George Gamow – a Biographical Sketch

Seldom does it happen that the ideas of a single scientist influence research in a variety of topics and spawn a few new ones. It is a rare event if the scientist also happens to be a great populariser of science. George Antonovich Gamow explained radioactive decay, described the rates and mechanisms of nuclear reactions inside stars, proposed how the elements were synthesized, and suggested how DNA might provide the code for protein synthesis. He is also well known for writing several popular books, including the famous 'Mr Tompkins' series.

Gamow was born on 4th March 1904 in Odessa, Ukraine. He was fascinated by astronomy during his school days, and his father, a school-teacher, gave him a telescope on his thirteenth birthday. After a brief stint at the Novorossia University at Odessa he went to study physics at the University of Leningrad in 1923. After receiving his PhD in 1928, he went to Copenhagen to work with Niels Bohr.

He had worked on explaining nuclear radioactivity as a quantum mechanical phenomenon (he was inspired by a summer school in Göttingen which was then bubbling with research on quantum mechanics). He successfully explained the 'alpha decay' (emission of alpha particle by a radioactive nucleus) with the help of quantum tunneling. At Copenhagen, Gamow proposed a hypothesis that the atomic nucleus can be treated as droplets of 'nuclear fluid', – with neutrons and protons behaving like the molecules in a drop of liquid – which became known as the liquid-drop model of the nucleus. Later, John Wheeler and Bohr explained the process of nuclear fission with the help of this model in 1939. According to them, the spherical nucleus may get distorted into a dumb-bell shape, if given sufficient extra energy (by the absorption of a neutron, for example), which then split into two fragments, releasing energy.

Gamow was also interested in the effect of quantum tunneling on nuclear fusion. Classically, the probability that two particles with similar sign get very close is zero. Gamow realised that quantum tunneling can make this probability non-zero (although small), and derived what is known as the 'Gamow factor' for this probability. This was later used by Gamow and Edward Teller to derive the rate at which nuclear reactions would proceed at high temperatures that exists in the interiors of stars. (The relevant reactions for the production of energy inside stars were finally explained by Hans Bethe in 1938.)

An interesting feature of this 'Gamow factor' is that it provides a mechanism for a star to maintain a stable temperature. Small variations in temperature cause a large change in the energy generation (because of the strong dependence of 'Gamow factor'), which cause expansion of the gas and then subsequent cooling back to the equilibrium temperature. It thus works like a thermostat for the interior of stars.

Gamow then spent a year (1929-30) at the Cambridge University, UK as a Rockefeller Fellow. He worked on the theoretical aspects of an experiment done by John Cockcroft and Ernest Walton to split the lithium-7 nucleus into two alpha particles (each containing two protons and two neutrons) by bombarding with high energy protons.

Gamow returned to Russia in 1931 to become a professor at the University of Leningrad. The situation of the then Soviet Union under Joseph Stalin was becoming unpleasant for many academicians. Gamow and his wife Lyubov Vokhminzeva (nicknamed 'Rho') first attempted to escape by crossing the Black Sea to Turkey in a small kayak, carrying small provisions like eggs, chocolate and two bottles of brandy for the 270 km journey. After 36 hours the weather turned hostile and they had to return. Luckily Gamow managed to convince the Soviet officials that they were doing experiments on the boat!

After a few such attempts, Gamow used the opportunity of being asked to participate in a conference in Brussels to escape. He somehow managed to convince the authorities to allow his wife to accompany him as his secretary. After the conference, he was invited to lecture at the University of Michigan, USA, and while there, he was offered a position at the George Washington University, Washington D.C., USA. He accepted the position on the condition that they also appoint Edward Teller, then at Birkbeck College in London.

Soon after coming to USA, Gamow started working with Teller on a theory of the 'beta decay' (emission of electrons from nuclei). Nuclei, however, not only emit electrons but also capture electrons. Gamow (along with Mario Schoenberg) found that both these processes lead to the emission of either a neutrino or an anti-neutrino. When these processes take place in the interior of stars, these neutrinos and anti-neutrinos escape, and matter in the stellar interior can rapidly lose energy. Gamow named this process 'Urca process' after a casino in Rio de Janeiro where the customer lost money with ease.

Gamow's interests however were not confined within the bounds of nuclear physics, but ranged from designs of turbine and internal combustion engines, properties and structure of the interior of the Earth, and so on. Instead of working in so-called glamorous (and therefore crowded) fields of research, he liked working in areas that he found challenging and even messy. For example, from pure nuclear physics he shifted to astrophysics and the application of his ideas in nuclear physics to the problems of birth and evolution of stars and production of energy inside them, especially the red giant stars. He also became interested in the synthesis of elements in the early universe and physical cosmology in general. As a matter of fact, cosmology today owes an immense debt to Gamow for his pioneering ideas.

With a former student, Ralph Alpher and colleague Robert Herman, he was the first to develop the physical aspects of the cosmological theories that were advocated in 1930s based on Einstein's general theory of relativity and supported by the observations by Edwin Hubble (for details, see the article on page 32). Based on simple but convincing ideas, they predicted that the universe would be bathed in a sea of radiation, which would be a cooled relic of the hot 'soup' of matter and radiation in the early universe (which he named 'Ylem', a Greek word for 'primordial matter' and pronounced 'eye-lem'), and would have a current temperature of a few degrees Kelvin. The discovery of the microwave background radiation, with a temperature of 2.7 K in 1965 by Arno Penzias and Robert Wilson thus provided a big support for the Big Bang model of the universe. (See article by Somak Raychaudhary and by Gamow himself in the Classics Section.)

True to his sense of humour, Gamow put a new label on a bottle of Cointreau liqueur, with 'YLEM' written on it, to celebrate the calculations done by his group.

When he spent a year in 1954 at Berkeley, he plunged into the theory of genetic coding and advocated a mathematical code connecting the structure of DNA with the existence of 20 amino acids. Although his ideas were not proved correct, they had a stimulating effect on the research at that time. (See article by Vidyanand Nanjundiah.)

Gamow then shifted to the University of Colorado, Boulder from 1956 and worked there until his death in 1968.

His charismatic and fun-loving nature is reflected in the number of popular books and articles that he wrote. The series of books featuring Mr. Tompkins (of which the first one appeared in 1939), in which Gamow explained such intricate concepts as curved space, or the uncertainty principle, through brilliant stories of a hapless bank clerk who happened to be the son-in-law of a physicist, has become legendary. They were also illustrated by Gamow himself! Among his other books are 'One, Two, Three... Infinity' (1947), 'The creation of the universe' (1952), 'A planet called Earth' (1963), 'A star called the Sun' (1964). He was awarded the Kalinga Prize by the UN in 1956 for his popular scientific writings.

Edward Teller once described Gamow : 'Gamow was fantastic in his ideas. He was right, he was wrong. More often wrong than right. Always interesting; ....and when his idea was not wrong it was not only right, it was new.'

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A picture contrived by Gamow's students showing Gamow emerging from a bottle of 'Ylem' with Alpher and Herman.

http://www.mrtompkins.dk/MR/jpg/ylem.jpg