Darshana Jolts

Restless Motion: Its Variety and Relevance

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Now here, now there, now to, now fro,
Now up, now down, the world goeth so,
And ever hath done and ever shall.

– John Gower

Motion, Motion, Everywhere: *Nothing in the world is at absolute rest.*

The most ubiquitous aspect of the world is *movement*. The tree branch gently moves to and fro at the touch of the breeze, the cat runs across the street, raindrops fall from up above, the bullock cart trudges along, automobiles speed on the highway, the pendulum swings routinely, the sun seems to rise and set: these are some of the countless instances of motion all around us. Even when we sit still for meditation, we feel the rhythmic beat of the heart and the in-and-out motion of air through the nostrils.

The massive rock in the park seems to have been sitting there, not moving, for a long time. It may have been sitting there for decades, sturdy and unmoving to all appearances. But it is not all that stationary when we realize that, being part of this earth, it is spinning around with the planet, swinging through cold space at the earth's orbital speed of some eighteen and a half miles a second.

Up there in the sky at night we see countless specks of twinkling stars. They too change positions as the hours pass by. Aside from their patterned revolutions resulting from the earth's spin, they are zooming in pitch dark space at unimaginable speeds. Even the apparently fixed Polaris which guided mariners in days of yore, and was regarded in the lore as ever unperturbed[1] is not without motion. But actually it is moving with a radial velocity of about 17 km/s.

Like every chunk of matter, the inert stone in the park, to all appearances motionless on ground, is made up of countless imperceptible molecules and atoms. These are vibrating vigorously, not staying immobile like their totality seems to be. The atoms themselves consist of perpetually orbiting tinier parts that play a role in the construction of matter.

[1] Dhruva, as per *Vishnu Purana*, was the prince whose persistence in his devotion to Vishnu was so admirable that he was transported to the heavens and became the North Star (Pole Star). The *Mahabharata* and *Surya Siddhanta* refer to the Pole Star as Dhruva. In Chinese mythology Beiji Dadi (Pole Star) was regarded as the Ruler of the Stars.

There is nothing in the universe that is utterly motionless. Every speck and star is in a ceaseless dance, as it were, displacing itself from point to point. Hence Descartes' pithy description of the world as *matter in motion*[2]. Let us think about this for a moment: all the range and splendor of the phenomenal world reduced to a single phrase! That is part of the quest for the roots of perceived reality: to seek underlying principles, to encapsulate multiplicity in terms of brief principles and in succinct formulas.

All motion may be viewed as the life-throb of the cosmos. If and when everything comes to an absolute standstill, then will it spell the silence of cosmic demise. The eighteenth century physicist-pholosopher Pierre Moreau de Maupertuis insightfully remarked, "*Le plus grand Phénomène de la Nature, le plus merveilleux, est le Mouvement*: [The greatest phenomenon in Nature, the most marvelous, is motion.]"

Motion's Variety: *There is an endless great range and variety in motion.*

The slow pace of the cow is very different from the fast flight of an arrow. The fall of a meteor is decidedly not the same as the flight of a bird. Clouds move and planets move, and so does water in a river, but not all in the same way. The pendulum moves and the ship on sea, but each very differently. One can go on and on listing movements in the world. There is rich variety in the motions we observe.

We describe motion by its magnitude: some bodies are moving fast, and some slow, though fast and slow are surely relative terms. We also refer to motion in terms of where a body is heading to: towards the north or the southeast, upwards of downwards, or whatever. At any instant of time, every moving body is in a particular *state of motion* which specifies its *slowness* or *fastness* as well as its *direction*[3].

As we observe and reflect on motion, we recognize that all its variety may be put under just two broad classes: Motion that does not change and motion that does. In other words, a body may be moving without changing its speed and direction, or these may change. It is remarkable that in one conceptual stroke we are able to reduce the stupendous multiplicity into just two simple categories.

Things are either standing still,
Or moving fast or slow.
Moving things sometimes will
A change in motion show.

[2] In his *Principles of Philosophy*, René Descartes said further that God is the first cause of movement and that he conserves the same quantity of it in the universe.

[3] This is the basic idea in the definition of a *vector* quantity in physics: one which has both magnitude and direction.

Here is an instance of the capacity of the human mind to classify and categorize even in the midst of a mound of variety[4]. Categorization enables us to uncover patterns and discover causes. Careful observations to begin with, and careful thinking about them; combine the two, and many aspects of the roots of perceived reality begin to emerge. We discern underlying simplicity behind all the complexity, there is unsuspected order underneath the confusing chaos, patterns behind what seems to be mindless randomness.

Measuring Motion: ***Much knowledge can be gained by measuring motion.***

We measure motion in terms of the distance traveled in a given amount of time. This is what we call the *speed* of a body. When we also specify the direction of motion, we speak of the *velocity* of the body. Thus, the speed of a car may be 60 km per hour, and its velocity could be 60 km per hour towards the West.

When motion remains unaffected, i.e., when something is moving with the same speed along the same direction, we describe it as *uniform*. A body in apparent rest may be looked upon as a special instance of uniform motion. Driving in the same direction with the same speed would be an example of uniform motion. More generally, uniform motion is any motion along a straight line with unchanging speed. We rarely encounter uniform motion for long. Every moving thing we see around us changes its magnitude or direction sooner or later. Not just vehicles and machines, people and animals, birds and insects, but falling stones, flowing waters, and blowing winds: everything seems to slow down or pick up speed, change direction, or stop.

When there is change in either the speed or the direction of a moving object, the motion is called *non-uniform* or *accelerated*. In common parlance the term acceleration implies only increasing speed. But not so in technical physics. Here it could be increase or decrease in speed; the latter may be called negative acceleration; or it could simply be direction change in motion. Thus, a stone whirled around a circular orbit by means of a string is displaying accelerated motion even if its speed remains the same, because the direction of its motion is constantly changing. The moon going around the earth is accelerating too.

Speeds in the Universe: ***There is an incredible range of speeds in the universe.***

The sign on the road may say that the speed limit is 30 km/hr. Is this fast or slow? Fast and slow do not have absolute meanings, even much less than beautiful and ugly. The snail which is

[4] It may be pointed out here that the genius of the classic Hindu mind was in its extraordinary capacity at categorization. In virtually every branch of Hindu thought (psychology, philosophy, medicine, human characteristics, human aptitudes, facial features, moods) one finds instances after instances of classification. But one stopped short of explanation or root causes for the entities classified.

stepped over by a camel may complain that a speeding body did it. But we can compare speeds. The train is moving faster than the trolley, and the buggy faster than the bug. Let us reflect a little on the kinds of speeds one encounters in the world around.

We can see a centipede crawling at a few centimeters in ten seconds, a fast walker can cover a few kilometers in an hour, but jaguars dart at more than a hundred. Racing cars zoom at a few hundred kilometers an hour, while jet planes travel at a thousand. Sound in air travels at a much greater speed, covering more than 3,000 meters a second, but there are supersonic jets that zoom still faster. We know of stars that rush through space at more than 7,000 kilometers an hour, while grand galaxies consisting of billions of stars are fleeing each other at speeds of the order of 20,000 kilometers a second. On the other hand, electrons in atoms whirl around atomic nuclei at speeds of more than 2 million meters a second! If we wonder if there is any limit to the possible speeds of bodies, the answer is yes, for it turns out that no physical entity can ever move, even in principle, with a speed exceeding that of light, which is about three hundred million km a second. So here we are in a world of restless bodies, from tiny electrons and mammoth galaxies, all constantly on the move, but with speeds spanning a remarkable range, and along all directions.

If the range and numbers are mind-boggling, it is even more remarkable that they have been tracked down by human ingenuity. It is difficult enough to recognize that sound and light travel with finite speeds, to know of hydrogen atoms and molecular motions, and to become aware of the existence of electrons and galaxies. But computing their speeds is far more impressive. We have been able to accomplish all this only in the past three and odd centuries: a fleeting instant in the span of human history. These are no meager achievements of human intelligence and ingenuity. They are intellectual conquests in the face of which all the lofty proclamations about

What if everything should suddenly come to a deadly standstill? No such instant can ever come to pass in the universe, any more than that as long as human civilization lasts there will ever again be a moment without a whirling wheel. The very existence of matter depends on the motion of electrons around atomic nuclei, even as the stability of planetary systems depends on the orbital motion of the planets. Contrary to appearances, stars do not and cannot stay put in the heavens. Ours has never been and will never be a static world.

Underlying all mute matter there is restless cosmic energy that keeps everything moving and moving for evermore. The mythic vision of a dancing Shiva conveys this cosmic dynamism powerfully. Matter is the static aspect of the world and motion is its dynamic aspect. There cannot be matter without motion, and there cannot be motion without matter.

Free Falling Bodies: *There is more physics in falling bodies than meets the eye.*

One of the most commonly observed motions in the world is the falling of bodies down to the ground. Anything thrown up in the air falls back to the ground. Other things fall down too: like fruits from tree branches, waters down the cliff, and meteors from the sky. So they have been observed and discussed since ancient times. When bodies fall, they tend to move faster and faster. It seemed reasonable to ancient thinkers (and does to many people still) to suppose that heavier bodies fall faster than lighter ones.

It was only in the seventeenth century that the phenomenon of falling bodies was investigated quantitatively. Galileo was one of the first to do this with carefully designed experiments. His studies led to two important results: First, that the rate of fall is independent of the mass of the body. In other words, if a lead ball and a cotton ball were both dropped from the same height, they would both take the same time to hit the ground. Many have heard of the legendary experiment from the leaning tower of Pisa[5]. This would be exactly true if there was no air to slow down the rate of fall.

Galileo also found that the distance traversed by a falling body was proportional to the square of the time elapsed[6]. This was one of the first formulas to enter the discourse of physics. It is a natural consequence of the result that all falling bodies suffer the same acceleration. Many experiments were undertaken to determine the precise value of this acceleration of falling bodies. The acceleration of falling bodies has come to be known as the acceleration due to gravity. The world of physics denotes it by the symbol[7] g. Its value diminishes with height, and changes ever so slightly from place to place.

It turns out that a good deal of information about the roots of perceived reality may be obtained from the precise value of g. For example, the oblate shape of the earth was uncovered by careful measurement of g at different latitudes. Sensitive instruments that measure g can tell geologists what lies underground.

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5 For more on the history of this story, see, V V Raman, The Leaning Tower of Pisa Experiement, *The Physics Teacher*, Vol.10, No.196, 1972. Galileo published details of this result in his classic work, *Discourses and Mathematical Demonstrations Relating to Two New Sciences*. It may be pointed out that Thomas Bradwardine had arrived at the $(1/2)at^2$ formula earlier.

6 This corresponds to the formula $s = 1/2at^2$.

7 The symbol g is use to denote that the acceleration is due to gravity.

On Meteors and Meteorites: ***Stony debris keep falling from the sky.***

Meteors are fiery falling bodies *par excellence*[8]. They have been observed since time immemorial, giving rise to much mythology, temple building, and piety. The *Rig Veda* refers to meteors[9]. One which fell in Phrygia millennia ago led to the cult of Cybele (the Divine Mother)[10]. Venus was represented in the form of a cone-shaped meteoritic stone. The Black Stone (known as Kaaba) stone which is venerated to this day in the holy precinct in Mecca is regarded by some as a meteorite[11].

In our own times, we look at comets as fascinating objects, and they do not strike terror in the hearts of normal people. We may observe an eclipse without invoking benign spirits to overcome the devouring demon. We stare at the aurora without reverting to the worship mode and prayerful pleas for personal safety. We see meteorites without imagining it is Diana who is descending from Jupiter, or a warning from God about something terrible to happen. It is important to know that it was only after the rise of modern science that such enlightenment has been slowly permeating our collective psyche, though this has by no means occurred as yet to humanity at large.

Millions of meteors zoom through our skies every day and night. It has been estimated that more than twenty metric tons of meteoritic mass plunge into the earth's air every day. That so few of them are actually seen should remind us that even with our enormous population, we human beings inhabit but a small fraction of the earth's total surface. It was only by the close of the eighteenth century that meteors were recognized as pellets from planetary space in the vicinity of the earth's orbit, intruding into our atmosphere. Ernst Chladni was the first to suggest in 1794 that atmospheric friction is what causes the glow[12]. After all, these objects are moving with speeds of the order of several hundred thousand kilometers per hour.

The spectacular *meteor showers* occurring periodically result from the debris of comets that stray into our atmosphere. They are not unlike a spurt of smoke from the exhaust of a polluting

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8 It is an etymological misnomer to call them thus, because the literal meaning of meteor refers to something in the atmosphere. It was once not known that meteors have an extra-atmospheric origin. But they are certainly atmospheric phenomena.

9 Known as *ulká* in Sanskrit, they are mentioned in the *Rig Veda* (IV: 4.2; X:68.4).

10 Mircea Eliade says (*The Sacred and the Profane* – 1961) that the Palladion of Troy, the Artemis of Ephesos, and the Cone of Elagabalus in Emesa, were all meteorites – stones that had fallen from the sky, objects from heaven, believed to contain supernatural powers.

11 According to tradition it was sent by God to Adam and Eve to indicate to them where to build a sacrificial altar.

12 For details on the controversy that was provoked by Chladni's idea of an extra-terrestrial source for meteorites, see, Williams Henry Smith, *A History of Science*. Harper, 1904.

truck. They become so bright and fiery only because of heating by friction in the air. We have records of major showers dating from medieval times, but it was only in 1867 that the correlation between a comet's orbit (Tempel's comet) and meteoric showers was first recognized[13].

Meteorites are the more massive rocks that are not completely vaporized during their swift passage through air, and fall to the ground. They range from small stones of modest sizes to huge rocks that can wreak havoc on people, community, or even on biological evolution. In 1954, a certain Mrs. Hewlett Hodges had the surprise of her life: A ten pound meteorite crash-landed into her living room, smack through the roof, and bumped on her thigh[14].

Disturbing though this was, it was nothing like the one that, in the view of some, hit the earth some sixty five million years ago and (among other things) served as death-knell for the last surviving dinosaurs[15]. According to estimates, that enormous chunk was some six miles across, and its impact was greater than five billion Hiroshima bombs. *The disappearance of the dinosaurs permitted the evolution of the larger mammals*, leading to the emergence of *Homo sapiens*. Let us reflect on this a little. If this is what happened, then but for a stray meteorite that bumped into the earth some sixty five million years ago, you and I wouldn't be here today! This gives a new twist to human genesis: We are the indirect offspring of meteoric motion. The theories of science often excel the strangest of fairy tales.

How likely is it that such an event will be repeated, spelling catastrophe on our species? The Spacewatch Telescope at Kitt Peak (Arizona) has been keeping close track of even minor asteroids (3 meters across) wandering in our neighborhood, i.e., within a few hundred thousand miles. Calculations suggest that sizable rocks may impinge on the earth's surface at least once every hundred years. If spotted in time our technologies may be able to shove them away. Some have even suggested firing nuclear missiles at them to accomplish this. If not, more craters and mammoth disasters could ensue on earth.

Meteors are not just free fireworks in the sky, and meteorites are more than extra-terrestrial tidbits. These utterly random intruders may impress us as shooting stars. If large enough, they also provide us with materials to explore the nature of out-of-reach matter.

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13 Sky-watchers have calculated that Tempel 1 will come pretty close to the asteroid Ceres on November 11, 2011, and that in October 2183 it will come very close to Mars. The point of this is to remind ourselves of how precise observational and computational astronomy can be.

14 John S Lewis, *Rain of iron and ice: the very real threat of comet and asteroid bombardment*, Basic Books, 1997.

15 This theory was put forward by the physicist Luis Alvarez and his son Walter Alvarez. For an account of how they were led to it see, C G Wohl, Scientist as detective: Luis Alvarez and the Pyramid Burial Chambers, the J F K Assassination, and the End of the Dinosaurs, *American Journal of Physics*, Vol.75, p.968, 2007.

We tend to look upon science as a source of power, as an instrument for useful gadgets, and as the culprit wreaking havoc on rain forests. We seldom recognize it as a torch of rational knowledge or as eraser of superstitions. Yet, more than anything else, these are the roles that science plays in human civilization. It is important to recognize the evolution of knowledge and ideas in human history.

Circular Motion: ***Celestial motions are not all circular*****.**

Seeing the periodic repetitions in the skies, many ancient observers of celestial bodies concluded that all motion up there must be circular. The Pythogoreans articulated this idea in the Western tradition. One imagined the stars to be fixed to a revolving crystal sphere, and the planets to be moving in their own spheres. This led them to believe that the motions of these bodies in their respective spheres produced a kind of cosmic music which a few fortunate souls could hear. Thus arose the notion of the music of the spheres whose echoes have been heard for long centuries. Poets, philosophers and mystics have referred to this celestial harmony.

Plato assigned to his students the problem of accounting for the changing celestial positions in terms of circular motions, and Eudoxus explored the matter extensively[16]. Aristotle who propounded that all celestial bodies are perfectly spherical in shape, was also convinced that they moved only in circular paths. After all, the circle is the most perfect of all geometric figures.

In the course of time, the idea of circular motion in the heavens became a tenet of Greek astronomy, reaching a climax in a classic work by Claudius Ptolemy, which came to be known as *Almagest*. This treatise, which spoke of cycles and epicycles to account for the retrograde motions of planets, reigned supreme until the rise of modern astronomy, as other classical works did in other cultures.

Projectile Motion: ***Projectiles move in parabolic paths.***

We have all kicked a football, hit a tennis ball, or seen one fly through the air when it is projected. One may wonder what keeps the ball moving when no one is pushing or pulling it. How is it that some things are moved continuously, though that which caused them to move is no longer in contact with them? What, if anything, was imparted to the flying ball that it finally hits the ground after following a curvy path? These are questions of great import in our search for the roots of perceived reality. They engaged keen minds for long centuries and provoked all kinds of answers before the truth about the matter was uncovered. It is safe to say that if these

[16] G L Huxley, 'Eudoxus of Cnidus', *The Dictionary of Scientific Biography*, IV, pp.465–7, 1980.

questions are posed to many in our own times, their answers would be more akin to the ancient or the medieval views than to the modern.

Then there is the curved path of the projectile: What kind of a curve is this? It looks very much like the arc of a circle, but it is not. It is, in fact, the portion of what mathematicians call a parabola: a very interesting and graceful curve whose geometrical properties had been studied by some ancients. It is quite unlike a circle, but it is also a symmetrical curve, rising elegantly and swinging back with the same gentle sweep. Its form may be obtained by slicing a cone at an angle and reaching the base.

It is legitimate to ask why the projectile path is parabolic, for the projected body could very well have gone to a height along a straight path, and fallen down plop vertically downwards. Why not? This is not a trivial question. Observation is one thing, and explanation is another.

Projectile paths are relevant, not just for playing ball, but in the more serious business of firing canon balls and launching missiles. No wonder physics becomes worthy of support by governments. The study of projectile motion, both at the practical and conceptual level, has a long history. But, like many other seeds of the modern scientific framework, it was analyzed with mathematical precision only in the seventeenth century. Here again the genius of Galileo played a role. In the last section of his book, *Discourses and Mathematical Demonstrations Concerning the Two New Sciences*[17] Galileo deduced the parabolic orbit of projectiles in an ingenious analysis of a complex motion into its component parts. It was only more than two centuries later that projectile motion was analyzed, taking into account the rotation of the earth[18].

Orbital Motion: ***The stability of mater and of the world is maintained by orbital motion.***

The earth goes around the sun; other planets also orbit the sun; tiny electrons move around their central nuclei, and our sun is circumambulating the galactic center. If we look at the stars with a pair of binoculars we will notice that some of them have a faint companion. These are the so-called double-stars (or binaries), systems in which two stars are locked into each other's gravitational grip for ever, each orbiting the other, a stellar waltz as it were, taking anywhere

[17] One of the great classics of modern science, the book shows what a superb experimenter Galileo was. He had but water clocks to measure time. Ironically, he was not allowed to publish the book – any book – after his infamous Inquisition. He managed to have the manuscript smuggled to the Netherlands where it was published. It should not be forgotten that wherever there is theocracy – where god-men dictate what truths are allowed to be published – this can happen.

[18] Siméon-Denis Poisson, *Recherches sur le mouvement des projectiles dans l'air*, (1839), incorporated the effects of the so-called Coriolis force in his calculations.

from a few hundred to more than a thousand years to go one full circle. Not all the wonders in the world are apparent to the naked eye.

There are orbital motions everywhere in the universe. Indeed, this is how even distant material bodies are kept together for long periods of time. Imagine a world where orbital motion is prohibited. In such a world there would be no planets whirling, no stable galaxies either. Each body would drift away from every other, and with the passage of time only isolated bodies separated by unimaginable stretches of space will be zooming alone and away from one another.

Once an astronomical orbit is established, barring significant external influences, the system can continue for eons on end. So it is that the moon has forever (almost) been close to our earth, the earth (almost forever) been affiliated to the sun. There are other planetary systems like our own where other planets are held under the sway of other stars. Bodies in space cannot be in static proximity, like cars in a garage. Orbital motion is required for astronomical togetherness, and also in the microcosm for atomic stability. Orbits make a dynamic bonding where the bodies are in each other's embrace, but always at safe distances away, literally giving each other some space.

We have all looked at the moon and seen it move amidst clouds and stars, even if we have not probed into the complexities of its motion. In broad terms, satellite motion is very similar to planetary motions which we will consider presently.

The earth-orbiting moon is only one instance of smaller bodies, called satellites, which circle various planets. As noted in another article in this series, it was not until Galileo's fruitful use of the telescope that we realized that some other planets also have satellites going around them. During the past few centuries we have recognized and studied a great many satellites in our solar system. The planets themselves appear as mere specks to the naked eye, but telescopes put into evidence the still tinier specks which are their satellites. In the late 1870s Asaph Hall, and his wife Angeline, not only discovered but charted the motions of the twin satellites of Mars[19].

The distance at which a ball falls back to the ground when kicked in the air depends on the speed with which it is launched, as well as on the angle of projection. As we increase the speed more and more, it will fall farther and farther away. Given that the earth is curved, at sufficiently large speeds the projectile may go so far that as it falls, there is no ground below. Then the object goes round and round. It becomes a satellite. Isaac Newton already considered this possibility in his masterpiece called the *Principia*[20].

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[19] Owen Gingerich, 'Hall, Asaph', in *Dictionary of Scientific Biography*, New York, Charles Scribners' Sons, 1971.

[20] Newton talks about satellites in the third book of the *Principia*.

This was a mere dream for a long time, unrealizable even in the middle of our century. But on October 4, 1957, the (then) Soviet Union launched the first artificial satellite, the so-called Sputnik[21], inaugurating what has come to be known as the Space Age. Since then, hundreds of artificial satellites have been put into orbit, and for a variety of purposes[22]. They circle the earth at various heights and speeds, many still active and useful, some silent and inert.

Spinning Motion: ***Spinning motion is responsible for day and night and for magnetism.***

Who has not seen a turning wheel or a spinning top. Here is motion of a different kind: motion about an axis. We may look upon it as a concentrated form of orbital motion. All matter in the body around the axis of rotation is participating.

Tops have been known since ancient times, in Egypt and India, in China and Japan also. Homer and Plato make references to tops. Leonardo Da Vinci tried to explain top-motion in terms of the physics of his day. But the mathematical analysis of top-like (*gyroscopic*) motion was done only in the nineteenth century. Such analysis reveals that the motion even of a sleeping top is not quite steady. There is always a little nutation[23].

The wheel set in motion tends to slow down and stop, unless it is kept rotating by an external influence. It is the spinning of the earth that causes day and night. If the earth stopped spinning, a whole hemisphere of earthlings would be denied the benefits of daylight and another the peace and quiet of nocturnal darkness. The moon, while it moves around the earth, is spinning too, but in such a way that it always shows the same face to us. Venus and Uranus are spinning in a direction contrary to their motion on their orbits. But celestial bodies, including our own earth, keep spinning indefinitely, yet they are slowing down very imperceptibly[24].

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[21] Sputnik is the Russian word for satellite. Launched on October 4, 1957, it was a marvelous technological achievement. For the first time in earth's history, the planet had a second moon, albeit quite small in comparison to the first. But it was human-made, and is a milestone in history. It also did scientific analysis of the upper layers of our atmosphere.

[22] It should be pointed out here that India has a dynamic program for space exploration. The Indian Space Research Organization was initiated more than forty years ago. But already in the 1920s the physicist S K Mitra was engaged in experiments on the ionosphere in Calcutta.

[23] The rotation of the axis of a spinning top about a vertical axis is its precession. In this process the axis itself could be gently swaying, This nodding is called nutation. The nutation of the earth's axis was discovered by James Bradley in 1728. It is caused by tidal forces.

[24] It has been estimated that every hundred years, the earth takes 1,4 milliseconds more to make one full rotation. If this has been happening since its formation 4.5 billion years ago, one can see that in those distant times, the earth was rotating much faster, less than ten hours a day. Astronomers who keep track of this say that a couple of centuries ago the earth was spinning two milliseconds faster.

The sun is made up of gaseous materials, and does not spin as a single unit: the equatorial regions take about twenty five days while at latitudes of 30° the period is some twenty seven and a half days. But how did we come to know that the sun is spinning at all? It was by carefully observing the changing positions of sunspots that Galileo discovered this[25].

We have come to know that deep down in the core of matter are tiny particles – electrons, protons, and the like – that keep spinning unceasingly. This is truly perpetual motion, for an electron that was formed when the universe emerged more than thirteen billion years ago has been spinning ever since at the same rate during all these eons! A remarkable discovery of twentieth century physics is that the phenomenon of magnetism arises from the spin of the electron.

[25] Sunspots have been observed since ancient times. Galileo's work showed how from their motion one could talk about the spinning of the sun. Some bitter controversies arose between Galileo and others as to who deserved credit for the sunspot discovery. Recently some astronomers have noted that sunspot activity has been diminishing considerably. The implications of this phenomenon are not yet clear.

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The Physical World: Vol.15, No.12, pp.1132–1141, 2010; Vol.16, No.1, pp.76–87, 2011;
On the Nature of Heat: Vol.16, No.2, pp.190–199, 2011;
Sound: The Vehicle for Speech and Music, No.3, pp.278–292, 2011;
Light: The Revealer of Chromatic Splendor, No.4, pp.359–371, 2011;
More on Light, No.5, pp.468–479, 2011;
Matter: The Stuff the World is Made of, No.7, pp.670–681, 2011;
More on Matter, No.8, pp.784–793, 2011.

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