The Evolution of Physics & Technology: A Saga with Ancient Middle-East Scientists

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Abstracts

The modern Physics is based on the findings and thinking of the people of historical age. If no one knows the base and work of the previous on a subject, he or she could mere develop a new thought or findings. For, a civilization must know its past. Hence, the present work is a small effort to find out the contribution of ancient Arabian and Egyptian scientists in the field of Physics and Technologyy. Different scientists of different school of thought, correlating different streams of science being Physics as a main subject, are described in the present work.

Key Words: ancient arabs, egyptian scientist, physics, technology, islam

The Muslim scientists studied deeply the fundamental questions of physics. For instance *Ibn Sina* made a profound study of such phenomena as force, motion, light, heat, vacuum, etc. A great progress was made in theoretical and applied mechanics. Useful work was done in the field of mechanics on the wheel, axle, lever, pulley, inclined plane, windmill, water-wheel, toothed wheel, etc. The physicist and astronomer *al-Khazini* wrote a book on mechanics, hydrostatics and physics, named *Kitab Mizan al-Hikmah* (Book of the balance of wisdom) which is the most remarkable medieval work on these subjects. It gives a theory of the force of the attraction of the earth (gravity), according to which the universal force is directed towards the centre of the universe, which was supposed at that time to be the centre of the earth. It includes the tables of specific gravity of many liquids and solids (based on the work of *al-Biruni*), and a history of the subject; the gravity of air; observations on capillarity; the use of aerometer for the measurement of densities and the appreciation of the temperature of liquids; the theory of lever; the application of balance to leveling and to the measurement of time. The analysis and extracts of this book have been published in Arabic and English. **(1)**

In another book on balance *al-Khazini* stresses the need to remove, as far as possible, the influences of temperature variation during weighing. When *al-Khazini*'s other studies are considered, he seems to be a precursor of Galileo.

Al-Khazini's full name was *Abu'l Fath 'Abd al-Rahman al-Mansur al-Khazini* (or *al-Khazin*). He flourished about 1115—1121. He was a Greek *(Rumi)* slave. His master *'Ali al-Khazin àl-Marwazi* arranged for his good scientific and philosophical education in Marw. *Al-Khäzin* Compiled the astronomical tables called *al-Zij al-Mu'tabar al-Sinjari* (The esteemed Sinjaric Tables) which were named after *Sinjar*

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Ibn Malikshah Ibn Alp Arsalãn, governor and later Sultan of Khurasän (1097—98 to 1157—58). They give the position of the stars for the year 1115—1116.

Before *al-Khazini*, *Umar al-Khayyam* did the greatest work on the balance. *Ibn Sina* and *al-Razi* contributed to the theory of the balance. *Banü Müsä* (the sons of *Musä*), who flourished during the reign of the Caliph *al-Ma'mun*, wrote many mechanical works. An important work on the balance called *Farastün'* or *'Qarastun* is ascribed to them. *Al-Räzi* (d. 923—24) made investigations on specific gravity by using the hydrostatic balance. This balance was called *al-Mizan al-Tabi'i* (the physical balance). **(2)**

Muhammad Ibn 'Ali Ibn Rustam al-Khurasani was a famous constructor of clocks and, therefore, he was called *al-Sa'ati* (the clock maker). Between 1146 and 1169, he constructed a clock placed in the *Bab Jairün.* (often called *'Bab al-Sa'ah,* the door of the clock). *Al-Sa'äti* remained in charge of his clock until his death in 1184—85. **(3)**

Another Muslim mechanician of the 13th century was *Abu'l-Isa Ismã'il Ibn Razzãz* (the son of rice merchant) *Badi'al-Zamàn al-Jazari*. He was patronized from 577—578 to 601—602 A.H. 1181—1182 to 1205—1206 A.C.,by the Urtuqid rulers of Diyar Bakr, a district of al-Jazirah. He wrote a treatise on the knowledge of the geometrical mechanical contrivances entitled *Kitab fi Ma'rifat al-Hiyal al-Handsiyyah,* which was dedicated to the Urtuqid *Nasir al-Din Mahmüd* (ruled from 1200 to 1222). It deals mainly with hydraulic apparatus (elepsydras, fountains, etc.). This important work is interesting from the technical point of view, and represents the best Arabic work on applied mechanics. It is divided into six parts. The first part which deals with the various types of the elepsydras indicating either equal or temporal hours is the most important. Muslims divided the day into twenty-four equal hours. But they adopted another type of division. They divided the day and night each into twelve hours of varying length according to the season. Such type of hours were also used by the Christians in Europe e.g., Italy, until the middle of the 18th century.

The book was translated into German, and commentaries on it were also written. **(4)**

Al-Sä'ãti's son *Ridwän* repaired and improved the clock, and also wrote a book to describe its construction and use. This book is an important source of the study of early Muslim clocks. *Ridwan* was a mechanician, physician and poet, and had knowledge of literature and music. He played the flute. Originally he belonged to Khurasan. He was appointed as *wazir* by the Ayyubi prince *al-Faiz Ibrahim* and his brother *al-Mu'azzam Isã*. *Ridwan* also wrote a supplement to *Ibn Sinà*'s treatise on grapes, and a commentary on his *Qanün* (Canon). **(5)**

Qaisar Ibn Abu'l-Qasim, the Egyptian mathematician, astronomer (d. 1251 A.C.) made a celestial globe. He probably made improvements on the water-wheels or water-mills. Such improved types of water-wheels are still seen on the Orontes, and are among the glories of Hama. He constructed these water-wheels *(naura)* for *al-Muzzaffar al-Taqi al-Din Mahmud*, the ruler of Hama from 1229 to 1244 A.C. **(6)**

The philosopher *Abu Nasr al-Farabi* refuted the existence of a vacuum. He wrote a remarkable essay on the elasticity of the air. It is an original piece of research. **(7)**

The Muslim scientists took interest in the determination of the specific gravity of various substances. *Sanad Ibn 'Ali*, a scientist of the ninth century made investigations on specific gravity. *Al-Biruni* determined the specific gravity of 18 precious stones and metals. *Ibn Sinã* and *al-Rãzi* also made research on this subject.

Ibn Yunus (d. 1009 A.C.) applied the pendulum to the measurement of time. *Al-Biruni* devised a time machine based on the Roman calendar. He constructed it for use in the mosque of Ghazna. But the Imam of the mosque rejected it saying that it was based on a non-Muslim work. At this *Al-Biruni* was very much annoyed. He said that the, determination of time is a purely secular matter. It is, therefore, of little value whether it is based on a Muslim calendar or a non-Muslim one. Only convenience should be taken into consideration.

Al-Biruni made reference to a certain kind of wells which are obtained by boring the earth to that level of water which is submitted to the hydrostatic pressure in which case due to the pressure water is driven upward as in the natural springs. He correctly explains the action of such wells by the principle of communicating vessels. **(8)**

The Muslims developed the techniques of bathing. They constructed the hot, steam bath called *Hammäm* (from the Arabic root Hamm meaning to heat). When the European Crusaders came to the East and experienced the comforts of these baths, they introduced them into their own countries.

The Muslims were the first to apply the directive property of the magnetic needle to the determination of the direction of their journey while traveling on sea. The Chinese were the first to discover this property. The maritime trade between the Muslims gave much importance to the southern end of the needle than the northern one as it is done these days. This was probably because in some places like Syria and Asia Minor the southern end pointed roughly towards Makkah. Thus this end of the needle gave the general direction of the *Qiblah.* In the West the compass was first of all used by the Italian sailors. Some Muslims have referred to the compass in their writings. For instance, *Bailak al-Qabajaqi* in his book entitled *Kanz al-Ahjär* described the use of a floating compass witnessed by him in l242—43. **(9)**

'The Muslims were also the first to invent guns and cannons and use explosive material in them. The purpose of this invention was to throw bullets at the enemy from a long distance. The Chinese used sodium nitrate only. But the penetrating power of explosives was discovered and made use of only by Muslims. The historians generally write that first of all guns were used in the war of Cressi, but from the writings of many Muslims it is revealed that guns had been used a long time ago. In one of these writings there is a story that some ruler named *Ya'qüb* besieged in 602 A.H. (1205 A.C.) an African town Mehdra which was under the control of his chief rebel, and attacked the walls with the help of sounding guns and machines. From every machine there came out a number of showers of big stones and fire balls.

The statement given by *Ibn Khaldün* in his 'History of Berbers' also proves the use of the guns at the time of war. He writes "*Abu Yusuf*, the Sultan of Morocco besieged in 672 A.H. (1273 A.C.) the city of Sijilmasa. He installed the instruments for besiege in front of the city. These instruments consisted of *Manjneeq*, *Urawe* and *Handam* with which the bits of iron were thrown. These bits were filled in the box of *Handam,* and the explosives kept behind them were set on fire. Its effect was strange and its results could be called an act of Allah. One day with the help of a stone thrown by *Manjneeq,* part of the wall fell, and from there the attack was made on the city. **(10)**

The Muslims developed the science of optics. *Ibn al-Haitham* (Latin *Alhazen*) made a remarkable contribution towards this science. Indeed modern optics began with him. Before *Ibn al-Haitham* it was generally thought by the Greek, Roman and Muslim scientists that rays are emitted from the eyes towards the objects seen. Plato suggested that there was another set of rays which emitted from the object seen. Alexandrians believed that the vision lies in the lens of the eye. *Ibn Sina* and *al-Biruni* also believed that the ray went from the object to the eye. Aristotle's ideas were very near to modern conception. The atomists put forward an atomical theory. *Hunain Ibn Ishãq* in his work entitled "Questions on the eye' put forward a theory which was somewhat like that of Plato. In his opinion the lens was the central organ of vision. Both the visual force coming from the brain and the image of the object coming from without were received in the lens. *Al-Razi*, too, in his monograph on the nature of vision showed that the eyes do not radiate light. **(11)**

Ibn al-Haitham changed the traditional view by putting forward the theory that the objects are seen by rays passing from them towards the eye and not by the opposite process. Most of his successors did not agree with his view, but *Al-Birüni* and *Ibn Sina* independently and fully agreed with him. *Ibn al-Haitham* solved a number of optical, problems on the basis of the mathematical knowledge of his day.

Ibn al-Haitham dealt with such a medley of topics as the structure of the eye, optical illusion, perspective, binocular vision, vision of outlines, shadows and colours, the ancient catoptrics and dioptrics with new developments, *camera obscura*, *Alhazen*'s problem, mirages, comets, the Milky Way, rainbows, halos, etc.

Ibn al-Haitham conducted research catoptrics which contains the problem known *Alhazen*'s problem. It is as follows:-

'From two points in the plane of a circle to draw lines meeting at a point of the circumference and making equal angles with the normal at that point'. This leads, to an equation, of the fourth degree. *Ibn al-Haitham* solved it by the help of an hyperbola intersecting a circle. He also solved the so-called *al-Mahani*'s cubic equation.

Ibn al-Haitham showed a marked progress in experimental techniques. He made research on spherical and parabolic mirrors; spherical aberration and dioptrics. He noticed that the ratio between the angles of incidence and reflection does not remain constant. He described the magnifying power of a lens and studied atmospheric refraction. He stated that the twilight only ceases or begins when the Sun is 19° below the horizon, and tried to measure the height of the atmosphere on that basis. He gave a better description of the eye and vision. He tried to explain, binocular vision, and gave a correct explanation of the apparent increase in the size of the sun and the moon near the horizon. He gave the first mathematical treatment of the 'camera obscura'.

Thus he deals with the problems which now come under at least seven subjects including anatomy, physiology, psychology, mathematics, astronomy, physics and meteorology.

The full name of *Ibn al-Haitham* is *Abu 'Ali Muhammad Ibn al-Hasan Ibn al-Haitham*. He was a native of Basra and was born in 354 A.H. (965 A.C.). He migrated to Egypt where he lived till his death. He was a noble person and a genius who had the knowledge of many sciences. He was the greatest mathematician of his age and one of the greatest opticians in history. He was also well versed in medicine and Arabic language. When the Caliph *al-Hakim bi-Amrillah*, who was very fond of philosophy, heard about *Ibn al-Haitham*, he had a great desire to see him. *Al-Häkim* was informed that *Ibn al-Haitham* had disclosed that if he had been in Egypt, he might have done something in connection with the river Nile, so that it would become beneficial in every case, whether the level of water was high or low. According to *Ibn al-Haitham*, the river water fell from a high place lying in the territory of Egypt. Hearing this report *Al-Hakim* became more fond of meeting *Ibn al-Haitham* .*Al-Hãkim* sent a great amount of money to him, and persuaded him to come to his court. *Ibn al-Haitham* left for Egypt. When he reached near Cairo *al-Hakim* went to receive him. They met in a village near *Bàb al-Qahirah* (the gate of Cairo). *Al-Hakim* honored him, provided him with all the facilities, and asked him to fulfill his promise regarding the river Nile. A group of workers was provided to help him in executing his plan. When *Ibn al-Haitham* made the survey of the site and came to a place called 'Janadil' (now called Shaläl), which lies near Aswan on an elevated ground, he realized the difficulties involved. Finding himself unable to fulfill his promise, he became very ashamed, Now he feared *al-Hàkim* and to get rid of him he acted as a mad man, and remained in the condition of madness until the death of *al-Hãkim*. Then he came to his senses and settled in Qubbah near the gate of Jami'ah al-Azhar, and engaged himself in writing books. He died in 1038.

Ibn al-Haitham is the author of many works. He summarized Aristotle's works, and wrote commentaries on them. He also summarized many medical works of Galen. His writings on mathematics and physics are 15 and on metaphysics and physics are 44 in number. His books include the one on plants and one on the properties of simple and Compound drugs. **(12)**

His *kitab al-Manazir* (the optical thesaurus), is one of the leading classics which influenced scientific thought for more than six centuries. The Latin, Muslim and Hebrew writers such as Roger Bacon, John Peckham, Witelo, *Ahmad Ibn Idris al-Qarafi*, *Qutb al-Din al-Shirãzi*, Levi Ben Gerson based their works on this great book.

Ibn Sinã made a deep study of light. He observed that if light is emitted due to the ejection of some sort of particles by the luminous source, the speed of light must be finite. **(13)** *Al-Biruni* noticed that the speed of light is immensely greater than that of the sound. **(14)**

Nasir al-Din al-Tusi wrote two books on Optics. One of them, is entitled *Al-Mabahith fi In'ikãs al-Shu'a'at wa In'itafiha* (Research on the reflection and refraction of rays), contains a proof of the equality of the angles of incidence and reflection.

The other is entitled *'Tahrir kitab al-Manãzir*. In the preface the author remarks that one perceive objects because of the light rays emanating from them, but that everything happens as if the rays emanated from our eyes. **(15)**

Qutb al-Din al-Shirazi, (d. 1311) who was one of the greatest scientist of all times presented his views on Optics in his astronomical works. In one of such works, entitled *'Nihãyat al-Idrãk fi Dirãyat al-Aflak*(Highest understanding of the knowledge of the Spheres); he discusses questions of geometrical optics, the nature of vision, and finally the rainbow. He was the first to give a satisfactory account of the rainbow. His explanation of the rainbow is based on his study of the passage of a ray of light through a transparent sphere (drop of water). He discovered that the rainbow is formed when the rays are refracted twice and reflected once (or tunice in the case of the secondary rainbow) in the humid atmosphere. **(16)**

Another, important physicist and mathematician of the 14th century, was *Kamal al-Din Abu'l- Hasan al-Farisi*. He wrote a book entitled *'Tanqih al-Manazir* (Correction of optics) which is an elaborate and original commentary on *Ibn al-Haitham*'s *Kitäb al-Manãzir* (the book of optics). It covers not only physical and physiological optics, but also meteorology, perspective and many other subjects. It includes remarks on serial perspective, colour effects, etc.

Kamal al-Din suggested the use, of hyperboloidal lenses in order to avoid spherical aberration. He gave an account of the refraction of light. According to George Sarton, this account implies the following facts; the speed of light is finite but very great; the speed of light in different media is inversely proportional to the optical density (not the same as the material density). The second of these facts seems to be an adumbration of the wave theory of light as against the corpuscular theory.

Kamãl al-Din performed a number of experiments on *camera obscura* and improved its use initiated by *Ibn al-Haitham*. He showed that the images obtained on a screen in a dark room by means, of the rays of light passing through a narrow hole, are independent of the shape of the ho1e, and that the smaller the hole, the sharper the images. It was also proved that the images of many objects are formed separately on the screen, but the images and the directions were reversed. With the help of the camera he observed eclipses and the movements of the clouds and birds. **(17)**

Al-Hasan al-Rammah (the lancer) *Najm al- Din al-Ahadab* (the hunchback) wrote on military subjects. He flourished in Syria. He wrote two treatises on horsemanship and the art of war, (1) *Kitab al-Furusiyah wa'l Munasab al-Harbiyah* (Horsemanship and war stratagems), (2) *Nihayat al-Su'ul wa'l 'Umniya fi Ta'allum al-A'mal al-Furusiyah.* **(18)**

The first treatise deals with the military matters such as the military operation, means of using lances, bows, siege engines, and the method of fighting at sea and the communication of fire etc. It contains various pyrotechnic recipes; *Al-Hasan* considered saltpeter the fundamental substance of pyrotechnics. He explained the methods of preparing and purifying it by means of potash and of repeated crystallizations.

In the opinion of George Sarton, that is more important than it may seem, for the impurities of saltpeter are hygroscopic, and thus tend to destroy its value. To discover saltpeter and its uses was one thing, to purify it was another. **(19)**

The Muslims improved the art of shipbuilding, taught Mediterranean seamen to construct lighter sailing-ships or caravels *(garaf),* to caulk their boats with tar still known in Romance languages by the Arabic name of *gatran* (Fr *goudron,* It. *caltrame)—to* handle sails and cables (Ar. *habl*). **(20)**

REFERENCES :-

1. A1-Khazini, 'Abd al-Rahmän, '*Mizan al-Hikmah,* Hyderabad Deccan, 1359 A.H. pp. 1—170.

2. Al-Qifti, 'Ali Ibn Yüsuf, *Tarikh al-Hukama,* Leipzig, 1903, p. 271.

3. Sarton, George, *Introduction to the History of Science,* Carneige Institution of Washington, 1951, Vol. I, p. 632.

4. *Ibid.,* p. 631.

5. *Ibid.,* 632.

6. *Ibid.,* vol. II, Part II, p. 623.

7. Al-Qifti, *op. cit.,* p. 277.

8. Sarton, *op. cit.*, vol. I, p. 707.

9. *Ibid.*, Vol. II, Part I, p. 24.

10. Balgirami, ‘Ali, *Tamaddun-e-Arab,* (Urdu translation of a French work by Lebon), Hyderabad Deccan, p. 441.

11. *Ibid.,* vol I, p. 609.

12. *Ibid.*, p. 721.

13 Isma’il Basha al-Baghdadi, *Hadiyyah al-Arifin,* Istanbul, 1951, Vol. II, p. 66.

14. Sarton, *op.cit.,* p. 707.

15. *Ibid.*, p. 709-713.

16. *Ibid.* vol. II, Part, II, p. 1009.

17. *Ibid.,p.* 1018.

18. *Ibid.*, Vol III, part I p. 707. Al-Fárisi, Kamál al-Din, *Tãnqih al-Manazir,* Hyderabad Decean, India.

19. Sarton *op. cit.,* Vol. II, Part II, p. 1039.

20. Briffault, Dr. Robert, *The Making of Humanity*, Islamic Book Foundation, 1980, p. 205.