in greater detail in Clarke (2017, §8.3).

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difference across the ends, the charges are stationary yet the novel suggestion made here is that magnetic fields permanently exist around both the protons and electrons. They do so as part of the proton and electron ring structure, not as a consequence of their motion. For a copper atom in the wire, not only is the magnetic field rotation of an electron equal and opposite to that of a proton but the atoms in the wire are randomly orientated so that the fields from different lattice sites cancel out. So, there is no net magnetic field around a copper atom, and a wire with no moving electrons has no *detectable* surrounding magnetic field.

Now, when a potential difference is applied to the ends of the wire, the axes of the magnetic field rotations line up along the wire. The axes of the moving electrons become aligned in parallel, while the axes of the stationary positive charge sites become aligned anti-parallel to them. The randomness of orientation is no longer responsible for the cancellation, but so long as nothing moves, there is still a cancellation of equal and opposite rotations, and there is no relative motion of oppositely rotating magnetic fields. When the current flows a moment after alignment, the electrons leave the positively charged sites and the aligned positive-charge magnetic fields surrounding these sites are exposed. We now invoke the Lorentz force, see Figure 1.1. For observer A, the free external electron (traveling parallel with the current electron in the wire) moves through the magnetic field of the protons that runs perpendicularly to their aligned axes (but not through the relatively stationary electron magnetic fields from the wire) and is thereby deflected toward the wire. From the point of view of observer B traveling with the free external electron, the wire moves and the proton magnetic flux lines pass through the electron (while the electron fields from the wire remain relatively stationary) and so the electron is still deflected the same way. In other words, the force arises from the relative motion between an electron charge and a proton magnetic field and it is a relative motion that exists for both observers A and B.

Let us now return to Feynman's example. If we remove the wire, and set two free electric charges in parallel motion at the same speed, for both A and B, although they each have a structural magnetic field

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surrounding them, there is no *relative motion* between a charge and a magnetic field, and so there is no Lorentz-type force between them. For this reason, we should not expect the electrons in cathode rays to interact magnetically with each other. We shall see in Chapter 6 that an electrostatic interaction between MVRs requires that the ring axis of one penetrates the ring of the other. On that basis, there is no electrostatic interaction either between Feynman's two parallel moving electrons.

1.3 Evolution of Human Understanding

Let us now focus on the way human knowledge of its environment has evolved. The theory as to how the brain attains knowledge has traditionally been the province of epistemology where only internal data have been available to the philosopher in the form of what he perceives, thinks, and feels. The arguments in Immanuel Kant's *Kritik der reinen Vernunft* (*Critique of Pure Reason*, 1781) were developed entirely on that basis. However, epistemology is now a growing science and if we are to make progress in our task of approaching a complete understanding of nature, account should be taken of the results of experiments on our human processing apparatus. This lends important guidance as to the form our theories must take in order to succeed in our task of bringing sense impressions into the greatest order, and making reliable and penetrating predictions about Nature.

The manner in which humans develop knowledge is the evolutionary product of the interaction between the information-processing subject and the external world beyond the senses. Information is evaluated in relation to the survival of the subject, or more fundamentally, the elusion of pain. For example, for the avoidance of predators and for the selection of nutritious food, those creatures who have built mental models that best correspond to the external world have endured. As Konrad Lorenz states,

> The 'spectacles' of our modes of thought and perception, such as causality, substance, quality, time, and place, are functions of a neurosensory organization that has evolved in the service of survival. (Lorenz 1978, 7)

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The following question arises: What is the process by which knowledge of this external world is secured? Let us explore this problem a little further before returning to our main project, the construction of a workable atomic model for hydrogen.

The processing subject has a predisposition to identify invariant features in experience when it is faced with contingent events. In order to make decisions, it needs information it can depend on. For example, the form of a chair is still recognizable whatever angle it is seen from. It is not seen as several different chairs. The color of an object is perceived as constant despite varying lighting conditions. The size of an object is unchanging even as it recedes from view. These are perceptual invariances.

On a deeper level, the laws of physics are held to be the same for all systems in uniform motion. It is the absence of variation and contingency and the presence of a common pattern or a persisting characteristic that mark out the objectively real. Feelings and wishes that have been associated with previous experiences have been stored in memory, and are imposed on similar new ones in order to speed up the decision making as to what should be approached or avoided. These evaluations intrude on our objective assessment. The more we can separate out these subjective contributions, and distance ourselves from the egocentric, the closer we can get to an image of external reality which exists independently of us. It is a process of extracting the subjective manner in which we process data.

Even at the level of visual perception, we can see that we are not merely passive receivers of facts. A conjecture is *imposed* on ambiguous data as a tentative best fit (postulate and test) rather than information being *extracted* from given sense data (induction). For example, it appears that there are already rules in place for interpreting groups of images before they arrive. Richard Gregory has developed the idea that examples of visual illusions support the presence of a 'hypothesis generator' for visual perception "to compensate neural signalling delay [...] so 'reaction time' is generally avoided" (Gregory 1997, 1121). Here, previous perceptual knowledge in memory is compared with new images to obtain the best possible interpretation. He cites the idea of an upright rotating face mask that alternates to our view between convex and concave, Figure 1.2.

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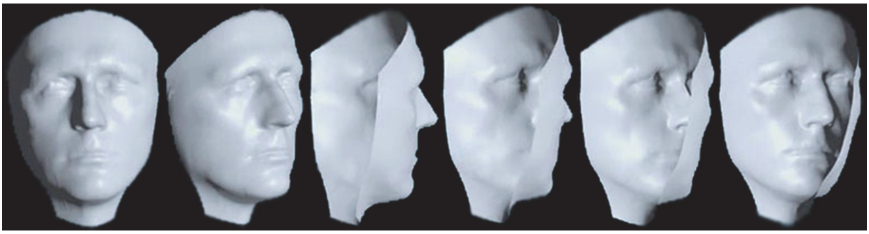

Figure 1.2 The rotating face mask. The first image is of the face convex as expected, and as the front of the mask rotates to the right we reach the last image which is concave. However, it is still understood as a convex face.

Through previous experience, we associate the idea of convexity with a real face. However, even when the angle of rotation is such that the view is concave, the mask still looks to us like a real face and so we falsely understand it to be convex. So Gregory suggests that there is a hypothesis generator acting on perception that is imposing the interpretation 'this face is convex' onto the concave image.[8]

> This bias of seeing faces as convex is so strong it counters competing monocular depth cues, such as shading and shadows, and also very considerable unambiguous information from the two eyes signalling stereoscopically that the object is hollow. (Gregory 1997)

Examples of visual illusions, and our errors in classifying them, are evidence of this hypothesis generator in action.

Although Immanuel Kant in the *Kritik der reinen Vernunft* (*Critique of Pure Reason*, 1781) decided that the external world or 'thing-in-itself' existed, he concluded that nothing could be known about it. This was his 'transcendental idealism'. For Kant, only direct experience was knowable and this arose from the application of our processing apparatus to given sense data. Unfortunately, there is no room for conjecture in Kant's theory, and so there is no opportunity to rise to more abstract and more widely applicable theoretical schemes. However, he appears to have been a pioneer in developing the interpretive character of human knowledge.

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[8] "[. . .] perceptions are regarded as similar to predictive hypotheses of science, but are psychologically projected into external space and accepted as our most immediate reality." (Gregory 1997)

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From birth, our apparatus is adapted to process our sense data, that is, even before receiving any input. In this sense, we possess *a priori* knowledge. It applies boundaries to the light-intensity map on the retina, groups together a set of contiguous moving images into a time-sequenced object, and then imposes causal laws on objects coincident in space and time. However, our sensory-processing equipment has acquired its form over a long period of selective adaptation in relation to the objects in the external world, and those human processors that have constructed the best models of this world have had the greatest success in extracting desirable consequences from it.

In this sense, we can know something about the thing-in-itself because our success in surviving is evidence that the models that we have adopted are a good approximation to the unobservable external world. The better our ability to understand the operation of the world independent of us, the better will be our predictions as to how it will behave in certain circumstances, and the better will be our chances of survival. The evolution of our modeling can be approximated by observing lower species. As Konrad Lorenz states, "it is possible to make statements as to whether agreement between appearance and actuality is more exact or less exact in comparing one human being to another, or one living organism to another" (1982, 235). Those lower on the evolutionary scale should exhibit less agreement.

There is the logical positivist view that only what can be observed is 'real'. However, I still believe my house exists when I am away from it, even though I am not continuously observing it. This means my belief is only a conjecture which I retain only because of its utility. The conjectured invariance of my house's existence is something that I regard as real, as it would be difficult to function without this confidence. However, being conjectural in character, my belief is always subject to the critical test of my observing my house when I return. So long as it survives this repeated test, then I retain confidence in the belief.[9] However, if I returned home one day and found that my house had gone, then I would be forced to modify it.

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[9] Should I live in a war zone where regular bombing occurs, I might not hold this belief with the same degree of confidence.

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There is also a philosophical creed known as 'naïve realism' in which it is believed that the world external to me exists in the same form that I perceive it. It holds that we simply receive a copy of it through our senses. The following considerations should illustrate why this view cannot be correct, although for most of our everyday interactions with the world, it is sufficient to assume that our perceptual images are mere copies of the external world.

1.4 A World of Changes

In 1885, Balmer (1885, 83) published a formula that corresponds reasonably well with the known experimental measurements for hydrogen lines in the visible and ultraviolet region

$$H = \frac{m^2}{m^2 - 2^2} h \tag{1.1}$$

where H is the wavelength, the integer $3 \leq m \leq 11$, and $h(10^{-10}\, m)$ is a constant. It was generalized three years later by Rydberg (1889; 1890, 333), for all hydrogen lines, and was presented as a wavenumber

$$n = n_o - \frac{N_o}{(m + \mu)^2} \tag{1.2}$$

where m is any positive integer, N_o is a constant common to all series and elements, and n_o and μ are constants particular to the series.[10] The calculation of a spectral line results from the difference between two different values of m in (1.2). It should be clear from this that the light we receive into our sensory apparatus results from the difference between an initial and a final state. The object, or 'thing in itself' as Kant called it, is not given to us directly. We do not receive a copy of it through our sensory apparatus. Only the *changes* in that object are presented to us, and these changes take the form of light signals. It is rather like observing a man depositing and withdrawing money from his bank account in predictable amounts without ever getting to see the balance. If one wants to know the balance, then

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[10] Balmer's formula results from the choice $\mu = 0$, $N_o = 4n_o$, and $n_o = 1/h$. Then, $H = 1/n$. N_o became known as the Rydberg constant.

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a model of the account needs to be imagined that will predict the given transactions.

1.5 Evolution of Vision

So, let us start at the most primitive part of our human understanding, that which is directly related to our visual apparatus. An organism develops senses to locate obstructions and threats in its environment. Those that possess the best detectors have the best chance of survival. A large part of our understanding of the external world has arisen out of the evolution of the eye and we now take examples from more primitive life forms to illustrate it.

A survey of the evolution of visual receptors can show how maps of the external world have achieved increasing precision. Eye type can be classified into four cases: (1) non-directional photoreception; (2) directional photoreception; (3) low-resolution vision; and (4) high-resolution vision (Nilsson 2013, 10). We now examine each case.

(a) Cyanobacteria possess unscreened photoreceptor pigments and have been found to exhibit phototaxis[11] according to absorbed light intensity (Häder 1987, 1, 12). At low intensities, they move toward the light source and at high intensities they move away. Their ability to migrate according to lighting conditions appears to optimize their ability to conduct self-preserving photosynthesis. Even with this primitive information, the cyanobacteria can still 'know' something about the unobservable source emitting the light, in this case its approximate direction.

(b) The pear-shaped larvae of a box jellyfish *Tripedalia cystophora* have 10–15 ocelli. These are cup-shaped structures that are evenly spaced on their posterior and are filled with photosensitive pigment. The cups screen light from certain directions and form a directional light meter. As the larvae rotate at 2 revolutions per second about their longitudinal axis, they continuously scan their

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[11] Phototaxis describes a direction of motion with respect to the direction of the light source. Photokinesis describes the speed in relation to the light intensity.

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environment to obtain a rough map of the spatial distribution of light (Nordström *et al.* 2003, 2351). So, the directions of several simultaneous light sources now become knowable.

(c) Low-resolution eyes usually have a lens at the entrance to a cup-shaped depression, but the retina is too close to it to yield a high-resolution image. Its original function might have been to “prevent foreign material to enter the eyecup” (Nilsson 2013, 12). An example is *Chiropsella bronzie*, the box jellyfish, which has four sensory indentations, or rhopalia, that between them carry 12 pigment pit eyes, 12 slit eyes, as well as four upper and four larger lower lens-eyes. Let us consider only the eyes with lenses. The lower lens-eye has an iris with a focal length that falls well behind the retina. With a spatial resolution of no more than 20°, it can only detect “very large structures at close range” (O’Connor 2009, 563). So, in addition to directional information, the box jellyfish now has access to simple close-distance data that it can incorporate into a primitive map of objects in its environment.

(d) Eyes capable of producing high-resolution images are given to vertebrates, cephalopods, and arthropods. This improvement allows the type of predator to be distinguished so that a judgment can be made on its threat-status and an appropriate response can be enacted. As the rate of data delivered to the nervous system increases, and the light-intensity map on the retina possesses greater detail, there is the need for an increase in brain-processing power.

1.6 ‘Particle’ is a Sensory Prejudice

So far, we have examined the most primitive form of interpretive understanding, that is, the direction, distance, and identity of light-emitting sources. This discrimination is clearly connected with the survival of the host. The next stage involves the processing of a high-definition visual map of the environment. A human brain is an electro-chemical information-processing unit confined to a bounded volume inside the skull. If we are to assess the justification for many

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of the concepts that enter our physical theories, we need to pay attention to how they have arisen.

How do we get from a 2D array of image-intensity values provided by the retinal photoreceptors to our experience of 3D bounded objects complete with an anticipation of the complex interactive relationships between them? The inputs to the brain are supplied by visual, aural, olfactory, gustatory, and tactile sensors. As far as visual sensation is concerned, the two eye lenses produce a highly focused image, one on each retina (Delbrück 1986, 95–108).[12] The slight displacement of these two images allows a reasonable computation of the direction and distance of the center of the light source.

The retina has about 10^8 photoreceptor cells; see Figure 1.3. A small area of these light-stimulated cells trigger a bipolar cell, several of which supply a retinal ganglion (RG) cell that surveys a circular area of about 100 photoreceptor cells. This circular area is divided into an annulus and an inner circle, and an RG cell is designed to compute the light contrast between the two regions.

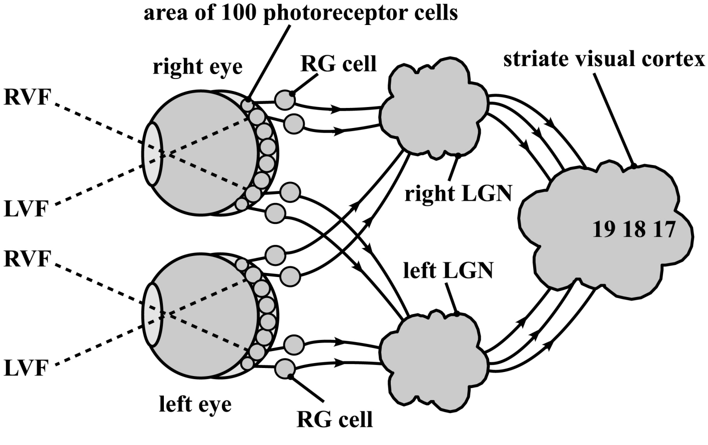

Figure 1.3 Plan view of the human brain showing the right visual field (RVF), left visual field (LVF), retinal ganglion (RG) cell, right and left lateral geniculate nucleus (LGN), and the striate visual cortex.

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[12] Delbrück provides a clear account of our processing apparatus.

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The 10^6 RG cells separate into two types: one type generates a strong signal when the annulus receives greater illumination than the inner circle, and the other when the inner circle is brighter than its surrounding annulus. As we shall see, the function of these cells is to supply clear boundaries to patches of light on the retina.

The RG cells in the left part of the visual field from both eyes transmit to the right side of the brain, to a region known as the right lateral geniculate nucleus (LGN). Similarly, the cells in the right visual field send signals to a similar area in the left LGN. These converge on simple and complex cortical cells, each one being supplied by a set of RG cells. For example, one such set might be constructed from RG cells that are supplied by photoreceptor cells lying in a straight line that has a particular orientation in the visual field. In fact, each cortical cell is dedicated to a particular line orientation or direction of motion of an orientation.

Area 17 in the striate visual cortex at the rear of the brain is dedicated to pattern recognition, and there we have the construction of continuous lines, linear or curved, indicated by areas of contrast. Information is then sent to regions 18 (visual area V2) and 19 (visual area V3) further forward where a primal sketch of the visual scene is created (Marr 1982, Table 1-1). From this, a so-called 2½D sketch is assembled containing information about the distance from the viewer, discontinuities in depth, and discontinuities in surface orientation. Finally, a 3D model is produced.

Now, here is the crucial point. Our sensory-processing apparatus has imposed a clearly defined boundary around an ‘object’ that did not exist in the original retinal intensity distribution.[13] Since the visual map presented to our consciousness arises from the light emissions from the source object, there is no necessity for the source object itself to be bounded. Recall that we only receive *changes* in the external object not the object itself. It might possibly have unlimited extent. Now, at first glance, our tactile experience appears to reinforce the notion that an object is bounded. We reach out to

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[13] Here, the ‘object’ is defined as an area of light intensity on the photoreceptor mosaic that is brighter than its surroundings.

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touch the desk and the motion of our finger is arrested at the visual boundary of the desk. However, this 'boundary' is only the region where the electrostatic force of repulsion between our finger and the object is sufficient to halt our motion toward it. It need not be a boundary-to-boundary contact as our visual experience leads us to understand.

Nevertheless, it is precisely this tactile resistance that fortifies our belief in an external world. If we were only conscious of a 3D visual map, we might be tempted to conclude that we are passive observers of a mere hallucination. We might then believe that an external world spatially separate from us is only our mental creation. However, not only would this make our possession of sensory apparatus superfluous but we would also need to account for the fact that before the age of 5–6 months, the human child intentionally reaches out toward a visually bounded object and finds resistance to the touch in the vicinity of the visualized boundary (Piaget 1973, 54–55, 66–67).[14] It is this coordination (or apparent mutual corroboration) of visual and tactile space boundaries, supplemented by directed auditory stimuli, that gives the child confidence in positing a world that exists in a different part of space to itself. Eventually, it is noticed that events occur that are both contrary to his will and contingent. There is a world that exists independently of his processing apparatus. This suggests that Kant's 'thing in itself', the source of the light signals, is *really* rather than *apparently* independent of us.

Is it possible that everything I 'know' is a product of my own imagination? There is an argument against this solipsist position. If there were not an external world spatially separated from my brain, then although my mental apparatus presents the works of Mozart, Newton, and Shakespeare to me as not being mine, my brain would still have to be capable of generating them by itself in all their intricate detail. However, in principle, when future medical technology permits, a surgical exploration of my brain could be carried out which could demonstrate its incapacity to perform such feats of originality. This fact would then lead to an inconsistency.

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[14] Piaget calls this the "coordination of vision and prehension".

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One could suggest that this medical examination might itself be part of the hallucination, and so brings no authority to the judgment. However, if my goal is to produce a logically consistent explanation for my experience, I would have to reject my solipsist position. I would then have to conclude that these works are not created by my brain but are presented to it by a source external to it. One would then have to decide if this source were supernatural, which has the advantage of needing no further thought, or material, in which case considerable effort would be needed to imagine its structure.

The idea that one is not the entire world and that there are objects that exist independently of oneself is an early lesson in human development. Before two years of age, the child comes to believe that the world conforms to his will, a view that is initially reinforced by an attentive and obliging mother. However, he is soon exposed to contingent events that are beyond his control. Piaget (1971, 397) remarks that in the second year of life, "The self [...] discovers itself as a cause among other causes and as an object subject to the same laws as other objects".

It should be clear by now that experience contains elements of human sensory processing that must be given up if we are to get closer to a model of the 'thing-in-itself', the unobservable world that gives rise to our retinal light-intensity distribution. As we abandon sensory concepts such as a bounded or particle-like object, as well as the survival-orientated feelings attached to them, the higher-level and more widely embracing ideas acquire a greater invariance.[15] The need to abandon egocentrism was clearly expressed by Konrad Lorenz:

> Every time we succeed in tracing an element in our experience to 'subjective' factors, and in then excluding it from the image we form of extra-subjective reality, we come a step closer to that which exists independently of our cognition. (Lorenz 1978, 3)

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[15] Max Planck said, "This constancy, independent of all human and intellectual individuality, is plainly what we call the real" (quoted by Ryckman 2017, p. 331). Survival-orientated feeling can also obstruct the adoption of new and more promising ideas.

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1.7 A Return to Visualizable Concepts

Although symbolic mathematics is the language in which this 'image we form of extra-subjective reality' is to be conveyed, being an atomic mechanism, its expression can only take a geometrical form. Both Bohr (1913) with his circular-orbit model of hydrogen and Sommerfeld (1916) with his elliptic-orbit model realized this and both posited a visualizable atomic structure. They were notable approximations to reality because whatever these structures absorbed or emitted and whatever their state of motion, they always retained the same form. However, Bohr was confounded by the wave-particle duality, and in an act of resignation contrived to save his own sanity with the assertion "evidence obtained under different experimental conditions cannot be comprehended within a single picture" (Bohr 1951, 210). So, he supported the Heisenberg position in which only concepts relating directly to observables are permissible.[16] This emphatically prohibits the construction of visualizable models, and paralyzes the only method of devising closer and closer approximations to the thing-in-itself.

Unfortunately, Bohr's personal authority on this matter has impeded the progress of theoretical physics for the last 100 years. Even 400 years ago, Francis Bacon knew of such men:

> they prefer to blame the common condition of man and nature rather than admit their own incapacity (2000, 8) [...] they turn the weakness of their own discoveries into an insult against nature itself and a note of non-confidence in other men (2000, LXXV, 62) [...] this is wholly due to a wilful limiting of human power, and to an artificially manufactured desperation, which not only dims any visions of hope, but also blights all the incentives and nerves of industry [...] (2000, LXXXVIII, 73)

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[16] Heisenberg held the view that any quantities that were unobservable had no place in a theory and claimed that "it appears better to give up the hope of an observation of the previously unobservable quantities (such as the position and time of revolution of the electron [in a hydrogen atom]) [... and instead] to attempt to formulate a quantum-theoretical mechanics analogous to classical mechanics in which only relations between observable quantities occur." (Heisenberg 1968, 168–169).

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For Heinrich Hertz, physical theories might well contain an image designed to approximate the thing-in-itself, but the former cannot be directly compared against the latter to discover how close to 'reality' it is. Instead, he gave criteria for deciding between models, especially ones that predict the same phenomena:

> The images [in models] which we may form of things are not determined without ambiguity by the requirement that the consequents of the images [in the theoretical model] must be the images of the consequents [representations of phenomena]. [. . .] We should at once denote as inadmissible all images which implicitly contradict the laws of thought. [. . .] We shall denote as incorrect any permissible images, if their essential relations contradict the relations of eternal things. [. . .] Of two images of the same object, that is the more appropriate which pictures more of the essential relations of the object [in experience . . . and contains] the smaller number of superfluous or empty relations — the simpler of the two. (Hertz 1899, 2)

He realized that these images are not extracted in any way from experience since "our requirement of simplicity does not apply to nature, but to the images thereof which we fashion" (Hertz, 1899, 24). However, despite stating the logical independence of the theoretical model and the images in experience,

> Hertz renounced the theoretician's supposed need for heuristic resemblances or visualizable models and promoted a new abstract conception of a physical theory in which the sole relation between the premises of the theory and entities or processes in nature need only be symbolic. (Ryckman 2017, 325)

Influenced by Hertz, Einstein set out his program of theoretical physics as follows:

> The essential thing is the aim to represent the multitude of concepts and propositions, close to experience, as propositions, logically deduced from a basis, as narrow as possible, of fundamental concepts and fundamental relations which themselves can be chosen freely (axioms). [. . .] Physics constitutes a logical system of thought which is in a state of evolution, whose basis cannot be distilled, as it were, from experience by an inductive [logical] method,

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> but can only be arrived at by free invention. [...] The justification (truth content) of the system rests in the verification of the derived propositions by sense experiences [... and] evolution is proceeding in the direction of increasing simplicity of the logical basis. (Einstein 1954, 294, 322)

As Ryckman observes (2017, 350–351),

> the ideas of theoretical reason [...] give expression to reason's capacity to surpass the confines of experience through the hypothetical adoption of maxims of systematic unity or unity of nature [... which ...] any current state of knowledge of the world only approximates.[17]

Two main points arise out of the foregoing considerations. First, Newton's classical program of recording the position and momentum of every object in the local universe to predict its future evolution through a system of mechanical equations cannot be carried out. This should have been evident long before the invention of quantum mechanics, when the difference between terms in spectral line formulae suggested that it is not the thing-in-itself that is given to the observer but changes in it. For this reason, obtaining the precise location of the emitter of these changes from the changes themselves is impossible. Second, if we subscribe to the Heisenberg–Bohr philosophy of confining ourselves *only* to concepts that directly relate to observables, then we are committed to the 'particle' representation of light. However, this is a prejudice that arises out of the way our sensory processing represents objects as bounded volumes. In that case, there is no theoretical freedom to posit an alternative structure of light.

The instrumentalist doctrine that one should not seek causal explanations in terms of models, but only descriptions of experience, appears to have originated with Pierre Duhemat at the start of the First World War. According to Duhem, "physical theory is not an explanation, but a simplified and orderly representation

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[17] For empirical science to exist, the assumption is needed that reason's striving for simplicity and unity corresponds with a world independent of the mind.

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grouping laws according to classification which grows more and more complete" (Duhem 1954, 54). However, this is rather like finding similarities in the blocks that form only the foundations of a pyramid. As we have seen, if we are to make progress in obtaining knowledge about the world beyond the senses, the human mind must build this pyramid into increasing levels of visualizable abstraction from the senses, heights from which the lowest levels of the structure supporting it can be predicted.

1.8 The Nature of the Photon

We have already seen the argument that the notion of mass as a bounded and filled volume is a prejudice arising from the way we process sense data.[18] These sense data are presented to us as a change in the object external to us from which they originated. So, if we wish to know the structure of the originating object, we must be prepared to abandon concepts that are only useful for the most primitive level of our understanding. This requires a construction which finds its justification not in its direct comparison with the external object — for that is impossible — but in how well it can predict the data we receive through our senses. The recommendation here is that this construction should be geometrical in form, a basic atomic mechanism capable of producing the observed line spectra. As Popper observes, this is exactly what Bohr (1913) attempted but later abandoned when he realized he could make no further improvements:

> [...] nobody could have been more keenly aware of the depth of the difficulties that beset his [Bohr's] atomic model of 1913. He never got rid of these difficulties. When he accepted quantum mechanics as the end of the road, it was partly in despair. (Popper 2000, 9)

The structure of mass and charge is still an unsolved problem. Lorentz thought the electron was a solid sphere where the charge was "distributed over a certain space, say over the whole volume

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[18] We are confined to thinking visually in space and time, there is no way out of this, but the challenge is as follows: Can we produce a structure in this form from which all phenomena can be deduced?

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occupied by the electron" (Lorentz 1916, 11). He later modified his view, suggesting that "the charge might be distributed over a thin layer on its surface" (Lorentz 1916, 16). What this smeared out charge consisted of he had no conception. Feynman also viewed the electron as a sphere stating that "the field from a single charge is spherically symmetric" (Feynman 2006, 1–5). However, since the charge — the smeared out unidentified agent — can be divided into parts which react with each other, then this kind of electron must have a self-energy that arises from bringing these parts together from an arbitrarily large distance. As Fermi recognized, "the problems connected with the internal properties of the electron are still very far from solution" (Fermi, 1932). This is still true today.

So, where do we start in constructing our model of the electron? In the treatise that follows, we begin with circularly polarized light, for if we wish to understand the most recent experiments on the spin angular momentum (SAM) and the orbital angular momentum (OAM) of light, then it is indispensable to optics; see Chapter 5. In Chapter 2, the theory of circularly polarized light is developed and certain quantities such as SAM density, linear momentum density, and energy density are derived from it and compared with Maxwell's theory. Once we have this as a conceptual foundation, our next problem is to isolate a single photon and analyze experiments on photonics to see what adjustments need to be made to the idea. This is the aim of Chapter 3.

Experiments using spontaneous parametric down conversion (SPDC) generate an idler and signal photon pair. This is the set-up of the Grangier *et al.* (1986) experiment, and it is reinterpreted to suggest that a single photon consists of an advancing array of parallel circularly polarized tubes, each capable of exciting a detector. There are two probabilities to consider here. The first is the probability that the signal photon excites a detector given that it is incident on it, known from the detection of its idler twin at another detector. From the experiments analyzed, this probability is about $7.5 \times 10^{-4} - 1.0 \times 10^{-2}$. The second concerns the separation of the signal photon at a beam splitter into two detectors. We are then interested in the coincidence probability that one detector

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records a hit given that the other has registered. This is about $5.0 \times 10^{-5} - 3.5 \times 10^{-4}$. The second registration is usually interpreted to be an intruding photon from an unrelated SPDC event, but this view will not be adopted here. Here, the coincidence will be taken as evidence that a single photon front is capable of multiple detector registrations, an occurrence that has such low probability that it has hitherto passed unnoticed. The photon front will be seen as an array of advancing screw threads or helical space dislocations (HSDs) transversely iterated.

Having covered the transverse iteration of a circularly polarized tube, in Chapter 4, we treat the longitudinal iteration. This is the idea that n tubes can be joined end to end with action nh. The Bose–Einstein counting result is given a novel reworking to show that the idea of indistinguishable elements is not necessary for its derivation but it can be produced with distinguishable photons. This involves a rotating sequence of photons and cells in a closed cavity in which a cell is defined by the direction that a photon approaches it. It is shown that in a cavity containing a known sequence of photons with distinct frequencies in which the photons follow a closed path, if one photon can be identified in one cell, then the possible distributions of the remaining photons among the remaining cells can be ascertained based on the assumption of distinguishability.

Chapter 5 covers the theory of optical OAM. A transverse array of circularly polarized tubes (HSD) can be modified by optical elements to produce light with OAM. This creates what we shall call here a ‘helical array dislocation’ (HAD) which amounts to a rotation of HSD around the optic axis. Here, the Poynting vector possesses both a linear and azimuthal momentum, the latter momentum being a feature that Maxwell’s theory of electrodynamics is at a loss to accommodate.

1.9 The Mass Vortex Ring

Chapters 6–9 develop the theory of the MVR. To some extent, this was carried out in *The Quantum Puzzle* (Clarke, 2017) but only for an ‘unloaded’ ring, that is, one that has absorbed no radiation. The focus in that work was on electrodynamics where a derivation

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was provided for the Lorentz force using a changing parallel proton spin-2 momentum field, and explanations were given for the deflection of currents in parallel conductors as well as electromagnetic induction.

The first step in constructing an OAM mass ring is to take optical OAM, which is to be called spin-2 here, and define mass in relation to its minimum beam waist. This is to be called an SAM mass ring. It is assumed that the space surrounding this minimum radius also contains angular momentum, where HSD tubes are stretched out to provide field momentum. The axis of the SAM ring is then bent round into a closed circle so that the SAM ring runs along the surface of a torus or OAM mass ring. This rotation is to be called spin-3 and its existence introduces charge to the mass. Electrons and protons (and presumably other 'particles') are constructed in this manner, the proton being a scaled-down version of the electron with an opposite spin-3 rotation sense. Coulomb's law is derived on the basis of these OAM rings. Also, a modification to dynamics is proposed in which it is suggested that there are two types of acceleration: active and passive. The first is well known (though not by this name) in which a mass ring A absorbs energy in order to accelerate, and is observed to do so from a non-absorbing mass ring B. The second type is observed from the absorbing system A, and here B accelerates without absorbing energy, as a consequence of A's absorption. The relationship of B to electrostatic repulsion and attraction is pointed out in Chapter 6.

In Chapter 7, our attention is directed to the absorption of radiation to create a 'loaded' OAM mass ring. At this point, a defect in both the Sommerfeld and quantum mechanical treatments of the hydrogen atom is pointed out. They both depend on an external potential to create hydrogen energy levels, yet, as stated earlier, there are experiments that show that an electron can have energy levels in the absence of such a potential (McMorran *et al.*, 2011). So, the Sommerfeld derivation of the fine-structure formula is modified here to exclude the external potential and include a self-potential. It turns out that if half of the OAM ring energy is radiated at the boundary to the hydrogen atom state, the fine-structure spectral line formula can be recovered to a slightly better accuracy than before.

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The proton–electron bound state is developed further in Chapter 8 where certain principles are set out for its operation as follows.

(i) All emissions and absorptions occur at the maximum oscillation amplitude of the electron.
(ii) For a transition to occur, an excited OAM ring must temporarily collapse to the ground state circular radius.
(iii) All emissions are subject to a Doppler effect based on the electron's ground state ring in which the proton's speed of approach is taken into account. This can either be a red shift, in which the radiation emission passes through the proton before exiting, or a blue shift in which the emission moves directly away from the proton.
(iv) The proton and electron oscillations are $\pi/2$ out of phase.

To execute an accurate fine-structure calculation, a *Kalpha* parameter (which multiplies the fine-structure constant) is varied to bring the state frequency into alignment with the average of the two experimental hyperfine values. Finally, Chapter 8 suggests how electron configuration and alpha particles might be fitted into the MVR theory.

The final step in the MVR treatment of the hydrogen atom is to raise or lower the above-mentioned average hyperfine frequency to obtain the exact high or low hyperfine frequency for the state in view. This is the aim of Chapter 9. Here, the rate of increase of the proton's spin-2 momentum field is taken into account, and the eccentricity of the electron's spin-2 circuit is varied for precise results. Same-sense proton and electron spin-2 rotations (input $+$) produce the low hyperfine value, while opposite rotations (input $-$) give the high value.

So, exact hyperfine frequencies essentially depend on two parameters: *Kalpha* which varies the fine-structure constant, and the electron spin-2 eccentricity which varies the strength of proton field momentum absorbed by the electron. A computer program is provided for the reader which automatically searches for these two parameters. There are 24 states available for input, as well as the two relative proton–electron spin-2 rotation senses (+ for the low hyperfine, − for the higher), the angle that the electron spin-2 major axis is orientated (usually 135° suffices), and the type of Doppler shift (red or blue).

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