

Chapter 1

All Matter Instantaneously Senses All Other Matter in the Universe

It is easy to live on our warm and fertile planet and feel that our lives are affected only by the natural and man-made systems that exist in our local environment and that we can see with the naked eye. We know that the sun provides most of our thermal energy and that the forces of nature act to ensure that the earth maintains the right separation to support life. In a lesser way, we are also aware that our moon directly causes the ocean tides and also determines biological growth and fertility cycles. It seems however that none of the other objects in our solar system affect anything on our planet in any discernible way.

The spectacle of the night sky, with our planetary companions and the much more distant stars of our Milky Way as well as other galaxies extending to the limits of our best telescopes has certainly inspired awe in all human societies. For practical purposes, this display has been monitored closely for centuries and since the planets are unrestricted by friction forces, they have helped us understand some of the basic laws of physics. Now, astronomers use the latest data in an attempt to discover the past and future history of the universe. Is it possible however that the universe is not simply something that we observe by telescope? Perhaps we are intimately affected by our universe and because of its vast extent, it may well be responsible for very real forces that act on us, the earth and all of the objects around us.

Ernst Mach (1838-1916) [1.1], a highly regarded figure of the European scientific establishment at the end of the 19th century, believed that the force that prevents the earth from falling into the sun or that

The most remarkable feature of these forces is that unlike electric, magnetic or gravitational forces, we do not seem to be able to attribute their cause to any one or group of nearby objects. Even more remarkably, the force seems to appear in the same magnitude regardless of the direction of motion or acceleration. It does not matter whether a car is travelling north, south, east or west or even uphill or downhill, but if you turn to the left, then you will feel an inertial force pushing you to the right. The heavier you are, the harder your ribs will be compressed against the door.

The hypothesis of an instantaneous connection between the distant universe and the inertial forces on every object we observe is generally referred to as Mach's principle and has fascinated thinkers, scientists, and philosophers throughout the twentieth century. The principle is reminiscent of Newton's gravitational particle interactions which reach to the furthest corners of the cosmos. The earth, the moon, the planets and the sun are the dominant objects causing gravitational forces on the surface of the earth. However it must be a more orderly distribution of matter which underlies Mach's principle. Isotropic inertia forces, therefore, must rely on a remote matter distribution which due to its symmetry produces no noticeable gravitational effects on earth.

At the dawn of the scientific revolution, Johannes Kepler (1571-1630) in southern Germany and Austria and Galileo Galilei (1564-1642) in northern Italy laid the foundations of a new science called inertia. Both pioneers had royal patronage. Kepler made his most important discoveries while at the Habsburg court of the Emperor of the Holy Roman Empire in Prague, while Galileo served the Medici Grand Duke of Tuscany in Florence, the glittering citadel of the renaissance. Both were astronomers and physicists fascinated with the solar system of Copernicus which deprived the earth of its privileged position at the center of the universe. At the time, the Christian God was said to have created the earth as a stationary object to be a home for the human race. Though both men were devoutly religious, their views on the solar system brought them into conflict with the separate wings of the Christian establishment. Kepler was a Protestant and Galileo a Catholic.

The outspoken and extrovert Galileo exuded the kind of self-confidence which eventually led to his trial and condemnation in Rome.

More timid and of fragile health, Kepler avoided confrontation. A book he wrote to explain the Copernican world system was not published until after his early death at the age of 59.

Kepler and Galileo held each other in great regard and they had a long correspondence. When the professors of Padua chose not to observe the moons orbiting Jupiter through Galileo's telescope, for they thought it might undermine their scientific beliefs, Galileo wrote to Kepler:

“what would you say of the learned here, who, replete with the pertinacity of the asp, have steadfastly refused to cast a glance through the telescope? What shall we make of this? Shall we laugh or shall we cry?”.

Fundamentally, however, the two men disagreed on an issue which has remained the most enduring controversy in the history of physics: how do two particles of matter interact with each other when they are not in contact? The term “physics” was introduced by Aristotle nearly two-and-a-half millennia ago. In the first major pronouncement of this science, Aristotle contended that matter could not act where it was not. With this opinion he chased away the spirits, ghosts and Gods of ancient times and all their occult trappings. For many centuries scholars treated Aristotle as their inspired leader who had introduced the Age of Reason.

Unfortunately, it is often warfare and national defence that provides the incentive and resources for scientific discovery. This was no different in the middle of the 16th century when Giovanni Benedetti (1530-1590) studied the problem of the flight of cannon balls. During his research, he tied two objects of equal weight together with a thin thread and expected that they would now fall twice as fast as each on its own according to the principles of Aristotle. He found however, that this was not the case, and confirmed that all objects fall to earth at the same rate, regardless of their weight. Benedetti was never publicly recognized for his discoveries and it fell to Galileo to take the wrath and the fame for breaking the Aristotelian spell and proving that many of the Greek philosopher's claims were wrong. What is more, he demonstrated it with a series of simple experiments. Nonetheless, he held on to Aristotle's belief that matter cannot act where it is not. Kepler turned out

to be a more adventurous spirit. By studying planetary motion he had come to the conclusion that the sun and earth attract each other and so do the earth and the moon. This mutual attraction across empty space was contrary to Aristotle's teaching.

When Kepler was 29 years old, William Gilbert (1540-1603) published his famous treatise on magnetism *De Magnete* [1.2] in England and argued that the earth was a spherical magnet. He demonstrated with many experiments how magnets attract and repel each other. It is hardly surprising, therefore, that Kepler attributed the mutual attraction between celestial objects to magnetism.

Galileo did not believe it and generally avoided the subject of attraction in his extensive writings. Cohen [1.3] attributed the following quotation to Galileo.

“But among all the great men who have philosophized about this remarkable effect (the attraction between celestial masses), I am more astonished at Kepler than any other. Despite his open and acute mind, and though he had at his fingertips the motions attributed to the earth, he has nevertheless lent his ear and his assent to the moon's dominium over the waters (tides) and to occult properties, and such puerilities.”

The profound issue which divided Kepler and Galileo is still not settled, 400 years later. Physics has progressed along a string of paradigm changes from Cartesian ether whirlpools to Newtonian instantaneous action at a distance, on to Faraday's magnetic lines of flux and Maxwell ether stresses, to be superseded by Einstein's flight of energy, curved space-time and the photon-electron collisions of quantum electrodynamics. But do we yet understand how two separated magnets attract each other?

Consider figure.1.2 which shows two horseshoe magnets sticking to the vertical sides of a copper plate. The magnets are held up, against the pull of gravity, by their attraction to each other and friction on the copper plate. If we wish to explain the attraction with modern physics, we have to call upon quantum electrodynamics (QED). One of the originators of QED, Richard Feynman [1.4], claimed it explains

everything except gravitation and nuclear forces. Hence it ought to cover the attraction of two magnets.

In QED, forces between particles of matter are mediated by the collision of photons with electrons and the accompanying momentum transfer. So streams of photons must leave each of the two magnets of figure 1.2, spontaneously and forever, and then pass through a copper plate, finally colliding with electrons at the surface and deep inside the opposite horseshoe magnets. A simple collision between two particles produces repulsion, therefore in order to generate attraction between the magnets, the photons must navigate around the magnets, turn and strike them in the back.

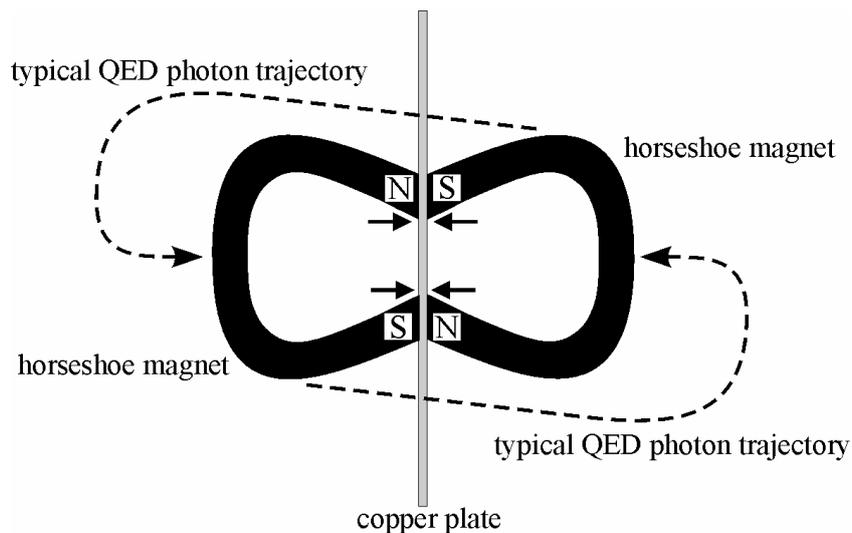


Figure 1.2 : Two horseshoe magnets attracting each other through a copper plate

This mechanism is so ludicrous that it will not be found discussed in textbooks. Nor will most professors mention it to a class of students. An exception was Guy Burniston-Brown [1.5], a reader of physics at the University of London. On one occasion he challenged an audience of students at Oxford University to explain the attraction and repulsion

between two magnets without employing action at a distance. He was met with silence. Later he described this incident in his book on retarded action at a distance and wrote:

“Why should we not admit that, sometimes, what appears to be happening is happening? The refusal to accept action at a distance has led to all the difficulties and tortuous explanations connected with ether-vortices, waves, twisted space-time and many others, together with abortive experimental efforts to detect the ether. The time now has surely come to cut the Gordian Knot by abolishing all the ethers, abandoning the attribution of physical properties to “nothing”, and rejecting purely mathematical constructions like space-time.”

So Burniston-Brown was on the side of Kepler and did not understand the doubts expressed by Galileo with respect to attraction. Burniston-Brown made an important contribution to inertia science which will be discussed in chapter 10.

During the past century physics has become increasingly more incomprehensible. This trend has been caused by layers of esoteric mathematics which the human intellect finds difficult to translate into mechanical models and pictures. However, in order to design and usefully interpret experiments, we are forced to devise mental constructs that represent the mathematical expressions. This has led to the seemingly paradoxical properties that are accepted as an unfortunate by-product of modern physical theory. Most people feel instinctively that an electron cannot, simultaneously, be both a particle as well as an extended wave of something. Similarly, since time is an abstract concept to begin with, there is considerable confusion regarding what is meant by relativistic time dilation. Einstein’s main doubt regarding quantum mechanics concerned how photons far apart from each other can instantaneously correlate their actions while adhering to the communication speed limit of the velocity of light? What makes particles increase their mass and weight with velocity relative to an arbitrary observer? Why should the orbiting planets be so exact in their wanderings while the motion of quantum particles is uncertain and

erratic? Matter is supposed to be continually created and annihilated, invisibly, all around us and the whole universe sprung from a single infinitesimally small point in a Big Bang.

Whatever happened to the Age of Reason? The wonders wrought by mathematics are no less mystifying than the stories told by religions. The dependability of the miracles hinges on the answer to one of the oldest riddles of science. The British astronomer W.H. McCrea [1.6] put it succinctly. In 1971 he wrote: "If we drop an apple, it falls towards the center of the Earth, but how does it know where the center of the Earth is?" Newton would have responded without hesitation and said that every particle of the earth attracts the apple and the sum total of these attractions is directed toward the center of the earth. To achieve this, all of the atoms of the apple must sense all the atoms of the earth. They must know each other's mass and their distance of separation in order to attract each other with the correct force. Since Newtonian gravitation works so well, we Neo-Newtonians believe the mutual awareness of matter particles is not just a theory but a fact.

Einstein saw things differently. He thought the simultaneous attraction of two particles was "spooky". He would not accept that this attraction was built into matter at the time of matter creation, even though the very existence of matter is equally inexplicable. Here we have reached the very foundations of science which can only be discussed in terms of metaphysics. Einstein justified his opinion as follows [1.7]:

"He (Newton) was also not quite comfortable about the introduction of forces operating at a distance. But the tremendous practical success of his doctrines may well have prevented him and the physicists of the eighteenth and nineteenth centuries from recognizing the fictitious character of the foundations of his system."

Einstein adhered to Aristotle's principle that matter could not act where it was not. He conjectured that matter would only respond to contact pressure from energy flying through space and striking it, or to collisions with other particles. This has become known as "Einstein

local-action". According to this view the apple falls toward the center of the earth because it is running in a groove of curved space-time which presses it to follow the path also predicted by Newtonian forces of gravitation and inertia.

We can now reverse the argument and express the opinion that the practical success of field and relativity theories may have prevented the physicists of the twentieth century from recognizing the fictitious character of curved space-time. So it seems that in the end the basic question of how matter interacts with other matter apparently rests on opinions and not on experimental facts. Both opinions have been fielded by many distinguished physicists, the respective groups being led by the figureheads of Newton and Einstein.

If, however, experiments should come to light which contradict either Newton's far-action theory or Einstein's local-action theory, then one of the two world views would no longer need to be considered. Of course it is possible that both theories are flawed. Then we would have to invent an entirely new matter interaction principle, however none has come to light in the 2300 years since Aristotle coined the word "physics". We therefore seem to be landed with Newtonian mutual simultaneous far-actions, that is attraction and repulsion between separated bodies, or the collision dynamics of Einsteinian local-actions.

It has to be recognized that certain theories are not relevant to all experiments, but remain valid in the appropriate situations. For example, Newtonian mechanics does not tell us anything about the velocity of light nor about optical effects near massive objects such as the sun. This limitation of the theory represents no disproof of Newtonian gravitation. If, however, the force of inertia, which controls the acceleration of falling objects, would not act in the same way for heavy and light objects, as predicted by Newtonian mechanics, then Newtonian far-action would be flawed. Galileo had already demonstrated to all of his peers that all bodies fall toward the earth with the same acceleration regardless of their mass, and with this one fact, toppled the long-held Aristotelian view of physics. Einstein later installed curved space-time and the general theory of relativity and consequently revived the Aristotelian philosophy.

A series of recent experiments performed by ourselves and others, have been published in the scientific literature and compiled in our earlier books, *Newton versus Einstein* [1.8] and *Newtonian Electrodynamics* [1.9], which have shown that the modern Lorentz force on metallic conductors is flawed. The earliest of these demonstrations were performed by Ampère (1775-1836) [1.10], the founding father of the subject of electrodynamics. His discoveries came more than 50 years prior to the proposal of the Lorentz force which eventually succeeded Ampère's original electrodynamic force law. The newer law became popular primarily because it suited the return to the philosophy of local-action which was being actively reinstated, mainly in England in the last two decades of the 19th century. However Ampère's law has never been experimentally disproved. Since Einstein's revolution, the Lorentz force has become the only force in the modern theory of relativistic electromagnetism. Its validity is taken for granted in the recent unification of the electromagnetic with the weak nuclear force [1.11]. As well, it is thought to explain the acceleration of the metallic conductors in all of our electric machines, including the generators that satisfy our insatiable demand for electricity. The Lorentz force represents a momentum transfer by collision between an electromagnetic field and a current carrying conductor and as such is part of the Einstein local-action philosophy.

Perhaps the most important discovery that the authors have made is best discerned by the geometry of an electromagnetic device called a railgun. During the 1980's, the railgun received a lot of interest as part of the US Star Wars research program and has since been investigated as a potential artillery weapon. However, disregarding its destructive capabilities, it has provided a very revealing test bed on which to compare the competing theories of electromagnetism. The basic elements and geometry of this device are seen in figure 1.3.

The metallic rails of the gun and the capacitor bank are heavy and fixed to the laboratory. The armature, however is free to slide along the rails. This is the bullet that is accelerated and eventually leaves the rails. The capacitors, which act like a very fast battery are charged so that they can be discharged very quickly through the rails/armature circuit. The force on the armature is a function of the electrical current flowing in the

circuit and its momentum gain is related to the force and the time duration of the current pulse. This measurable momentum is equally well predicted by the local Lorentz law as well as the non-local Ampère force law. However, a problem surfaces when the Lorentz force has to account for local Einstein action regarding the impact of electromagnetic energy flying through the air between the rails from the capacitor to the armature. The Lorentz force must come about as a result of the collision of this flying energy (which also carries momentum) with the metal of the armature. If we believe in momentum conservation, which Newton discovered and Einstein never disputed, we know the momentum of the flying energy because it must be equal to the easily measured momentum acquired by the projectile. In Einstein's theory the energy travels with the velocity of light. It is then easy to calculate with $E=mc^2$ how much energy must have been transferred between the rails to satisfy Einstein's local-action. This mechanism turns out to require thousands of times as much energy as was originally stored in the capacitor prior to the discharge. If we also cherish the principle of energy conservation, then this is a clear violation of Einstein's local-action principle. It is a huge discrepancy which also occurs all the time in every electric motor and generator. [1.9, 12, 13]

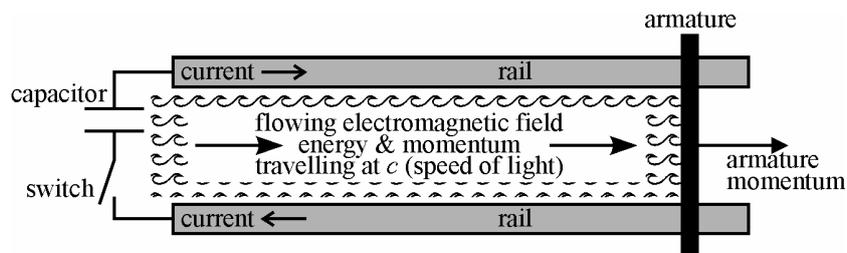


Figure 1.3 : Railgun geometry, depicting the field energy mechanism of the Lorentz force

To overlook this fact is synonymous with the blind adherence to doctrine demonstrated by the professors at Pisa in spite of Galileo's free fall demonstrations. They told their students to ignore the experiments. Aristotle had taught that heavy weights fall faster than light weights and

the established academicians claimed that he could not possibly be wrong.

We claim that with the railgun experiment, in which Einstein's famous equation ($E=mc^2$) fails, we have proved the veracity of the far-action philosophy embodied in Ampère's force law which simply predicts a repulsion between the rails and the armature. By insisting on the conservation of both momentum and energy, the local-action mechanism of relativity and field theories has been disproved, at least with respect to the electrodynamic forces between metallic conductors.

The indoctrination of physics students, their blind faith in what they have been taught by their elders, and the career punishment of those who challenge the consensus metered out in textbooks, has been widely discussed and has been reported since Galileo's time. There is no need to dwell on this social phenomenon. But it should be understood that Nature has spoken, and as far as Her remarks go, She supports the Newtonian world view.

What are the implications of this view? With respect to Newton's law of gravitation, the attraction between two particles depends on both masses, their distance of separation, and the direction of the straight line connecting them. Therefore, whatever determines the strength and nature of the attraction must from the outset have information about the masses and separation of the two objects. If no outside agency controls the strength of the attraction, then each particle must have knowledge of the other's existence and whereabouts. In other words, all particles of matter must be aware of each other. They must sense each other at a distance simultaneously at the same instant of time. This is the rationale behind the assertion that all matter feels all of the other matter in the cosmos.

Einstein disagreed vehemently with mainstream physicists about the probabilistic interpretation of quantum mechanics. For thirty years he stood almost alone in maintaining that the then new quantum theory of atomic and subatomic particles must be incomplete. He reasoned that, when the missing parts would be found sometime in the future, the theory would become as deterministic as Newtonian mechanics and relativity theories. Toward the end of his life, Einstein seems to have realized that the nature of the theory of quantum mechanics stems from

the principle that matter can indeed act where it is not, which is in strong disagreement with the local Aristotelian philosophy. Particles are simply aware of each other and there is no need for signaling between them, as relativistic field theory requires.

Many attempts, including Einstein's own efforts, have been unable to combine general relativity with quantum theory. Even though the subject is still being actively pursued, the dilemma persists. Quantum particles apparently interact non-locally at a distance. To have come to this conclusion must have been a great disappointment for Einstein because it threatened to destroy - to use his own words - "the castle in the air" which he had erected to defend local-action. He confessed this pessimistic outlook only to his closest and oldest friends from the Bern period during which special relativity was born. Maurice Solovine was one of the members of the Olympia Academy, a circle of friends around Einstein who met frequently to discuss scientific topics. When Solovine sent greetings to his friend on Einstein's seventieth birthday on March 14, 1949, and congratulated him on the great success of his life, Einstein replied two weeks later that he thought none of his theories would stand firm [1.7].

His best friend from the Bern years was Michele Besso who actually drew Einstein's attention to the writings of Ernst Mach and Mach's understanding of Galilean relativity. There remain 110 letters which Einstein wrote to Besso. The very last letter was dated August 10, 1954, eight months before Einstein's death. In the last sentences of this letter one reads:

"I concede, however, that it is quite possible that physics cannot be founded on the concept of the field (local-action) - that is to say, on continuous elements. But then out of my castle in the air - including the theory of gravitation, but also most of current physics - there would remain almost nothing."

One must not confuse human opinion, however well founded on logic and mathematics, with laws of nature. There is no evidence that these laws have changed during the existence of the universe. Whoever or whatever was responsible for their formation did his work billions of

years ago, long before the human race arose on earth. It seems unlikely, therefore, that the laws of nature were written to conform with anything that human brains would create as, for example, logic or mathematics.

One of Newton's opinions, which he may have held only for a short time, is often invoked against his own concept of mutual simultaneous attraction between particles of matter. No letter of science has been more frequently quoted than the one in which Isaac Newton, then a Fellow of Trinity College and Professor of Mathematics at the University of Cambridge, wrote to the young clergyman Richard Bentley on January 17, 1693. It contained arguments on proof of Deity which Bentley was to use in his Boyle Lectures intended to combat the atheism widely professed in taverns and coffee houses. At the urging of Newton, Bentley would later be appointed to the Mastership of Trinity College. In this capacity he persuaded Roger Cotes, another Fellow of Trinity College, to write the preface to the second edition of Newton's *Principia* [1.14, Vol.1]. This preface turned out to be a most outspoken defense of action at a distance and it had Newton's approval. However twenty years earlier Newton had written in his private letter to Bentley [1.14, Vol.2]:

“It is inconceivable, that innate brute matter, should, without the mediation of anything else, which is not material, operate upon and affect other matter without mutual contact, as it must be, if gravitation, in the sense of Epicurus, be essential and inherent in it. And this is one reason why I desire you would not ascribe innate gravity to me. That gravity should be innate, and essential to matter, so that one body may act upon another at a distance through the vacuum, without the mediation of anything else, by and through which their action and force may be conveyed from one to another, is to me so great an absurdity, that I believe no man, who has in philosophical matters a competent faculty and thinking, can ever fall into it.”

Strong words indeed, but not strong facts. In this letter Newton maintained that anyone believing in instantaneous action at a distance must be mentally impaired.

Six years before the Bentley letter the same Isaac Newton published the Principia which has become the most useful scientific treatise ever written. Newtonian gravitation, for the first time outlined in this treatise, was utterly dependent on the mutual simultaneous attraction of particles. Nothing was said in the Principia which raised doubt as to the existence of action at a distance.

Ten years after the Bentley letter Newton added his famous “General Scholium” to the second edition of the Principia. In it he confessed that he had not discovered the cause of gravity “from the phenomena”, and he would suggest no hypothesis which could explain this cause. Roger Cotes’ preface to the second edition of the Principia strongly argued in favor of simultaneous far-actions and Newton agreed to its publication.

This story illustrates that human beings, including Isaac Newton, hold opinions which change with time. These opinions must not be confused with objective scientific facts. However creative the human brain may be, it is not a generator of unshakable experimental evidence.

A reminder of the Bentley letter will be found in the letter which Einstein wrote to his old friend Maurice Solovine in 1949 [1.7]. Just after his seventieth birthday Einstein wrote:

“You imagine that I look back on my life’s work with calm satisfaction. But from nearby it looks quite different. There is not a single concept of which I am convinced that it will stand firm, and I feel uncertain whether I am in general on the right track.”

Again it was a private opinion which found no expression in Einstein’s scientific writings. We can only surmise that, like the Bentley letter, it concerned instantaneous action at a distance. All of his relativity theories rested on Einstein’s early opinion that action at a distance was “spooky”. Just like Newton, he may have thought that only insane minds could believe it. Nevertheless by the time he reached his seventieth birthday, it had become clear to Einstein that quantum mechanics required instant remote interactions. In the following decades many more physicists came to the same conclusion. The rest continue to fight a losing battle in which they have recently introduced the new term

quantum entanglement as an alternative to a discussion of the now taboo phrase 'action-at-a-distance'.

The remarkable difference between Newton and Einstein was that, but for some notable exceptions, Newton adhered to his self declared creed, *hypothesis non fingo*, (I do not make hypotheses) and in public he only described experimental facts and observations. Einstein, on the other hand, was proud and indeed became famous for his boundless imagination and thought experiments. The human element in relativistic field theory has become its undoing. Newton struggled with the same questions, but he recognized that the truth of nature can only be found in the objective world outside the human brain. The lesson to be learned is that if one cannot directly observe a mechanism for a physical action, it is best not to conjecture.

A modern theoretical astronomer who deserves much admiration is Tom van Flandern [1.15], who clearly recognized that many astronomical observations are not compatible with the propagation of gravity limited to the velocity of light. He updated the calculations of Pierre-Simon de LaPlace (1749-1827) [1.16,X,vii] who was the first to demonstrate that gravitational interactions had to be at least seven million times faster than what we now call the speed of light. Van Flandern used modern data to show that in fact if gravitational interactions involved messages sent between interacting bodies, then the messages must be travelling at least at twenty billion times the speed of light in order to retain the stability that we observe in our solar system. Einsteinian relativists consider the speed of light to be the cosmic speed limit and as a result find this result very difficult to assimilate in their theory. It seems a small mental step from Van Flandern's very large gravity velocity to acceptance of simultaneous remote particle interactions. LaPlace made this leap but Van Flandern is not prepared to take this step because of the human element and what he calls logic. Instead he postulates, by hypothesis, the existence of gravitons which travel much faster than photons.

Van Flandern reasons Newtonian attraction is illogical because one particle must be the cause of gravity and the other particle must feel the effect a little later. This kind of causality is clearly a human hypothesis and not a demonstrable fact of the objective world. Here we come face

to face with the question of whether the maker of the laws of nature was in awe of man's intellectual power and logic? Van Flandern's logic, Newton's remark about insane minds, and Einstein's spookiness are not cold objective experimental facts which compel us to believe that two particles of matter cannot attract or repel each other at a distance. We need something better to establish the interaction principle by which nature abides.

A most remarkable example of the interference of the human brain with objective nature is provided by the concepts of space and time. When asked out of the blue, almost every adult human being will say that he or she knows what is meant by space and time. Yet there exists not a scrap of objective empirical evidence that either entity exists at all. Faced with the experimental situation, the honest scientist should admit that space is nothingness and so is time. Experimental observations deal only with the relative measures of space and time. They are the distance between material objects and the intervals between material events. We know how many measuring sticks can be laid end to end between two stones. Thus distance becomes a ratio between something variable and something that we are familiar with and that we believe remains constant such as the standard metre stick stored safely in a glass case in Paris. This ratio is just a number based on observations of objects and is certainly not something that can be called space. Similarly, our measurement of time always represents the ratio of the period of a cyclical event that we are familiar with and another event. For instance, we observe that the sun rises 365.25 times in the interval that it takes for the earth to go once around the sun. This is a ratio of intervals and not time itself, but is enough to give us the feeling that we know how long a year is.

Immanuel Kant (1724-1804) [1.17], the German philosopher addressed these problems. Fifty years after Newton's death he said-in English translation-:

“ Therefore, we shall understand by *a priori* knowledge, not knowledge independent of this or that experience, but absolutely independent of all experience.”

Then he goes on to explain that space and time are *a priori* knowledge stored in our brain before birth, while what we know of the objective world is observed by the senses and then stored in the brain *a posteriori*. Why should nature find it necessary to store the *a priori* notions of space and time in our brains? A likely explanation is that without them we would not be able to sense motion and could not interpret our flexible bodies and our ever changing environment.

If we are to remain true to Newton's dictum and only create mathematical equations which model the features of the universe that we can observe, then we have to base our physics on the only motion that we can perceive, which is relative acceleration between a pair of objects. Any two objects certainly exert a gravitational force and possibly an electrostatic or electromagnetic force on each other and if they are free to move, they consequently accelerate toward or away from each other. By observation, Newton discovered that there are attractions for which the relative acceleration is related only to the masses of the two objects. He described these motions and related them to a force which he called gravitation. Coulomb and Ampère observed that charge and electric current also affect the relative acceleration of objects and ascribed their relative accelerations to electrostatic and electromagnetic forces respectively. These three pioneering scientists were all able to empirically discover non-local force laws which describe observed accelerations without any consideration of the mechanism by which they acted.

Another type of force is however also detectable. This is the force of inertia. It can be generalised as a force which counteracts any acceleration of an object with respect to the frame that Mach described, in which the bodies of the distant universe are observed to be at rest. This instantaneous force appears to be related to the mass of the object and its acceleration with respect to the Machian frame. An interaction between an observed object on earth and one in the distant universe must be a non-local interaction. The stars in our galaxy are far enough away from us that however fast they are moving, they form a virtually fixed background upon which we measure the motion of our much closer planetary companions. In the same way the relative motion between the galaxies other than our own also can be considered a fixed background

relative to which we can measure acceleration. Further, since the laws of inertia appear to be the same for all directions of motion, then we can assume that the parts of the universe that significantly contribute to the inertia force are distributed uniformly in all directions. This is called an isotropic distribution.

The most familiar manifestation of the force of inertia is the linear resistance to acceleration. This is the force that appears whenever an object is subjected to an applied force either by contact or by gravity, electrostatics or electromagnetism. The inertia force precisely opposes the applied force in such a manner as to allow a finite and predictable acceleration. It is the reason that all objects fall toward the earth with the same acceleration regardless of their mass. If this force did not exist, then any applied force would produce an infinite acceleration and the universe would have collapsed long ago due to the force of gravity.

If however, a force is applied to an object which is already moving perpendicular to the direction of the applied force, then the inertial opposition becomes known as a centrifugal force. This is the force that stretches and sometimes breaks a string used to swing a weight around our head. It is also the force that pushes a race car off a high speed corner and most importantly prevents the earth from falling into the sun.

Possibly due to the fact that the inertia forces are so uniform and also that a search for their source implies the currently unfashionable non-local interaction principle, they have been treated differently from the other forces in modern physics textbooks and are often only described as “pseudo-forces”[1.18]. Part of the problem with the image of inertial forces is that nobody has yet proposed a Newtonian non-local force law which can give the inertial force the same “true-force” status as the laws of gravitation, electrostatics and electrodynamics. Such a law is proposed in Chapter 12 of this book. Like its predecessors, the laws of Newton, Coulomb and Ampère, it makes no assumptions regarding the mechanism of non-local interaction, but simply aims to fit the observed acceleration measurements.

If indeed, objects are directly pushed and pulled by all of the bodies in the universe, then a perfect demonstration of these forces is the space compass, better known as a gyroscope as shown in figure 1.4. Once the axis of a flywheel is aligned to point from one fixed galaxy to another

and is held in gimballed bearings which are secured to a space capsule, it will point in this direction forever, whatever maneuvers the space ship will perform, so long as the gyroscope is kept rotating and no electric, magnetic, or contact forces can apply a torque to the axis of rotation. The atoms simply feel where the fixed stars are and are pushed and pulled by them. It is not the inertial or gravitational interaction with the nearby stars that stabilizes the gyroscope alignment. It has to be other isotropically distributed matter arranged in an unchanging way with respect to our galaxy. Every time we become aware that we are accelerating, it is because the distant universe noticed it and has pushed us.

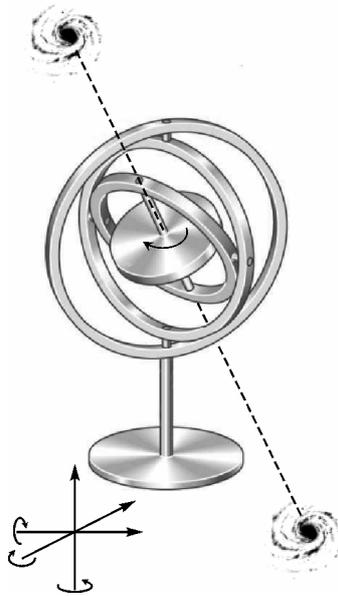


Figure 1.4 : A rotating gyroscope in gimballed bearings. The axis of rotation remains aligned with two galaxies, however the base is moved.

Chapter 1 References

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