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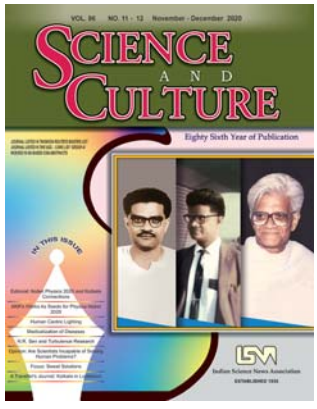
EDITORIAL

PHYSICS NOBEL 2020 AND KOLKATA CONNECTIONS



Every year in October, the Nobel Prize Committee announces prizes to persons who have made a breakthrough in the fields of physics, chemistry, literature, economics, medicine and peace. The awards are generally a cause of delight for the nations that the awardees belong to except may be in cases where the awardee is an emigrant national and the country that he/she originally belonged to also rejoices along with the country of emigration. A recent example of such a case is that of American economist Abhijit Banerjee, who was awarded the Nobel Prize in Economics last year, is a Bengali, was educated in India, and thus the entire country was caught up in the euphoria of his achievement.

This year's Nobel Prize in physics has been awarded to three scientists: Roger Penrose of Oxford University, UK, *"for the discovery that black hole formation is a robust prediction of the general theory of relativity"* and to Reinherd Genzel of Max Planck Institute, Germany and University of California, Berkley, USA and Andrea Ghez of University of California, Los Angeles, USA *"for the discovery of a supermassive compact object at the centre of our galaxy"*. Interestingly, the prize elated the physics community of the country, more so the Bengalis, and much more the physics community of Kolkata, for the connection with the works of two Bengali physicists of Kolkata.

Roger Penrose is a theoretical physicist. Theoretical works of Penrose on black hole, for which this year's Nobel in physics has been awarded, rests heavily on the works of Amal Kumar Raychaudhuri (AKRC) and Stephen Hawking. Stephen Hawking was Penrose's collaborator and his contribution towards developing the black hole theory is no less important than that of Penrose. Stephen Hawking died in March 2018. Had Hawking been alive today, I am sure, he would have shared the prize with Penrose (Nobel Prize is not awarded to anyone posthumously). Raychaudhuri was a professor of physics at Presidency College (now university), Kolkata and published papers in the fifties when cosmological studies was at its infancy. Raychaudhuri did not work directly with either Penrose or Hawking but they found the equation, known as 'Raychaudhuri equation', in the field of general theory of relativity (GTR) and cosmology very useful for furtherance of their research.

Interestingly, the prize elated the physics community of the country, more so the Bengalis, and much more the physics community of Kolkata, for the connection with the works of two Bengali physicists of Kolkata. Theoretical works of Penrose on black hole, for which this year's Nobel in physics has been awarded, rests heavily on the works of Amal Kumar Raychaudhuri (AKRC) and Stephen Hawking.

Roger Penrose, by his complex mathematical methods, proved that black hole is a direct consequence of GTR. Interestingly, a phenomenon similar to that of a black hole was said to occur as per Newtonian theory as well. As early as in 1798, Pierre Simon de Laplace used Newtonian theory to predict that a sufficiently massive and concentrated body would be invisible because the escape velocity at the surface would be greater than the velocity of light. In this context Penrose himself said "a photon or particle of light emitted from the surface of the body would simply fall back to the surface, it would not escape to be observed at large distances from the body. This description is perhaps arguable, but shows that there is a situation to be faced, even in Newtonian theory". Many have predicted the existence of a massive object which attracts all other objects but once the matter or energy gets inside the object nothing can come out of it. The name 'black hole' was first coined by John A Wheeler at a conference in New York in 1967.

To a theoretical physicist, a black hole is formed when "a space can be crumpled like a piece of paper into an infinitesimal dot, that time can be extinguished like a blown-out flame". But to a layman, black hole is a dense (super)massive object, as if mass of a mountain has been compressed into the size of the nucleus of an atom, in which the gravitational attraction is so high that nothing can come out of it.

The importance of Raychaudhuri equation and how it helped Penrose and others to progress their research findings has been narrated in detail in an article in this issue by reputed theoretical physicist Parthasarathi Majumdar.

The importance of Raychaudhuri equation has been justifiably enumerated in the famous book *A Brief History of Time* written by Hawking as given below:

"The reason one gets conjugate points in spacetime is that gravity is an attractive force. It therefore curves spacetime in such a way that the neighbouring geodesics are bent towards each other rather than away. One can see this from the Raychaudhuri or Newman-Penrose equation, which I will write in a unified form."

Raychaudhuri equation talks about the condition under which these geodesics will be convergent or divergent. The equation is very important in the field of cosmology because if the geodesics are moving apart then one can conclude that there is no singularity in this continuum. But if the geodesics cross each other, which may have happened in the past or may happen anytime in distant future, there must be a singularity. A singularity is a point at which the curvature of space, according to the GTR, is infinite. Some cosmologists believe that at a distant past geodesics crossed each other and the universe may have been created from such a singularity which is now known as 'big bang'. One of the most relevant papers of AKRC published in *Physical Review* has been presented at the end of this issue for the interested readers.

This work is distantly related to the work of another Bengali, Mrinal Kumar Dasgupta (MKDG), who was a professor of physics at the Institute of Radiophysics and Electronics under the University of Calcutta. The discovery of double radio source in Cygnus A using radio interferometer with post detection correlator designed and fabricated by MKDG and his co-worker Roger Jennison is now considered as one of the 10 classical discoveries in radio astronomy. This discovery of Dasgupta and Jennison is perhaps the first indirect evidence of black holes.

There are black holes throughout our Galaxy and across the Universe. The one at a distance of about 26,000 light years from the Earth at the centre of the Milky way, known as Sagittarius A^* (Sgr A^*), is the closest supermassive black hole. Reinhard Genzel and Andrea Ghez are astronomers who using the world's largest telescope focused on a region at the centre of our galaxy and mapped the orbits of the brightest stars near Sgr A^* with extreme precision. Their work provided the most convincing evidence of a supermassive black hole at the centre of the Milky Way.

This work is distantly related to the work of another Bengali, Mrinal Kumar Dasgupta (MKDG), who was a professor of physics at the Institute of Radiophysics and Electronics under the University of Calcutta. Unlike AKRC

who did his pioneering work in Calcutta, MKDG did his work while he was in England in the fifties. The discovery of double radio source in Cygnus A using radio interferometer with post detection correlator designed and fabricated by MKDG and his co-worker Roger Jennison is now considered as one of the 10 classical discoveries in radio astronomy. This discovery of Dasgupta and Jennison is perhaps the first indirect evidence of black holes. Incidentally, MKDG was on the editorial board of *Science and Culture* for many years and was actively associated with the Indian Science News Association (ISNA). The paper of MKDG with Jennison published in *Nature* is presented at the end of this issue for interested readers.

Is the study of black holes limited to only satisfying the thirst of knowledge of theoretical physicists and for proving the correctness of the theory by experimentalists? Or could it have some importance in our daily lives as well? I am tempted here to mention that black hole is an enormous power house emitting energy at a rate of about ten thousand megawatts. According to Stephen Hawking "one such black hole could run ten large power stations, if only we could harness its power." To conceive of harnessing power from the black hole is itself a difficult proposition, and its extraction by existing technology is a far cry. Stephen Hawking conceived such a possibility of extracting energy out of a black hole. I quote from Hawking:

According to Stephen Hawking "one such black hole could run ten large power stations, if only we could harness its power." To conceive of harnessing power from the black hole is itself a difficult proposition, and its extraction by existing technology is a far cry. Stephen Hawking conceived such a possibility of extracting energy out of a black hole. Who knows whether Hawking's proposition, which looks like a fantasy now, may not turn into a reality sometime in the distant future. We may not be there to see it but our grand, great-grand, great-great... children may be excited to see it happen.

"If you had one of these black holes on the surface of the earth, there would be no way to stop it from falling through the floor to the centre of the earth. It would oscillate through the earth and back, until eventually it settled down at the centre. So only place to put such a black hole, in which one might use the energy that it emitted, would be in orbit around the earth—and the only way that one could get it to orbit the earth would be to attract it there by towing a large mass in front of it, rather like a carrot in front of a donkey." He ended by saying "this does not sound like a very practical proposition, at least not in the immediate future."

We are aware of many such propositions of Jules Verne to Carl Sagan which seemed like fantasies at one time but became true later. Who knows whether Hawking's proposition, which looks like a fantasy now, may not turn into a reality sometime in the distant future. We may not be there to see it but our grand, great-grand, great-great… children may be excited to see it happen. ❐

S. C. Roy