Indian Journal of History of Science, 41.1 (2006) 97-110

HISTORICAL NOTES

EINSTEIN AND INDIA: HIS SCIENTIFIC, INTELLECTUAL, SOCIAL AND MORAL LINK

Albert Einstein (1879 - 1955) never visited India, but his scientific, intellectual, social and moral link with India was very strong. Satyendranath Bose (1894 - 1974) worked with Einstein in Berlin during 1925 - 1926, Rabindranath Thakur (1861 - 1941) met Einstein several times in Berlin in 1930 and Pandit Jawaharlal Nehru (1889 - 1964), First Prime Minister (1947 - 1964) of India, met him at Princeton, New Jersey, USA in 1950. Einstein never met Mahatma Gandhi (1869-1948) but Gandhi was his moral guru. Like Mohandas Karamchand Gandhi, Einstein was a life-long pacifist (except in the case of Nazi Germany)

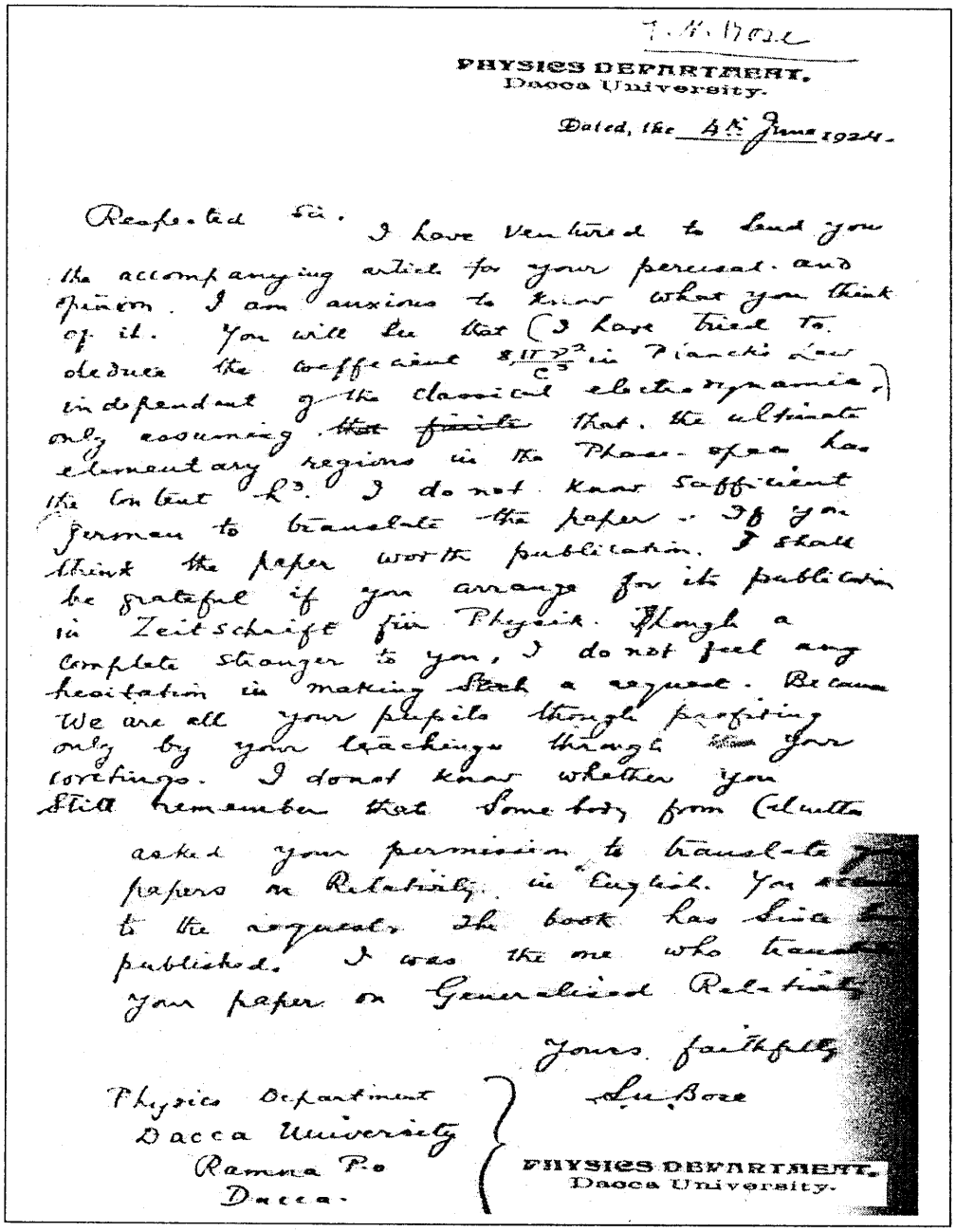
This short article is a humble attempt to spread the thread of that interaction between these personalities - both direct and indirect. It is also a small Indian tribute to Einstein,"Copernicus of the 20th Century", "Person of the 20th Century" "Newton of our Time" and so on in this "World Year Physics" (2005).

THE SCIENTIFIC LINK

The genesis of the quantum statistical mechanics of gases - what we now call Bose-Einstein statistics for gases - is interesting. Satyendranath, at that time teaching in the Physics Department of Dacca University (Dhaka - now in Bangladesh, originally East Bengal), had sent to Einstein a short manuscript in English in 1924 with a request to translate it into German for publication in a leading physics journal in Germany if he agreed with the theme of his paper (Letter to Albert Einstein, June 4, 1924: Photocopy of the original letter printed in - *Bose and his Statistics* by G. Venkataraman, Vignettes in Physics, Sangam Books, London/Universities Press (India) Ltd. 1992, p.13 - *ANNEX I*).

Einstein was impressed with the work and accepted his request, and translated the paper into German and got it published in the leading physics

ANNEX - I



S. N. Bose
PHYSICS DEPARTMENT,
Dacca University.

Dated, the 4th June 1924.

Respected Sir,

I have ventured to send you the accompanying article for your perusal and opinion. I am anxious to know what you think of it. You will see that I have tried to deduce the coefficient $8\pi\nu^2/c^3$ in Planck's Law independent of the classical electrodynamics, only assuming that the ultimate elementary regions in the Phase-space has the content h^3. I do not know sufficient German to translate the paper. If you think the paper worth publication, I shall be grateful if you arrange for its publication in Zeitschrift für Physik. Though a complete stranger to you, I do not feel any hesitation in making such a request. Because We are all your pupils though profiting only by your teachings through your writings. I do not know whether you still remember that Somebody from Calcutta asked your permission to translate papers on Relativity in English. You agreed to the request. The book has since been published. I was the one who translated your paper on Generalised Relativity.

Yours faithfully,
S. N. Bose

Physics Department
Dacca University
Ramna P.O
Dacca.

PHYSICS DEPARTMENT,
Dacca University.

Facsimile of the letter of S. N. Bose to Einstein

journal of the day, *Zeitschrift fur Physik* (Vol.26, 1924, p.178) under Bose's name as the author in 1924, with his comment that the paper was important ("Plancks Law and the Hypothesis of Light Quanta"). Einstein started working on Bose's concept himself. All this changed 30-year old Bose's destiny from being an obscure physicist of colonial India to one with a place in the Hall of Fame in the international arena of Physics.

Satyendranath worked with Einstein in Berlin during 1925 - 1926. Einstein was then Director of Kaiser Wilhelm Physical Institute in Berlin (1914 - 1933). In 1926, Bose also briefly worked with the Polish-French physicist, Madame Marie Curie (1867 - 1934), double Nobel Laureate (Physics, 1903; Chemistry, 1911) in her Radium Institute in Paris, France.

In 1924 Bose derived black body radiation law of Karl Ernst Ludwig Max Planck (1858-1947), Nobel Laureate in Physics, (1918), without the use of classical electro-dynamics which Planck needed. Bose's paper - "Planck 's Law and the Hypothesis of Light Quanta", published in 1924 with Einstein's comment on it, led Einstein to seek him out for collaboration. In 1924, Bose was granted two years' study leave with expenses, by the University of Dacca to go to France and Germany for research. Satyendranath was the first Indian scientist to work with Einstein and probably the last.

In 1924 Bose made important theoretical calculations about the nature of light particles or photons. The phenomenon of the propagation of light in discrete packets of energy travelling through space was already recognized. Bose, in his above-mentioned paper presented an alternative derivation of a law about the behaviour of photons that had been developed earlier by the German physicist, Max Planck. These kinds of particles obeying Bose's description eventually were named "BOSONS" in his honour.

"Bosons" are a class of subatomic particles having integer spin, considered to be carriers of basic physical properties. In theory such a force is transmitted from one particle to another by a carrier-field, which is embodied in a corresponding "Boson". Force-carrying particles such as photons, gluons and gravitons are all "Bosons". They have a property that allows them to con-gregate without number, occupying the same quantum state at the same time.

Bose's work focused on particles such as photons that have no rest mass. Einstein extended it to particles that have mass, such as atoms in a dilute gas. He theoretically predicted that if a sufficient number of such atoms get close enough together and move slowly enough, they will undergo a phase transition into a new state. That new state of matter became known as a "Bose-Einstein Condensate" (BEC).

Physicists recognized the keys to achieving a "BEC". The major challenge was to make the gas very cold, about a tenth of a millionth of a degree of absolute zero (-273.15°C or -459.67°F) to slow down the motion of the atoms without causing them to condense to a liquid. Atoms in gases usually move about in an uncontrolled way, ricocheting off each other and nearby objects. Under the specific conditions described by Einstein, however, the atoms "sense" one another and transform from a mass of uncoordinated individuals to a coherent group that acts like a single giant atom (the BEC).

After 1925 - 1926, Satyendranath never met Einstein again. In 1955, he participated at the International Conference held in Bern, capital of Switzerland, to commemorate the Golden Jubilee of Einstein's Special Theory of Relativity. Einstein was due to attend but he died before that on April 18, 1955. Einstein emigrated to the USA in 1933, and he never crossed the Atlantic back to Europe. But his former flat (Kramgasse 49) in Bern, where he lived as a young man for nearly two years (while working as a second division clerk at the Swiss Patent Office) is now a museum open to visitors. It was here where Einstein wrote all his five ground-breaking papers in 1905 ("Annus Mirabilis"). He was not a proper academic at that time.

The intellectual kinship between Bose and Einstein developed even before he went to Berlin to work with Einstein. In Calcutta, Bose translated into English Einstein's epoch-making paper "Special Theory of Relativity" published in *Annalen der Physik*, 17 (1905) 891-921, and also the second paper "General Theory of Relativity" published in 1915. All these translations were published by the University of Calcutta for post-graduate studies with, of course, permission from Einstein. Meghnath Saha (1893 - 1956) and Satyendrath jointly brought out this publication, a copy of which is available at the Central Library of the University of Calcutta. Though invited to visit India, Einstein could not make it.

Like the French Link "de Broglie-Einstein" waves with the French theoretical physicist, Louis de Broglie (1892 - 1987), the Bose-Einstein statistics (1924) for gases could be termed as Albert Einstein's intellectual connection with India - the land of the most ancient civilisation in the world.

"Boson" made Satyendranath an immortal icon in the world of modern physics. :"... .. ... . "Sixty years later, Pais calls Bose's work the fourth and last of the revolutionary papers of the old quantum theory', putting it alongside the seminal works of Planck, Einstein and Bohr" (Andrew Whitaker: *Einstein, Bohr and the Quantum Dilemma*, Cambridge University Press, England, 1996, p.127). Abraham Pais, initially a student and then a colleague of Einstein for many years at the Institute for Advanced Study at Princeton University, New Jersey, is the author of the famous book: '*Subtle is the Lord.....The Science and the Life of Albert Einstein,* Oxford University Press, England, 1982.

The Bose-Einstein Condensate (BEC) Theory stole the limelight in the Nobel parlour of Physics in 2001. The scientific souls of Albert Einstein (1879 - 1955) and Satyendranath Bose (1894 - 1974) were resurrected. It looked like the Easter Monday resurrection of Jesus Christ (BC 4; 29 or 30 AD) in the realm of science! Three physicists [Eric A. Cornell (1961 -), Carl E. Wieman 1951 -), both of the USA, and Wolfgang Ketterle (1957 -), a German], who first created independently a new ultra solid state of matter that both Albert Einstein (1879 - 1955), Nobel Physics Laureate (1921) and Satyendranath, in their Bose-Einstein Condensation theory, had predicted independently some 75 years ago, were jointly awarded the Nobel Prize in Physics (2001) for their production in 1995 of the so-called Bose-Einstein Condensate (BEC).

The cycle which Satyendranath and Einstein initiated jointly in 1924 appears to be complete in a full circle and immortality of Bose shines in every ring of it. It is best expressed by Satyendranath himself. In January, 1974, the University of Calcutta organised an international seminar in honour of Satyendranath Bose. Many leading physicists from allover the world came for the seminar. Bose was also present but frail and weak in health. He was asked to say a few words. He tried to speak standing, but had difficulty.He therefore delivered his address seated. He concluded with these words:

> "Well, after all, if one has lived through so many years of struggle, and if at the end he finds that his work has been appreciated, he feels that he does not need to live long."

Prophetic words indeed! Bose passed away soon after, on 4th February, 1974. Bose is no more, but 'Bosons' and 'BEC' will be there for ever to sing the song of his immortality in the world of science

Nobel Prize, or no Nobel Prize, Bose was a genius. Incidentally, Jean-Paul Sartre (1905 - 1980), one of the most original thinkers of the twentieth century - a genius, and the founder of French existentialism, was awarded the Nobel Prize for Literature in 1964, but declined. A genius is above such earthly award or reward. Amidst the names of physicists that crowd the columns of history of quantum physics, Karl Ernst Ludwig Max Planck (1858 - 1947), Einstein, Henreich David Neils Bohr (1885 - 1962), the name of Satyendranath shines, and shines as a glittering star.

The Intellectual Link

Rabindranath met Einstein in Berlin on a couple or so occasions. In the West, Rabindranath, Nobel Laureate in Literature in 1913,was, and is even today, known as an Indian mystic, poet and musician. On his observations of a conversation between Einstein and Rabindranath on July 14, 1930, in Berlin, journalist Dmitri Marianoff (Einstein's step-son-in-law) reported to the New York Times:

> "It was interesting to see them together - Tagore, the poet with the head of a thinker, and Einstein, the thinker with the head of a poet. It seemed to an observer as though two planets were engaged in a chat." See Tagore, *Farewell to the West* (1930 - 1931), pp. 294-295; Tagore, *The Religion of Man*, New York: Macmillan, 1931, Appendix 2, pp.221 - 225).

On science, the Poet told the Scientist during the conversation:

> "science is concerned with that which is not confined to individuals; it is the impersonal human world of truths."

In another conversation on August 19, 1930, the Poet and the Scientist discussed the possibility of self-expression in Eastern and Western music. The Scientist said:

> "In Europe, music has come too far away from popular art and popular feeling and has become something like a secret art with conventions and traditions of its own."

The conversation edited from the original published in *Asia* 31(March, 1931) pp. 138 - 142: "Tagore talks with Einstein", is given below:

TAGORE: There is in human affairs an element of elasticity, some freedom within a small range, which is for the expression of our personality. It is like the musical system in India, which is not so rigidly fixed as [it is] in western music. Our composers give a certain definite outline, a system of melody and rhythmic arrangement, and within a certain limit the player can improvise upon it. He must be one with the law of that particular melody, and then he can give spontaneous expression to his musical feeling within the prescribed regulation. We praise the composer for his genius in creating a foundation along with a superstructure of melodies, but we expect from the player his own skill in the creation of variations of melodic flourish and ornamentation...

EINSTEIN: That is only possible where there is a strong artistic tradition in music to guide the people's mind. In Europe, music has come too far away from popular art and popular feeling and has become something like a secret art with conventions and traditions of its own.

TAGORE: So you have to be absolutely obedient to this too complicated music. In India the measure of a singer's freedom is in his own creative personality. He can sing the composer's song as his own, if he has the power creatively to assert himself in his interpretation of the general law of the rnelody which he is given to interpret.

EINSTEIN: It requires a very high standard of art fully to realise the great idea in the original music, so that one can make variations upon it. In our country the variations are often prescribed.

TAGORE: If in our conduct we can follow the law of goodness, we can have real liberty of self-expression. The principle of conduct is there, but the character which makes it true and individual is our own creation. In our music there is a duality of freedom and prescribed order.

EINSTEIN: Are the words of a song also free? I mean to say, is the singer at liberty to add his own words to the song which he is singing?

TAGORE: Yes. In Bengal we have a kind of song - *kirtan* we call it - which gives freedom to the singer to introduce parenthetical comments, phrases not in the original song. This occasions great enthusiasm, since the audience is constantly thrilled by some beautiful spontaneous sentiment added by the singer.

EINSTEIN: Is the metrical form quite severe?

TAGORE: Yes, quite. You cannot exceed the limits of versification; the singer in all his variations must keep the rhythm and the time, which is fixed. In European music you have comparative liberty about time, but not about melody. But in India we have freedom of melody with no freedom of time.

EINSTEIN: Can Indian music be sung without words? Can one understand a song without words?

TAGORE: Yes, we have songs with unmeaning words, sounds which just help to act as carriers of the notes. In north India music is an independent art, not the interpretation of words and thoughts, as in Bengal. The music is very intricate and subtle and is a complete world of melody by itself.

EINSTEIN: It is not polyphonic?

TAGORE: Instruments are used, not for harmony, but for keeping time and for adding to the volume and depth. Has melody suffered in your music by the imposition of harmony?

EINSTEIN: Sometimes it does suffer very much. Sometimes the harmony swallows up the melody altogether.

TAGORE: Melody and harmony are like lines and colours in pictures. A simple linear picture may be completely beautiful; the introduction of colour may make it vague and insignificant. Yet colour may, by combination with lines, create great pictures, so long as it does not smother and destroy their value.

EINSTEIN: It is a beautiful comparison; line is also much older than colour. It seems that your melody is much richer in structure than ours. Japanese music seems to be so.

TAGORE: It is difficult to analyse the effect of eastern and western music on our minds. I am deeply moved by western music. I feel that it is great, that it is vast in its structure and grand in its composition. Our own music touches me more deeply by its fundamental lyrical appeal. European music is epic in character; it has a broad background and is Gothic in its structure.

EINSTEIN: Yes, yes, that is very true. When did you first hear European music?

TAGORE: At seventeen. when I first came to Europe. I came to know it intimately, but even before that time I had heard European music in our own household. I had heard the music of Chopin and others at an early age.

EINSTEIN: There is a question we Europeans cannot properly answer, we are so used to our own music. We want to know whether our own music is a convention or a fundamental human feeling; whether to feel consonance and dissonance is natural or a convention which we accept.

TAGORE: Somehow the piano confounds me.The violin pleases me much more.

EINSTEIN: It would be interesting to study the effects of European music on an Indian who had never heard it when he was young.

TAGORE: Once I asked an English musician to analyze for me some classical music and explain to me what elements makes for the beauty of a piece.

EINSTEIN: The difficulty is that the really good music, whether of the East or the West, cannot be analysed.

TAGORE: Yes, and what deeply affects the hearer is beyond himself.

EINSTEIN: The same uncertainty will always be there about everything fundamental in our experience, in our reaction to art, whether in Europe or in Asia. Even the red flower I see before me on your table may not be the same to you and me.

TAGORE: And yet there is always going on the process of reconciliation between [the two reactions] the individual taste conforming to the university standard.

Einstein finally commented:

"The difficulty is that really good music, whether of the East or of the West cannot be analyzed".

In another philosophical discourse Einstein and Tagore discussed the nature of beauty and truth ["The Nature of Reality", *Modern Review*, Calcutta, 49 (1931) 42-43].

About the universe, the Scientist told the Poet in 1930:

"There are two different conceptions about the nature of the universe: (1) the world as a unity dependent on humanity, (2) the world as a reality, independent of the human factor." (*New York Times*, August 10, 1930.)

After these meetings in Berlin, they never met again. Rabindranath died on August 7, 1941, in Calcutta, and Einstein on April 18, 1955, at Princeton. Rabindranath never travelled to the West after 1931, and Einstein never travelled to the East or in Europe, once he settled in the USA in 1933.

The Social Link

Jawaharlal paid courtesy call on Einstein at his residence at Princeton, New Jersey (112 Mercer Street) in 1950. The house is now privately owned. He also presented him with a copy of his celebrated book, *The Discovery of India*. Einstein did acknowledge this with great appreciation in a personal letter:

Princeton, New Jersey USA
February 18, 1950

Dear Mr. Nehru

I have read with extreme interest your marvellous book, *The Discovery of India*. The first half of it is not easy reading for a Westerner. But it gives an understanding of the glorious intellectual and spiritual tradition of your great country.

The analysis you have given in the second part of the book of the tragic influence and forced economic, moral and intellectual decline by the British rule and the vicious exploitation of the Indian people has deeply impressed me. My admiration for Gandhi's and your work for liberation through non-violence and non-cooperation has become even greater than it was already before. The inner struggle to conserve objective understanding despite the pressure of tyranny from the outside and the struggle against becoming inwardly a victim of resentment and hatred may well be unique in world history. I feel deeply grateful to you for having given to me your admirable work.

With my best wishes for your important and beneficent work and with kind greetings,

Please remember me kindly to your daughter.

Yours cordially

Albert Einstein

Einstein was a great humanist.

"British scientist J. B. S. Haldane called him the greatest Jew since Jesus" (Denis Brian:*Einstein - A Life*. John Wiley & Sons, Inc., New York, 1996, p. 104).

John Burdon Sanderson Haldane (1892 - 1964) was a famous British biologist and geneticist, but he emigrated to India in 1956 as a protest against the Anglo-French-Israeli invasion of the Suez Canal in 1956 after its perfectly legitimate nationalization by Egypt. He adopted Indian nationality, worked at Calcutta and Orissa and died at Bhubaneswar. On abolition of untouchability in India, he wrote to Jawarlal again:

"May I tell you of the deep emotion with which I read recently that the Indian Constituent Assembly has abolished untouchability? I know how large a part you have played in the various phases of India's struggle for emancipation, and how grateful lovers of freedom must be to you, as well as to your great teacher Mahatma Gandhi."

To the Indian prime minister (1947 - 1964). [Letter of June 13, 1947.]

Unfortunately, abolition of untouchability in India is still a distant echo! Law only cannot change a society.

The Moral Link

Einstein never met Gandhi. But, in 1925, in solidarity with Gandhi, he signed a manifesto against compulsory military service while the Nazi leader-lover German dictator Adolf Hitler (1889-1945) thrilled to the German composer - Richard Wagner's (1813-1883) martial music glorifying pagan heroes. Mahatma was his moral *guru*. In his study at Princeton home among the sagging bookshelves and frayed books there were a photo of Gandhi and print of English physicist and chemist - Michael Faraday (1791-1867) and Scottish physicist - James Clerk Maxwell (1831 - 1879) in old-fashioned picture frames (Denis Brian, *Einstein - A Life*, John Wiley & Sons Inc., New York, 1996,p. 406).

Einstein's socio-political psyche was greatly influenced by Mahatma. His autobiography, *My Experiments with Truth,* was one of his favourite readings (Alice Calaprice: *The New Quotable Einstein*, Princeton University Press, Princeton and Oxford, 2005, p. 335). The following quotes bear testimony to his deep respect for Mahatma:

> "A leader of his people, unsupported by any outward authority: a politician whose success rests not upon craft or the mastery of technical devices, but simply on the convincing power of his personality; a victorious fighter who has always scorned the use of force; a man of wisdom and humility, armed with resolve and inflexible consistency, who has devoted all his strength to the uplifting of his people and the betterment of their lot; a man who has confronted the brutality of Europe with the dignity of the simple human being, and thus at all times risen superior. Generations to come, it may well be, will scarce believe that such a one as this ever in flesh and blood walked upon this Earth".
>
> **Statement on the occasion of Gandhi's seventieth birthday 1939. (In *Einstein on Humanism*, 94, Einstein Archive 32-60l).**
>
> I believe that Gandhi's views were the most enlightened among all of the political men of our time. We should strive to do things in his spirit; not to use violence in fighting for our cause, but by nonparticipation in what we believe is evil.
>
> **From a United Nations Radio interview, June 16,1950 recorded in the study of Einstein's home in Princeton. Reprinted in the *New York Times*, June 19, 1950;**

also quoted in Pais, *Einstein Lived Here*, 110.

Gandhi, the greatest political genius of our time, indicated the path to be taken. He gave proof of what sacrifice man is capable once he has discovered the right path. His work on behalf of India's liberation is living testimony to the fact that man's will, sustained by an indomitable conviction, is more powerful than material forces that seem insurmountable.

To the editor of the Japanese magazine *Kaizo*, Sept. 20, 1952. [Quoted in Nathan and Norden, *Einstein on Peace,* Einstein Archive 60-039].

Gandhi's development resulted from extraordinary intellectual and moral forces in combination with political ingenuity and a unique situation. I think Gandhi would have been Gandhi even without Thoreau and Tolstoy.

To Walter Harding, a member of the Thoreau Society, August 19,1953. [Quoted in Nathan and Norden, *Einstein on Peace*, 594, Einstein Archive 32-616].

But great souls do differ on certain issues.Einstein was no exception. He differed with Gandhi on the application of non-violent methods in Nazi Germany and on his attitude to technological revolution vis-a-vis role of machines in modern civilization:

"I admire Gandhi greatly but I believe there are two weaknesses in his program. Non resistance is the most intelligent way to face difficulty, but it can be practiced only under ideal conditions... It could not be carried out against the Nazi Party today. Then, Gandhi makes a mistake, in trying to abolish the machine from modern civilization. It is here, and it must be dealt with."

From an interview, *Survey Graphic* (24 August 1935), 384, 413, discussing the Indian pacifist's goals:

Both are right. It is the circumstances that matters. Relevance is what is important at the end. Everything is not applicable to everywhere - lock, stock and barrel. It is man that matters and not machines.Humanism is the key point. Balance only fruitfully sustains changes in life and society. Adjustment and compromise hold the ultimate key. Gandhi was there thinking, rightly so, in the context of village-based rural people and their economies within traditional Indian extended family frame-work while Einstein was born, brought up and was in the thick of post-industrial-revolution Europe with nuclearisation and breaking-up of family set-up, breeding individualism, selfishness, greed and crave for exploitation of countries of Asia, Africa, Latin America and Australia through imperial aggression, occupation and dehumanisation. Their spectrum was different and hence the perception. Today's globalisation, its discontent and its resultant impoverishment of the rural and the semi-urban world confirm what Gandhi apprehended many decades ago.

> Of course, there are and always have been technological advancement and breakthroughs by machine. But sad reality is that scientific revolution has overtaken social development. So, while substantial sections of the urban and semi-urban people have been drawn into the world of machines and technology, larger numbers - the vast majority survive in slums without basic needs such as shelter or roof over-head, clothes to cover bare bodies, safe drinking water, sanitation, elementary health care and elementary education in countries of the underdeveloped and the developing world - India included. Gandhi was a social scientist - knew the grassroots - the cells of the society he lived in - he could foresee things, while Einstein - a product of industrialized West - detached from real society, could not.

The Epilogue

Albert Einstein was an exceptional human being. Perhaps nothing reflects the breadth and scope of his brilliance, and his interests and his influence better than his publications - more than six hundred scientific papers, books, essays, reviews and opinion pieces. Einstein began publishing in March 1901 with a scientific work that appeared in the German journal *Annalen der Physik* ("Conclusions Drawn from the Phenomena of Capillarity" Vol. 4, 1901, 513-523), when he was twenty two; the last publication was an editorial in the journal, *Common Cause*, which appeared a few months before his death in 1955 ("What is the task of an International Journal?", *Common Cause*, Florence, Italy, Vol. 1, No. 1:3). Rabindranath also had his last publication - "Crisis of Civilisation" written on April 14, 1941, about three months before his death on August 7, 1947 - it was his last message for mankind, beaming with hope and assurance, even in that dark hour at the beginning of World War II (1939-1945):

> "But it is a sin to lose faith. I will preserve faith to the very end one day once again invincible man will resume his onward march for recovering his destined dignity and nobility, having overcome all the obstacles on the way."

His talent for the German language was second only to his gift for science. He wrote all his scientific papers in German, whether or not they eventually appeared in that language. Likewise, Rabindranath wrote mainly in Bengali but also wrote some in English. Both were gifted persons.Rabindranath also wrote on Isaac Newton's (1643 - 1727) theory of gravitation, Einstein's theory of relativity, cosmology, etc., in Bengali, *Viśva Paricay* (Āswin, Bengali 1344, English 1937, Viswabharati, Calcutta.) and dedicated it to Satyendranath as an

appreciation of his dedication to propagating science through mother tongue.

Einstein had always high regard for India - a land of ancient civilization with vibrant continuity.

Dr. Sisir K. Majumdar
Hasiniketan
200 Summer House Drive
Wilmington, Dartford
Kent DA2 7PB,
England, UK

Indian Journal of History of Science, 41.1 (2006) 111-120

Einstein, Molecule and Medicine

Physics is the mother of all technologies. Albert Einstein (1879-1955) is hailed to be the theoretical father of "LASER" (Light Amplification by Stimulated Emission of Radiation) - a direct product of his Nobel Prize-winning (1921) work in 1905 on photoelectricity. It is his superb contribution to medicine. Incidentally, the name of Satyendra Nath Bose (1894-1974), Father of 'Boson', is also conceptually associated with the evolution of LASER. Bose-Einstein Condensate (BEC) occurs in the, action of LASER; large numbers of particles participate collectively in a single quantum state. There is a wave function. All participating particles - the entire collection of particles,behave like a single particle.There is large scale quantum coherence presenting many of the strange features of quantum wave functions at a macroscopic level. That measurement of molecule can be done was also conceptualized in Einstein's work ("A Determination of Molecular Dimension") in 1905 - it laid the scientific basis of Molecular Biology and Molecular Medicine of today. Even basic principles of Quantum Mechanics is applied now to explain the dynamics of human consciousness, feeling and other functions of the brain.

Albert Einstein - "Chief Engineer of the Universe" is omni-present in the corridors of modern science - not only Laser but also computers, iPods, mobile phones, all came about because of Einstein's work on the photoelectric effect; satellite navigation system is only possible because of relativity.

Albert Einstein (1879-1955) was a versatile man - a genius par excellence. First half of the twentieth century is rightly termed as the "Age of Einstein", and he has been declared "Person of the Century" by *Time Magazine*. In the Centenary Year (1905 - 2005) of his Special Theory of Relativity (also "World Year of Physics" as declared by the United Nations) we need to explore the diversity of his genius. Hence, this small attempt. It is all history now. It is an eternal source of inspiration for today and for all generations to come. Because history is a dialogue between the past and the present. Though it is also true that history is not always what happened at a particular time, but is

what is written by individuals at a different time about what happened. Einstein probably never imagined that his Nobel Prize (1921) - winning work on photo-electricity in 1905 (ANNEX - I: PAPER - I) would lay the theoretical foundation of modern LASER (Light Amplification by Stimulated Emission of Radiation), nor did he guess that his doctoral dissertation in the University of Zurich in the same year (ANNEX - I: PAPER II) would signal the conceptual basis of Molecular Biology of today. This is not new in the history of science. History often repeats itself. The Austrian monk - Gregor Mendel(1822 - 1884), Father of Genetics, never knew or thought about the implications of his experiments with hybridization of garden peas in his chapel's small garden. His seminal work discovered in 1900, 16 years after his death in 1884, laid the mathematical foundation of modern genetics.All great men sometimes face similar predicaments. It may also be that history can be how people today interpret what people have discovered in the past.

However, it is fair to say that the Miraculous Year - 1905 (*Annus Mirabilis*) of Einstein at the age of 26 also brought miracles in today's modern medicine and molecular biology. This is only comparable to *Annus Mirabilis* - 1666 of Isaac Newton (1642-1727) when only at the age of 24, this posthumous child, born on Christmas Day in 1642, laid the foundations of classical science with his version of the differential and integral calculus, his theory of colours (optics), his theory of universal gravitation and with his formulation of the basic laws of mechanics (ANNEX - II).

We all know that the five epoch-making papers (ANNEX - I) of Einstein, "the Copernicus of the 20th Century", changed the face of physics. It needs to be mentioned in this connection that the discovery of the Polish clergyman - Nicolaus Copernicus (1473 - 1543) that the earth moves around the sun (heliocentric: Greek - 'helios' = sun) fundamentally changed our perception of the universe and our place on it. The Year "1543" is the "*Annus Mirabilis*" in the annals of Natural Sciences and Medical Sciences when *De Revolutionibus Orbrium Coelestium* (On the Revolution of Heavenly Bodies) of Nicolaus Copernicus and *De Humani Corporis Fabrica Libri Septem* (The Seven Books on the Structure of the Human Body) of the Paduan anatomist, Andreas Vesalius (1514 - 1564) were published. The years '1543', '1666' and '1905' were all auspicious in the annals of our civilization.

But the Miraculous Year of Einstein could neither tell at the time nor predict what the legendary genius kept hidden in his intellectual locker for posterity, particularly for medicine.

LASER AND EINSTEIN

The name LASER is an acronym of 'Light Amplification by Stimulated Emisston of Radiation'. It is a system of coherent application of energy; it is a device which produces light, infra-red or ultra-violet radiation with special properties, using a system of excited atoms. The first working model of Laser was built in 1960 by the US physicist, Theodore Harold Maiman (1927 -), following theoretical work by Charles Hard Townes (1915 -),Nobel Laureate in Physics 1964 for development of MASER (Microwave Amplification by Stimulated Emission of Radiation) and Arthur Leonard Schawlow (1921 -), Nobel Laureate in Physics in 1981. Atoms absorb energy in well-defined amounts, raising electrons to excited states; the electrons are said to move from one energy level to a level of higher energy. An atom is a unit of matter, consisting of a nucleus of positively charged protons and unchanged (neutral) neutrons, orbited by negatively charged electrons. A complete atom has the same number of electrons as protons balancing the charge. The nucleus is a Pandora's box of sub-particles or elementary particles like Leptons, Photons,Gravitons, Bosons, Gluons, Mesons, Baryons, etc. Each atom contains approxirnately 350 fundamental particles. After being excited, an electron usually returns to its original level after less than 10^{-8} seconds, releasing energy as photon of light.

Photon is the quantum or particle of light - a particle that transmits the energy in light, x-rays and other forms of electro-magnetic radiation. Light and other electro magnetic radiation comprises a stream of photons. If photon of energy similar to that of another photon about to be released strikes the excited atom,then the proton production is more rapid;this is called 'stimulated emission' after Einstein's work on photo-electricity in 1917.The result is two photons identical in phase moving in the same direction. Should these photons themselves interact with more excited atoms, eventually a cascade of identical photons will be produced, all moving in one direction. Laser action depends on the choice of special atomic systems for which an energy supply is able to raise large number of atoms to excited states, ready to emit photons when stimu-

lated. Mirrors at either end of the 'Laser'reflect light end-to-end inside the 'Laser' to maintain its action. At one end,the mirror is partially transparent allowing a portion of light to escape to produce a Laser beam. Typically, energy is supplied to the 'Laser' by electrical discharge or a powerful light source.

Light and all other electromagnetic radiation comprises a stream of photons, each of which has energy E = hv, where 'h' is Planck's constant (6.626 x 10^{-34} j.s - joule second) and 'v' is frequency. Photons of yellow light have energy 3.4 x 10^{-19} j. A household light emits c.$l0^{20}$ photons every second. Photons have no (rest) mass (weightless) and are of spin 1. In quantum theory they transmit electromagnetic force. German physicist, Max Ernst Ludwig Planck (1858 - 1947), Nobelist in Physics 1918, was the formulator of the quantum theory in 1900. Among the many technologically important applications of quantum physics (mechanics)are laser, superconductors and electronics. Further evidence that light exists in packets (quanta) came from the photoelectric effect of Einstein in 1905 (ANNEX - I: PAPER - 1) and Compton effect (1923) of US physicist, Arthur Holly Compton (1892 - 1962), Nobel Laureate in Physics in 1927.

Light is a form of energy. It is a form of electromagnetic radiation. Glowing luminous objects, such as the sun, fires and candles, emit light when their atoms receive large amounts of energy. In an electric lamp, this energy is provided by electricity. Sometimes all the atoms in a material can be made to emit their excess energy at the same moment. In some cases, a narrow and extremely intense beam of light can be produced. This is the basis of lasers. Laser beams are very concentrated energy source. Lasers can be used for a variety of operations from cutting through metal sheets to performing delicate surgical operations. The discovery of photon is due principally to the research of Max Planck in 1900 and Albert Einstein in 1905 in one of his five ground-breaking papers.

'Laser' light is monochromatic (all one colour, coherent in step) produced as a beam which does not spread, and travels large distances undiminished in intensity. The light is produced either as a continuous beam or as pulses.

'Laser' has got many uses; in medicine it is used on phototherapy,eye and brain surgery, and in other aspects of surgery. 'Laser' waves have high energy - can be focused to a microscopic point and are perfectly sterile, and cause minimal bleeding and scarring.

Medical 'Lasers' are made mainly of carbon dioxide, argon or matetials like neodymium and Yag (Yttrium - Aluminium - Garnet). They cut tissue by heating and coagulating it, or by producing photochemical reactions. Some of these optical 'knives' or 'cauters' are employed in eye surgery, while others penetrate more deeply for tumour treatment. The beam can also be aimed from -inside the body with endoscopy. However, 'Lasers' will never fully replace the mechanical scalpel, but their uses are expanding steadily in all fields of surgery.

Interestingly, it was Einstein who unveiled the fundamental theoretical basis of 'Laser' first in 1905 in his Nobel Prize-winning work - 'On a Heuristic Point of View Concerning the Production and Transformation of Light' (*Annalen der Physik*, 17, 1905, 891-921) - all his five epoch-making papers were published in the same volume: 1905 - *Anna Mirabilis* of Einstein) and then elaborated it in 1917. This turned out to be his sole contribution to medicine. The practical application of his photo-electric theory has been the "electric eye" used for opening and closing doors by remote control, for detecting intruders, for counting and sorting goods and for making radio and television possible. Einstein is the theoretical father of Laser; US experimental physicist - Robert A Millikan (1868 - 1953), Nobel Laureate in Physics, 1923 - confirmed Einstein's theory of the photoelectric effect.

Surgery: Application of Lasers

* Laser scalpel in areas prone to bleeding
* Removal of moles, warts, resurfacing scars, dermabrading,spider veins, port wine stains, birthmarks, hemangioma, tattoos, hair removal, pigments, freckles
* Used in dentistry
* Removal of pre-cancerous and cancerous tissues
* Eye, nose and inner ear surgery
* Used in orthopaedic surgery, arthroscopy
* Endoscopic sinus surgery

* Spine surgery
* Removal of prostate gland
* Treatment of leg and facial veins
* Cardiac revascularisation
* Lithotripsy (removal of kidney stones) and removal of gall stones
* Removal of fibroids and ovarian cysts

Einstein and Molecule

Einstein first attempted to determine the dimensions of a molecule . (Annex - I: Paper - 2). It was a macro-study. But it established the fact that a molecule can be measured. It laid down the theoretical basis of the micro-study of the inner core of the molecule. It was the real beginning of the exploration of the molecule, wherever it is - be it in the physical world or in the biological world. Today's molecular biology has got the insight of the inner dynamics of the molecule. It has opened a new vista in the elucidation of the functions of the inner ingredients of the molecule. Thus, it has helped in laying the foundation of molecular medicine. Einstein was, unwittingly, the explorer of this new micro-world of medical science. Today,neuro-physicists also are trying to quantify brain activities like consciousness, feeling, etc., by applying the principles of quantum physics.

The Epilogue

It is apparent from the above discussion that the advancement of medical science was, and is, and will always be, dependent on the progress of fundamental sciences like mathematics, physics and chemistry. It is true that pure science is not rapidly converted to applied science. That has always to depend further techno-logical advancement and on craftsmen's innovation. The role of physics in the evolution of some modern medical equipment - both diagnostic and therapeutic, is simply unique. A chemical pathology laboratory also comprises overall physics (i.e. laboratory machinery, pressures, radioactivity, voltage, etc.)

In the world 'of Nature - the macrocosm - man is but the microcosm and "the Book of Nature is written in Mathematical Characters", so said Galileo Galilei (1564 - 1642). The contribution of physics and other basic sciences to modern medicine is immense. It has gathered momentum with the march of time. Throughout our contemporary era, the science of medicine is inseparable from the science of physics, mathematics, chemistry, statistics and some of the other natural sciences. In the 50th anniversary of Einstein's death (April 18, 1955) coinciding with the centenary (1905-2005) of his ground-breaking discoveries, we can still see the results of his theories in innovations ranging from the atom bomb to microwave and medicine.

ANNEX - I

***ANNUS MIRABILIS* (MIRACULOUS YEAR, 1905) OF ALBERT EINSTEIN (1879-1955)**

(ONLY 26 YEARS OLD AT THF TIME) (FIVE/SIX PAPERS THAT CHANGED THE FACE OF PHYSICS: *ANNALEN DER PHYSIK*, 1905)

Paper I :

"On a Heuristic Point of View Concerning the Production and Transformation of Light" (Ober einen die Erzeugung und Verwandlung des Lichtes betreffenden heuristischen Gesichtspunkt). *Annalen Qer Physik* 17 (1905) 132-148 (Completed March 17, 1905).

Einstein expounded on the peculiar discrepancy between material bodies and radiation and introduced the concept of light quanta, or photons, providing the basis for much of the later work in quantum theory, especially Bohr's theory of the atom. Challenging the wave theory of light, Einstein showed that electromagnetic radiation interacts with matter as if the radiation has a granular structure (the so-called photoelectric effect). He determined that a massless quantum of light, the photon, would have to impart the energy required according to Planck's radiation law to break the attractive forces holding the electrons in the metal. This theory was one of the milestones in the development of quantum mechanics, making Einstein the foremost pioneer in the field and opening the world of quantum physics. The first of the five great papers he published in 1905; it earned him the Nobel Prize in physics sixteen years later in 1921.

Paper II:

"A New Determination of Molecular Dimensions" (Eine neue Bestimmung der Molekuldimensionen), Dated April 30, 1905, but not published until the following year, Bern: Wyss, 1906. Also slightly revised in *Annalen der Physik* 29 (1906) 289-305 (Completed, April 30, 1905).

This document is Einstein's doctoral dissertation, resubmitted in the spring of 1905 after he withdrew his first submission in 1902. Here, he combined the techniques of classical

thermodynamics with those of the theory of diffusion to create a new method for determining molecular sizes. He wanted to discover facts that would establish once and for all the existence of atoms of a specific finite size, since at the turn of the century the atom's existence was still in contention. After he submitted his copy of the thesis to the University of Zurich, his petition to receive the doctorate was approved.

Paper III:

"On the Motion of Small Particles Suspended in Liquids at Rest Required by the Molecular-Kinetic Theory of Heat" (Uber die von der molekularkinetischen Theorie der Warme geforderte Bewegung von in ruhenden F1ussig-keiten suspendierten Teilchen), *Annalen der Physik,* 17(1905), 549-560 (Received by the Editor, May 11, 1905).

For the first time, Einstein discussed Brownian motion, the irregular movement of microscopic particles suspended in a liquid,which was named after the eighteenth-century Scottish botanist who first observed it. As Einstein explained in a letter to his friend Conrad Habicht on May 25, he proved in this paper that particles about 1/1000 millimeter in diameter suspended in liquids and too small to see move randomly because of thermal dynamics. By inverting Boltzmann's formula, Einstein described its mathematics, deriving the probability of a macroscopic state for the distribution of gas molecules. This paper led to experiments validating the kinetic-molecular theory of heat. To date, this is Einstein's most cited paper.

Paper IV:

"On the Electrodynamics of Moving Bodies"(Zur Elektrodynamik bewegter Korper), *Annalen der Physik,* 17 (1905) 801-921 (the Editor, June, 30, 1905).

This landmark in the development of physics, one of the two papers that laid out the theory of special relativity (the other is no.5), formulated a new conception of time. By assuming that the speed of light is the same to every observer moving at a constant velocity, Einstein showed that space and time were not independent; spacetime was born. According to Hermann Weyl in 1918, this theory "led to the discovery that time is associated as a fourth coordinate on an equal footing with the other three coordinates of space, and that the scene of material events, the world, is therefore a four-dimensional, metrical continuum". It was a revolutionary piece of scientific work.

Einstein's exploration of the nature of simultaneity and expression of the necessity of defining simultaneity led to widespread discussion of the conventionality of simultaneity" in the philosophy of science, which is still a hot topic today.

Henri Poincare, also in 1905, obtained, independently from Einstein, many of the results of the special theory.

Paper V:

"Does the Inertia of a Body Depend on its Energy Content?"(Ist die Tragheit eines Korpers von seinem Energie-inhalt abhangig?), *Annalen der Physik,* 18 (1905) 639-641 (Received by the Editor, Sept. 27, 1905).

Using the postulates of the special theory of relativity, Einstein showed that energy radiated is equivalent to mass lost, which would eventually lead to the famous equation $E = mc^2$. He considered the conservation of energy of a radiating body in a system at rest and in a system in uniform motion relative to it. For the first time he concluded that "the mass of a body is a measure of its energy content". The special theory of relativity paved the way for a deeper appreciation of symmetry criteria in physics and introduced new views on space and time, yet it took twenty-five years for experimental evidence in its favour to emerge. Einstein credited Galileo, Isaac Newton, James Clerk Maxwell and H.A. Lorentz for laying the foundation for the theory.

Paper VI:

"On the Theory of Brownian Motion" (Zur Theorie der Brownschen Bewegung), *Annalen der Physik*, 19 (1906) 371-381(Received by the Editor, on December 19, 1905).

In this second paper on Brownian Motion, Einstein presented his earlier ideas on Brownian motion in more elegant form, adding two new applications- the vertical distribution of a suspension under the influence of gravitation and a calculation for a Brownian rotational movement for a rotating solid sphere. Jean Perrin's experiments on the former would win him Nobel Prize in 1926.

SOURCE

Calaprice Alice: *The Einstein Almanac*, John Hopkins University Press, Baltimore and London, 2005, p.12-18.

Abraham Pais: *Subtle is the Lord -- The Science and the Life of Albert Einstein.* Oxford University Press, Oxford and New York, 1982, p.17-18.

Sisir K. Majumdar: "Reception of Relativity Theory", Autumn Annual, Presidency College, Alumni Association, Kolkata, Vol.XXII, pp.30-36, 1993-1994.

Sisir K. Majumdar: "Centenary of Einstein's Theory of Relativity (1905-2005)" *Frontier*, Kolkata, Vol.37, pp.4-8, March 6-12,2005.

ANNEX - II

ANNUS MIRABILIS - 1666 OF CLASSICAL SCIENCE: ISAAC NEWTON (1642- 1727)

(ONLY 24 YEARS OLD AT THE TIME)

In 1666 Newton laid the foundations of his version of the differential and integral calculus, his theory of colors (optics), the theory of universal gravitation and formulated his basic laws of mechanics.

Dr. Sisir K. Majumdar
Hasiniketan
200 Summer House Drive
Wilmington, Dartford
Kent DA2 7PB,
England, UK

Indian Journal of History of Science, 41.1 (2006) 121-122

MAGIC SQUARE FOR 2006

The article published in the *IJHS*, 39.1 (2004) 143-144 has informed us that in the early 14th century in the city called Patrapunjanagar in the region of Naimisa (near the modern Sitapur in the state of Uttar Pradesh), Harṣa composed the tract *Aṅkayantra Cintāmaṇi* which roughly translates to Magic Squares that are effective like wish fulfiling gems'.

The historical details or historicity of such Magic Squares and the methods of their construction have elaborately been discussed by B. B. Datta and A. N. Singh, revised by K. S. Shukla, vide *IJHS*, 27.1 (1992) 51-120.

V. G. Unkalkar (Research Officer of the West Coast Paper Mills Ltd, Dandeli, Karnatak State 581325) has published a book (30 pages) 'Magic Squares by Vedic Methods' in January 2001. The Book also gives methods of construction of Magic Squares of sums and of products.

This article intends to enumerate the Magic tricks or qualities of the Magic Squares of sums. A Magic Square of the order of four with magic constant 2006 carrying 'Good Wishes for the New Year 2006' is given below. In this square the first term is 59 and the common difference is also 59 through out from the initial number 59 to the last (16th) number 944.

059	885	590	472
708	354	177	767
413	531	944	118
826	236	295	649

The Magic sums of 4 columns, 4 rows and 2 diagonals are as under.

1) 059 + 708 + 413 + 826 = 2006
2) 885 + 354 + 531 + 236 = 2006
3) 590 + 177 + 944 + 295 = 2006
4) 472 + 767 + 118 + 649 = 2006
5) 059 + 885 + 590 + 472 = 2006
6) 708 + 354 + 177 + 767 = 2006
7) 413 + 531 + 944 + 118 = 2006
8) 826 + 236 + 295 + 649 =2006
9) 826 + 531 + 177 + 472 =2006
10) 059 + 354 + 944 + 649 =2006

The Magic sums of 4 numbers in the adjacent cells are as under

11) 059 + 885 + 708 + 354 = 2006
12) 590 +1472 + 177 + 767 = 2006
13) 413 + 531 + 826 + 236 = 2006
14) 944 + 118 + 295 + 649 = 2006
15) 885 + 590 + 354 + 177 = 2006
16) 767 + 118+ 177 + 944 = 2006
17) 236 + 295 + 531 + 944 = 2006
18) 708 + 354 + 413 + 531 = 2006
19) 059 + 472 + 649 + 826 = 2006
20) 354 + 177' + 531 + 944 = 2006

The Magic sums of 4 numbers in different groups

21) 059 + 885 + 826 + 236 = 2006
22) 590 + 472 + 295 + 649 = 2006
23) 472 + 767 + 059 + 708 = 2006
24) 118 + 649 + 413 + 826 =2006
25) 590 + 767 + 413 + 236 =2006
26) 708 + 885 + 118 + 295 = 2006
27) 411 + 354 + 590 + 649 = 2006
28) 236 + 944 + 767 + 059 = 2006
29) 708 + 531 + 295 + 472 = 2006
30) 885 + 177 + 118 + 826 = 2006

There are six more Magic tricks. They are as under:

If we delete the left side first column and join it at the right side of the square the sums of columns, rows and diagonals are not affected. Similarly if we remove the last row of the square and put it as first row, still the sums are not affected. Similarly if the second and third columns or rows are removed from their respective positions and replaced correspondingly, the square is not affected.

D.N. Ukidwe
D-238, New Sabniswada
Savantwadi 416510