Fred Hoyle: Scientist of multifaceted talents

Sir Fred Hoyle, the most original and versatile astrophysicist of our times passed away on 20 August 2001. He is survived by his wife Lady Barbara Hoyle, son Geoffrey and daughter Elizabeth. I had the privilege of being his student and later a coworker. The following impressions do only partial justice to a multifaceted personality.

I recall an event in 1964–1965. A play was staged in the newly built Mermaid Theatre in London, on the south bank of the river Thames. London is well-known for plays, both established ones as well as new experimental plays. In Shakespeare's times, there had been a theatre of the same name on the south bank of the river. The new Mermaid Theatre had been rebuilt on the same site. That evening, the theatre was full to capacity, but not for a Shakespearean play.

And, there was another difference. The average age of the majority of the audience was 8–14 years. Because, the play was based on science fiction and was written specially for children. To suit them, these shows had been arranged during the Easter vacation. The unusual thing was that it was not written by a professional playwright from the literary world, but by a scientist, famous for his research in astronomy. The name of the play was 'Rockets in Ursa Major', and the author was Fred Hoyle.

In the early part of the twentieth century, the distinguished scientist James Jeans from Cambridge contributed

significantly towards making astronomy popular amongst common people. The lecture halls used to be 'packed' during his lectures and his books were internationally read and acclaimed. Hoyle, also from Cambridge, was a worthy successor of Jeans.

Fred Hoyle was born on 24 June 1915, in a little village called Bingley in Yorkshire. (Fred is not a shortened version of Frederick; in Yorkshire it is a complete name by itself.) Fred's father used to trade in cloth materials and his mother was an expert in music, especially in playing the piano. Fred developed interest in the piano as well as in mathematics, when he was small. His power of analytical reasoning was demonstrated at the age of three, when he had worked out the way to read the clock and tell the time, all by himself.

At a young age, Fred developed interest in astronomy. The Hoyles, father and son, would walk eight miles to the house of a friend who had a telescope, and would return early in the morning after a night of sky-watching. Astronomy encouraged his inquisitive and highly original mind. He also was something of a rebel and would not accept the conventional wisdom, unless his mind was satisfied as to its correctness.

In his first primary school, a teacher once taught in the class that a certain type of flower has five petals. The next day, Fred produced a flower of the same kind with six petals and asked the teacher to justify her statement. The teacher,

embarrassed and angered by this counter-example, smote the boy's ear. Shocked by this unjustified response, Fred left school at once and came back home. He told his mother that he would never go to the school where such injustice prevailed. His mother supported his stand and argued his case with the school authorities, who finally gave her permission to change the boy's school. Later in his life, Hoyle had to face many such incidents, whenever he challenged the set attitudes of the establishment.

Considered a bright student in his school, Fred entered the University of Cambridge with two scholarships, to do the mathematical tripos. He distinguished himself with a Mayhew Prize in the Part III of the tripos and a Smith's prize as a research student. His early work was more in atomic and particle physics rather than astrophysics; and he was elected to fellowship of St John's College for his essay on quantum electrodynamics.

When the second World War began, like many other scientists, Hoyle, too worked on wartime projects and helped develop research on the radar system. After the war was over, Hoyle came back to Cambridge and started work on his favourite subject – astronomy. This was a new era in his life, and it was Raymond Lyttleton who got him interested in problems of stellar structure. While Lyttleton was more in the classical mould of dynamics and worked with an overall mathematical approach, Hoyle brought more of physics into their collaboration.

The work on stellar structure naturally led him to the next step of stellar evolution. The problem facing astrophysicists in the early 1950s was how to proceed beyond the fusion of hydrogen to helium. An exothermic reaction was needed, if a star like the sun were to keep shining beyond this stage. Moreover, to Hoyle, who had a grand vision of making most, if not all chemical elements in stars, the problem posed by instability of nuclei of atomic masses 5 and 8 seemed a crucial one to solve. How otherwise can one climb the nuclear ladder? Ed Salpeter had suggested the triple-alpha process, in which three helium nuclei get together to form a carbon nucleus. But the problem was that a three-body collision seemed too rare an event to generate enough carbon or provide enough energy for the star to continue shining. This was where Fred used his intuitive brilliance to propose that the three-body reaction is a *resonant* reaction, which proceeds fast and so compensates for the low probability of collision. He calculated the energy level of the resulting carbon nucleus so formed and found that it was an excited level. He therefore urged the nuclear physicists to look for such an excited level. Ward Whaling and Willy Fowler at Caltech after initial scepticism, performed the necessary experiments and found that Hoyle's prediction was correct.

This tour de force of Hoyle was motivated by anthropic considerations too! He had argued that unless such an excited level existed, there would not be enough carbon formed and so our own existence (with carbon as an essential ingredient) would have to be denied.

This success essentially began the new programme of nuclear astrophysics, with Fowler collaborating with Hoyle in problems of stellar evolution and nucleosynthesis. Later, they were joined by the husband–wife team of Geoffrey and Margaret Burbidge in a mammoth exercise of demonstrating how most nuclei are indeed formed in stellar processes, from a sun-like beginning, and in the extreme case, a supernova-type explosive end. This work published in 1957 in the *Reviews of Modern Physics* has stood the test of time and is referred to after its four authors as the B^2FH theory.

Hoyle's researches have given new directions to many branches of astrophysics. The origin of solar system, the evolution of stars, the origin of cosmic rays, the mystery of dust in the interstellar space, the phenomenon of accretion on stars, the formation of the Milky Way, radio sources, pulsars, quasars and, of course, his favourite branch – cosmology . . . . In today's era of narrow specialization, it is extremely rare to find a scientist with such a variety of research interests and with such a seminal record of contributions with high impact factor.

In 1948, together with Hermann Bondi and Tommy Gold, he proposed the steady state theory of the universe. At that time, the established opinion was that the universe was created in a huge explosion, the so-called 'big bang'; and most of the scientists opposed this new theory. But Hoyle was firm in his conviction about the untenability of the big bang cosmology and was always ready to argue with other scientists. In fact, the name 'big bang' was given by Hoyle to this model in the course of a programme of popular radio talks on the BBC, more as a cynical description of that mythical primeval event than as a serious epithet.

If a theory is to be scientifically disproved, then one should point out a logical contradiction in it or demonstrate that some prediction of the theory is disproved by observations. During 1950–1960, many observers claimed to have results relating to discrete sources like galaxies, radio sources, etc. that were contradictory to the steady state theory; but later, after close scrutiny, all of them turned out to be unfounded. The observation that really fatally affected the theory, however, was the discovery in 1965 of the cosmic microwave background.

There was a time, perhaps for 4–5 years after this event, when Hoyle wavered in his opposition to the big bang. His work with Bob Wagoner and Willy Fowler in 1967 demonstrated in a most comprehensive way, how light elements could be produced just after the big bang. This is still cited as the cornerstone of modern big bang nucleosynthesis. Most astronomers were surprised when Hoyle's name did not appear alongside Fowler's in the 1983 list of Nobel awards in physics. He did, however, receive two prestigious awards, the Crafoord Prize and the Balzan Prize.

However, as time passed he felt that the big bang paradigm was sinking more and more into speculations of the very early universe, with nothing beyond the microwave background and light element abundances to show for it as direct evidence. He therefore returned to his initial scepticism and by 1993 had revived the old steady state theory with Geoffrey Burbidge and Jayant Narlikar, in a modified form. Called the quasi-steady state cosmology, this alternative was able to account for the elemental abundances and the microwave background, besides explaining observations of discrete source counts. His last book was the magnum opus called *A Different Approach to Cosmology*, written with his above two coworkers. Despite propagating heretical views, the book is doing well in terms of readership.

Hoyle believed that a scientist should be sensitive to the issues affecting society and he himself did not hesitate to express his opinions publicly. In the 1970s, he wrote a book arguing that nuclear power

alone can solve the energy crisis of the world. He had published a scholarly book which seeks to relate the old relics at Stonehenge in England to practices related to astronomy in the ancient civilization. He gave well-argued lectures on the dangers of the future growth of population.

In 1957, Fred Hoyle published his first science-fiction novel, called *The Black Cloud*. This book was a great success and many readers felt that in Hoyle they had a reincarnation of H. G. Wells! But the difference here was that an internationally renowned scientist had attempted writing science fiction. The black cloud in the novel is formed of thinly-packed molecules with a brain which could think. The cloud needs energy for its survival and obtains it from stars. When it comes near the sun to 'charge' its energy reservoir, a havoc is created on the earth and the novel describes how, with the help of scientists, all the nations club together and face the calamity. The administrators, the politicians, and the eccentric scientists are all depicted very well. The fictional cloud of the novel turned out to have a realistic aspect too; when a few years later, through millimetre astronomy, clouds with molecules were detected by astronomers. (It is not yet known if there are any clouds with brains!) Indeed Hoyle once confessed that he was driven to write this novel when his scientific paper proposing the existence of giant molécular clouds was turned down by scientific referees on the grounds that such clouds could not exist in the interstellar space.

Hoyle has written quite a few science-fiction novels. Some of them were written in collaboration with his son Geoffrey. The children's play. 'Rockets in Ursa Major' described above, was subsequently written up as a novel by the father and son. *A for Andromeda* and its sequel *The Andromeda Breakthrough* were novels that grew out of very successful television serials (and brought the then relatively unknown actress Julie Christie before the British audiences). In 1969, Hoyle was given the Kalinga award by UNESCO, for popularizing science.

In 1958, Hoyle became the Plumian Professor of Astronomy and Experimental Philosophy in the University of Cambridge. This Chair was earlier occupied by Arthur Eddington and Harold Jeffreys, both stalwarts in their respective fields. He felt, however, that the accelerated mode of astronomy research with growing collaborations between theorists and observers and with the increasing role of the electronic computer, needed a research institute in order to keep Cambridge at the apex of astronomical development. He therefore worked hard for and ultimately succeeded in establishing in 1966, the Institute of Theoretical Astronomy (IOTA). IOTA indeed proved to be a great success and was later expanded to include observational astronomy as well. In 1972, he was knighted by the Queen. It was largely due to his stewardship as the Chairman of the Anglo-Australian Telescope (AAT) Board, that the Anglo-Australian Telescope was successfully commissioned.

But, though very well-known and distinguished, and creator of institutions, Hoyle was never a part of the establishment. Because, to be established, one requires a conformist attitude. Hoyle, by nature had the stubbornness proverbially associated with his native county of Yorkshire. So, even though he worked on different committees, he kept aloof from the establishment.

In 1972, following a policy disagreement, he resigned directorship of IOTA, as well as the Plumian Chair and his natural love for hiking in the hills, prompted him to live in a small village in the Lake District. Living like a recluse and without any formal day-to-day connection with any institution, he still kept his research going.

In the mid-1970s, Hoyle created another controversy by challenging the generally believed ideas of terrestrial origin of life and its Darwinian evolution. With his former student Chandra Wickramasinghe he proposed a theory of extraterrestrial origin of life. This theory requires that bacteria and viruses enter the earth's atmosphere on cometary tails and may have seeded life on the earth four billion years ago. Although severely attacked by biologists and astronomers, their theory is now gaining more support. Ironically, he passed away while an Indian balloon experiment testing this hypothesis of panspermia had been successfully completed and its results are being analysed.

In spite of all this controversy, even his critics admit his unique creativity, originality and extraordinary perception. It would not be an exaggeration to call this extraordinary personality, the Galileo of modern times.

J. V. NARLIKAR

Inter-University Centre for Astronomy and Astrophysics,
Post Bag No. 4, Ganeshkhind,
Pune 411 007, India
e-mail: jayant@iucaa.ernet.in