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How history helps physicists

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Abstract

The present investigation studies the history of science and of physics in particular. We learn from this study, how physics has really been done. We study how history helps us to understand not only the past, but also the present and it will guide us toward the future. It basically illustrates the power of stories. A historical perspective on science can help physicists understand what is going when they practice and it provides numerous useful tools for physicists. As every discovery has come out of a messy mix of peoples' ideas, accidents and arguments. It takes great efforts to understand what the observation means .Thus the diversity of ideas and interpretation serves as a reminder that physics is under progress. Thus, the history of physics should make one to claim that current theories will hold forever. By this, the history of science and of physics in particular provides new ways of thinking to scientists and forces them to examine what is known to us.

Keywords: Ancient Astronomy, Modern Astronomy, Indian Astronomy

Introduction

Some facts and studies about physics are not covered in a physics education because some facts and observations contain messy thoughts, views and rough edges that make the study of physics difficult. Physicists do not think about these facts as contributing to science itself. But socialism really influences the discovery of researchers .Actually, physicists learn that lesson the hard way, but they represent their work to the world in an idealized manner so that people could well understand their work.

History can help. The history of science helps the physicists to overcome the mesh of thoughts, ideas and facts. History basically illustrating the power of stories. It tells about the way we were thinking so far and relates to the present day studies. A historical perspective on science can help physicists understand what is going on when they practice and it provides numerous tools that are useful for physicists themselves. Physicists are not disintegrated figures without political views, philosophical preferences and personal feelings. The history of science can help to come out of the myth of the purely rational genius living outside the everyday world. It makes physics more human. Every discovery has come out of a messy mix of peoples' ideas, accidents and arguments. Generally it takes a great deal of effort to understand what observation and theory means. Thus history helps us to understand what is going on.

Development of Ancient Astronomy: In early times, astronomy only comprised the observation and predictions of the motions of objects visible to the naked eye. In some locations, such as Stonehenge, early cultures assembled massive artifacts that likely had some astronomical purpose. In addition to their ceremonial uses, these observatories could be employed to determine the seasons, an important factor in knowing when to plant crops, as well as in understanding the length of the year.

Before tools such as the telescope were invented early study of the stars had to be conducted from the only vantage points available, namely tall buildings and high ground using the naked eye. As civilizations developed, most notably in Mesopotamia, China, Egypt, Greece, India, and Central America, astronomical observatories were assembled, and ideas on the nature of the universe began to be explored. Most of early astronomy actually consisted of mapping the positions of the stars and planets, a science now referred to as astrometry. From these observations, early ideas about the motions of the planets were formed, and the nature of the Sun, Moon and the Earth in the universe were explored philosophically. The Earth was believed to be the center of the universe with the Sun, the Moon and the stars rotating around it. This is known as the geocentric model of the universe.

A particularly important early development was the beginning of mathematical and scientific astronomy, which began among the Babylonians, who laid the foundations for the later astronomical traditions that developed in many other civilizations. The Babylonians discovered that lunar eclipses recurred in a repeating cycle known as a saros.

Following the Babylonians, significant advances in astronomy were made in ancient Greece and the Hellenistic world. Greek astronomy is characterized from the start by seeking a rational, physical explanation for celestial phenomena. In the 3rd century BC, Aristarchus of Samos calculated the size of the Earth, and measured the size and distance of the Moon and Sun, and was the first to propose a heliocentric model of the solar system. In the 2nd century BC, Hipparchus discovered precession, calculated the size and distance of the Moon and invented the earliest known astronomical devices such as the astrolabe. Hipparchus also created a comprehensive catalog of 1020 stars, and most of the constellations of the northern hemisphere derive are taken from Greek astronomy. The Antikythera mechanism (c. 150–80 BC) was an early analog computer designed to calculating the location of the Sun, Moon, and planets for a given date. Technological artifacts of similar complexity did not reappear until the 14th century, when mechanical astronomical clocks appeared in Europe.

During the middle Ages, astronomy was mostly stagnant in medieval Europe, at least until the 13th century. However, astronomy flourished in the Islamic world and other parts of the world. This led to the emergence of the first astronomical observatories in the Muslim world by the early 9th century. In 964, the Andromeda Galaxy, the nearest galaxy to the Milky Way, was discovered by the Persian astronomer Azophi and first described in his Book of Fixed Stars. The SN 1006 supernova, the brightest apparent magnitude stellar event in recorded history, was observed by the Egyptian Arabic astronomer Ali ibn Ridwan and the Chinese astronomers in 1006. Some of the prominent Islamic (mostly Persian and Arab) astronomers who made significant contributions to the science include Al-Battani, Thebit,

Azophi, Albumasar, Biruni, Arzachel, Al-Birjandi, and the astronomers of the Maragheh and Samarkand observatories. Astronomers during that time introduced many Arabic names now used for individual stars. It is also believed that the ruins at Great Zimbabwe and Timbuktu may have housed an astronomical observatory. Europeans had previously believed that there had been no astronomical observation in pre-colonial Middle Ages sub-Saharan Africa but modern discoveries show otherwise.

Scientific Revolutions: During the Renaissance, Nicolaus Copernicus proposed a heliocentric model of the solar system. His work was defended, expanded upon, and corrected by Galileo Galilei and Johannes Kepler. Galileo innovated by using telescopes to enhance his observations. Kepler was the first to devise a system that described correctly the details of the motion of the planets with the Sun at the center. However, Kepler did not succeed in formulating a theory behind the laws he wrote down. It was left to Newton's invention of celestial dynamics and his law of gravitation to finally explain the motions of the planets. Newton also developed the reflecting telescope.

Further discoveries paralleled the improvements in the size and quality of the telescope. More extensive star catalogues were produced by Lacaille. The astronomer William Herschel made a detailed catalog of nebulosity and clusters and in 1781 discovered the planet Uranus, the first new planet found. The distance to a star was first announced in 1838 when the parallax of 61 Cygni was measured by Friedrich Bessel.

During the 18–19th centuries, attention to the three body problem by Euler, Clairaut, and D'Alembert led to more accurate predictions about the motions of the Moon and planets. This work was further refined by Lagrange and Laplace, allowing the masses of the planets and moons to be estimated from their perturbations. Significant advances in astronomy came about with the introduction of new technology, including the spectroscope and photography. Fraunhofer discovered about 600 bands in the spectrum of the Sun in 1814–15, which, in 1859, Kirchhoff ascribed to the presence of different elements. Stars were proven to be similar to the Earth's own Sun, but with a wide range of temperatures, masses, and sizes.

The existence of the Earth's galaxy, the Milky Way, as a separate group of stars, was only proved in the 20th century, along with the existence of "external" galaxies, and soon after, the expansion of the Universe, seen in the recession of most galaxies from us. Modern astronomy has also discovered many exotic objects such as quasars, pulsars, blazars, and radio galaxies, and has used these observations to develop physical theories which describe some of these objects in terms of equally exotic objects such as black holes and neutron stars. Physical cosmology made huge advances during the 20th century, with the model of the Big Bang heavily supported by the evidence provided by astronomy and physics, such as the cosmic microwave background radiation, Hubble's law, and cosmological abundances of elements.

Modern Astronomy: At the end of the 19th century it was discovered that, when decomposing the light from the Sun, a multitude of spectral lines were observed (regions where there was less or no light). Experiments with hot gases showed that the same lines could be observed in the spectra of gases, specific lines corresponding to unique elements. It was proved that the chemical elements found in the Sun (chiefly hydrogen and helium)

were also found on Earth. During the 20th century spectrometry (the study of these lines) advanced, especially because of the advent of quantum physics that was necessary to understand the observations.

Although in previous centuries noted astronomers were exclusively male, at the turn of the 20th century women began to play a role in the great discoveries. In this period prior to modern computers, women at the United States Naval Observatory (USNO), Harvard University, and other astronomy research institutions began to be hired as human "computers," who performed the tedious calculations while scientists performed research requiring more background knowledge. A number of discoveries in this period were originally noted by the women "computers" and reported to their supervisors. For example, at the Harvard Observatory Henrietta Swan Leavitt discovered the Cepheid variable star period-luminosity relation which she further developed into the first method of measuring distance outside of our solar system. Annie Jump Cannon organized the stellar spectral types according to stellar temperature, and Maria Mitchell discovered a comet using a telescope. According to Lewis D. Eigen, Cannon alone, "in only 4 years discovered and catalogued more stars than all the men in history put together." Most of these women received little or no recognition during their lives due to their lower professional standing in the field of astronomy. Although their discoveries and methods are taught in classrooms around the world, few students of astronomy can attribute the works to their authors or have any idea that there were active female astronomers at the end of the 19th century.

Cosmology and the expansion of the universe: Most of our current knowledge was gained during the 20th century. With the help of the use of photography, fainter objects were observed. Our sun was found to be part of a galaxy made up of more than 1010 stars (10 billion stars). The existence of other galaxies, one of the matters of *the great debate*, was settled by Edwin Hubble, who identified the Andromeda nebula as a different galaxy, and many others at large distances and receding, moving away from our galaxy.

Physical cosmology, a discipline that has a large intersection with astronomy, made huge advances during the 20th century, with the model of the hot big bang heavily supported by the evidence provided by astronomy and physics, such as the redshifts of very distant galaxies and radio sources, the cosmic microwave background radiation, Hubble's law and cosmological abundances of elements.

New windows into the Cosmos open: Late in the 19th century, scientists began discovering forms of light which were invisible to the naked eye: X-Rays, gamma rays, radio waves, microwaves, ultraviolet radiation, and infrared radiation. This had a major impact on astronomy, spawning the fields of infrared astronomy, radio astronomy, x-ray astronomy and finally gamma-ray astronomy. With the advent of spectroscopy it was proven that other stars were similar to our own sun, but with a range of temperatures, masses and sizes. The existence of our galaxy, the Milky Way, as a separate group of stars was only proven in the 20th century, along with the existence of "external" galaxies, and soon after, the expansion of the universe seen in the recession of most galaxies from us.

Astronomy in Ancient India: The splendor of the night sky provides a beauty that is immediately endearing, and captivating. Heavens have fascinated humans from the earliest period. Today, of course, we divide this study of heavens into several levels of atmosphere, the near earth sky, solar system and the astronomy of objects beyond. This is a recent phenomenon in human history no more than 400 years old. Until recently, everything that was not terrestrial was called astronomical. This subject of astronomy has had a profound effect on humans. It has fascinated artists, poets, and all kinds of romantics by its sheer beauty. On the other hand, because sky and what falls from it is so crucial to life on earth, humans have been fascinated and terrified by the forces of nature that originate in the sky and their apparently unpredictable behavior. These natural forces with their own sense of time have been held precious by humans and in all civilizations Gods who manifest and control these forces have resided in the heavens. All myths lead to the Gods in the heavens, watching over humans and blessing them or cursing them as the case may be. Heavens, therefore, have been the playground of shamans, priests and philosophers.

However, astronomy has had one more profound effect. It has taught us science and given us the first stepping stones of scientific work of systematic observation, correlation, long-term follow up and objective analysis like no other pursuit of human study has done. While biology, chemistry and physics have been bogged down by 10 divine readers, medicine men, shamans, alchemists and jugglers, astronomy is not mired by astrologers until much later. It took a long time for the humans to realize that the idea that the heavens could affect their live. In some sense, this is surprising since Gods, who control human lives lived in heaven for long. However, these gods operated through invisible forces and their association with planetary positions was an afterthought.

Astronomy introduced the first ideas of linking movement of objects in the sky and seasons on the earth. So how did humans gather and evolve their ideas of astronomy from the first stages of their evolution of understanding? We meander through a scenario of how this could have happened. This may or may not be the exact path, but it makes a fascinating story.

Astronomy and myth: Attempts made by humans in trying to understand the heavens are of profound interest and importance. Astronomy is one field, which at one level is highly utilitarian for its ability to predict weather, and at another level is completely abstract, more related to the human place in the vastness of the universe. At one level, rains, thunder, lightning and other extraordinary events provide the source of life. At another level, the steady and unaffected movement of stars and serenity of heavens on clear nights must have always fascinated humans. Completely arbitrary but spectacular events such as the appearance of comets and meteor showers must have had a profound impact on the human psyche. Together therefore, the study of astronomy must have attracted the attention of some of the best minds of that time. It must have also profoundly affected the growth of mathematics as humans tried to keep track of these complex, if subtle movements of heavenly objects.

The only activity comparable to astronomical knowledge is the pursuit of understanding the relevance of human life in the wider perspective of nature. That is, creation of myths, creation of fantastic, complex stories of events past and yet to come, all of which place human existence in perspective. These creative works have been used from time immemorial in a variety of ways, from consoling people on the death of their dear ones to explaining the irrational events as activities of more mighty beings and hidden variables that are introduced by gods. In most cases, these myths begin to formalize and revolve around a common, if complex theme of supernatural powers and their relation to humans. Religion, in many ways is a natural evolutionary track for myths.Each feed on the other and enrich both for their breadth of reach and profound philosophy and symbolism that they can provide. Just as astronomy fed mathematics, myths and religion must have fed literature and together, the human intellect grew to reach far beyond it was ever designed to go and to achieve what it was never meant to achieve.

Yet, at a more profound level, these two pillars of human intellectual growth, astronomy and mythology, are deeply connected. The life giving ability of the sky, through rain, sun and moon and its ability to invigorate and fertilize earth must have been noticed very early in human existence. Most religions therefore begin with the concept of Mother Earth and Father Sky whose rain invigorates and impregnates mother earth with new life. From this step, to making heavens an abode for gods would have been a linear progression.

The purpose of myths is manifold. These include giving a sense of purpose to life, giving meaning to life's irrational experiences, such as birth and death, by speculating on rebirth or higher existence and so on. In the original form of Hinduism, for example, the structure of the religion is that of a tripartite relation between gods, humans and ancestors, where each appeases others by giving boon depending on their powers and receiving favors in turn. Myths also give a sense of purpose to life, especially, by providing heroes whose examples can be emulated by others and provide a yardstick by which actions of others can be measured. Lastly, in many ways, they hold out a promise of manipulating gods who control the cosmos so that they may live under favorable conditions. Together therefore they provide a sense of connectivity between humans and the magnificence of nature, providing a sense of belonging and proportion against this vast expanse of the universe which can often disorient human life. Like all human activities, myths also change and evolve with time as people become more sophisticated.

In many ways, connected with astronomy, many cultures have seen their life's dramas being played out in heaven and have placed their most revered stories amongst the various imagined patterns in the sky. Myths and astronomy therefore have a closer relation than we normally appreciate.

Development of astronomical ideas: Advancement in astronomical knowledge of a culture primarily depends on the following factors: 1) Requirement of the society 2) Available technology 3) Available calibre of the people

All these factors are sensitive to the period of the culture. The first two of these are more or less monotonic, with both requirements and available technology becoming more sophisticated with time. We briefly discuss each of these below.

Requirement of the society, while linearly increasing with time, is a curious entity. The requirement can change in sudden jumps of demand as societies become more sophisticated. In the hunter-gatherer phase, for example, a rough idea about animal migratory patterns and general feeling of warmth are sufficient. With the advent of farming, or even pre-farming, a high sensitivity to seasons emerges. Farming requires more precise knowledge and predictability of seasons and sunrise point. Once a society acquires a certain level of sophistication and wealth, preservation of wealth, good fortune and the desire to pass on the wealth and good fortune to their offspring result in development of astrology and attendant studies. Once a civilization reaches a level of sophistication, where it has enough resources to spare and stability to pursue pure curiosity, cosmogony and other fields begin to emerge.

Available technology is a predictable parameter based on the general technological sophistication of the culture. A specific, inspired piece of technology can result in a critical sudden spurt and history is replete with such examples. Invention of radio receivers and highly accurate clocks are two such examples. But even without such sudden spurts, all societies either acquire or circumvent the needed technology and broadly move towards higher level of sophistication.

Against this, the calibre of people is a matter of greatest vagary and is practically unpredictable. Given a broad idea of the calibre of the most influential people, their influence on the advancement of knowledge can be estimated. Unfortunately, there lies a rather strong requirement of understanding the calibre of the most influential thinkers at any time in order to understand the growth in astronomy. Such persons can produce dramatic changes but their appearance or calibre is impossible to predict. In societies such as the Indian one, with a poor sense of history, most records of important individuals are missing and often, it needs to be inferred from the ideas that emerge at any time. In spite of this limitation, a general idea that people become increasingly sophisticated with time will permit some measure of predictability on the growth of astronomy in a culture.

In all this, we have disregarded sudden catastrophic social and ecological changes which can set societies back by centuries if not millennia. We have also implicitly ignored cross-cultural spread of knowledge which can also allow civilization to make dramatic transitions to higher levels of learning and sophistication by borrowing the learning of other cultures. While these induced changes are often conspicuous, it is often not appreciated that such sudden spurts can only be introduced to civilizations already prepared (or due) for such spurt of knowledge and external infusion only accelerates the process of knowledge gain rather than change the track of the civilization.

The combined effect of all this is that societies go through various transitions in their knowledge of astronomy, in a manner that is almost analogous to phase transitions in physics.

Myths of India: Here we will explore the complex relation between not just myths and astronomy but also between astronomy and the continuing human struggle to define themselves and to understand the complex set-up of heavenly beauty.

At the roots of India is a religion that we call Hinduism. The word Hinduism means the religion of the people from the land of Indus. But the religion itself is as diverse and varied and indeed as evolving as the idea of India itself. It is therefore not surprising that the attitude of Indians towards the heavens and their cosmogony have also evolved and mythological stories have been rendered, reinterpreted and re-ordered. Here we briefly discuss some of the most common aspects of the relation of people of the subcontinent with the heavens.

Hinduism is renowned for an infinite number of gods. However, at a fundamental level lies the great formless god often referred to as Brahman. He is all pervading and all creation arose from his pure thought. After creating the universe, he felt lonely. Hence, he created life and the living, and in particular the male – female dichotomy. However, this formless one is not worshipped. Below him is the trinity of gods called Bramha, Vishnu and Mahesh or Shiva. Bramha is the creator and often confused with the Great Brahman. Vishnu is the preserver and often comes to the earth in human form to assist humans. Vishnu has had nine incarnations and the tenth (and last) incarnation is yet to come. These are: Matsya (fish form), Kurma (Tortoise form), Varaha (boar form), Narasimha (in the form of half lion, half man), Vamana (dwarf form), Parasurama (human form), Rama (human form), Krishna (human form), Buddha (human form) and the tenth Kalki (the destroyer feminine) who is yet to come). Each has a mythological story associated with it but we shall not deal with them here since they are not related to astronomy. Shiva is a complex but destructive god. He is an intellectual amongst gods, an excellent dancer and fond of long stretches of meditative isolation. Below them is the entire plethora of other Gods connected to each other in many ways.

In its original format, the world is run by a tripartite agreement between Gods, Ancestors and Humans. Of these, Gods are immortal, ancestors are worshipped for 7 generations and humans of course have a limited lifespan. The three essentially exchange favors and that keeps everyone happy. However, through meditation and learning, humans can become so knowledgeable that they become Sages and as sages they even become teachers to Gods. Asura's are another category of beings who are rivals of the Devas. In early literature, the Asuras preside over moral and social phenomena (e.g. asura Varuna is the patron of marriages) and the Devas preside over natural phenomena (e.g. Ushas whose name means "dawn"). As the mythologies evolve, many Asuras later became known as Devas. In later literature, Asura's transform into a group of power-seeking deities, who are given to worldly pleasures, are materialistic in their outlook and prone to sins. They are the rivals of the Gods (Devas). However, both groups are children of the same sage Kasyapa.

In general they are not to be confused with Rakshasas who are a race of mythological humanoid beings or unrighteous spirit. Rakshasas are also called man-eaters. In early Indian epics, Rakshasas are supernatural humanoids. There are both, good and evil rakshasas. They are powerful warriors, expert magicians and illusionists. As illusionists, they are capable of creating appearances and take various physical forms. Some of the rakshasas are said to be man-eaters. Occasionally they participate as soldiers in the service of various warlords. The most famous Rakshasa is Ravana who fought against Rama in Lanka.

Story of eclipse: Eclipses are explained in early mythologies in India as a story of an Asura trying to eat up the Sun and the Moon. A mural depicting the story can be seen in Angkor Wat, Kampuchia. The mythological story is as follows.

Once upon a time, the warrior God Indra and other Gods incurred the wrath of the great Sage Durvasa. Durvasa had given a garland to Indra who carelessly gave it to his elephant who trampled on it. Upset by this casual treatment of his gift, Durvasa cursed Indra and other gods that they would lose their immortality and their Kingdom. The Gods therefore lost their immortality and kingdom. Frightened by the consequences of this, they approached Lord Vishnu for help. Vishnu advised them that they can regain their original stature if they consume the nectar of immortality (Amrit) from the bottom of the ocean of milk. The task was a mammoth one and they realized that in order to get the Amrit, they needed the help of their arch foes, the Asuras with whom they had a long war of dominance over the affairs of humans. The Gods called a truce with the Asuras and offered to churn the ocean of milk together and share the outcome. The Gods and the Asuras churned the ocean together using the serpent Vasuki belonging to the Asuras as a churning rope and the mount Mandara as the churning staff. When the pressure of the churning shaft became too difficult to bear, Vishnu appeared as a Tortoise in one of his incarnations and took the load on his back.

Eventually, the nectar of immortality came out of the Ocean, carried out by Dhanvantar, the physician of the Gods. The Asuras immediately took charge of the pot. Vishnu again came to the rescue of the Devas in the form of a beautiful damsel, Mohini and distracted the Asuras. She then retrieved the potion and distributed it to the Devas. By the time the Asuras realized Vishnu's tricks, it was too late, as the Devas regained their renowned prowess and defeated them.

When Amrit was being served to the gods, an Asura, disguised as a god, sat between the Sun and the Moon in an attempt to procure the nectar. When his presence was detected by the Sun and the Moon, Lord Vishnu immediately severed his head from his body. Unfortunately, it was not fast enough, for the Asura had already tasted a small quantity of the nectar and had become immortal. Ever since, this Asura is said to wreak vengeance on the Sun and Moon. The Asura continuously pursues them and tries to eat them up whenever they come near. The head of this Asura is known as Rahu and his tail is known as Ketu. Rahu causes the eclipses. However, since Rahu has an open oesophagus, the swallowed Sun and Moon soon emerge from the Asura's body.

Hence, in Hindu astrology Rahu and Ketu are known as two invisible planets. They are enemies of the Sun and the Moon, since they swallow the Sun or the Moon causing the eclipses. Hence, they are considered inauspicious.

In later evolution of the myth, Rahu and Ketu are defined as the ascending and descending nodes of the ecliptic and equator. When the Sun and the Moon come together at these points, we get solar eclipse at ascending node and lunar eclipse at descending node. Their mathematical equations were set up by the time of Arybhatta (about 500 AD) and eclipses have been accurately calculated thereafter.

Rahu and Ketu Eclipses: Rahu and Ketu are considered to be dark planets in Indian mythology. However, from the original belief of demons trying to eat up the Sun and the Moon, the concept continued to develop.

With the arrival of mathematical astronomy formalized by Aryabhata around 500 AD, Rahu and Ketu were defined as ascending and descending nodes of the points at which Sun's and Moon's orbit and their location is calculated along with the distances of Sun and Moon from these points. Eclipse is therefore predicted based the merger of these three points. By calculating the vertical drift of the disc of the Sun and the Moon from the mean line of the motion, the nature of eclipses (total, partial or annular) can be calculated.

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