In Relative Terms

The Heavier Side of Gravity

By J V NARLIKAR

IN 1915, Einstein proposed his general theory of relativity. For the first few years it was said that only three people in the world really understood what the theory was about. Today, 82 years later, the International Society on General Relativity and Gravitation has several hundred members on its roll. There must be hundreds more who are not members but who use relativity for their research. The GRG-Society meets once in three years in different parts of the world to take stock of how our knowledge in the field of gravitation has advanced over the years. Its 15th meeting was held for the first time in India, at the Inter University Centre for Astronomy and Astro Physics (IUCAA), Pune in December 1997. Had Einstein been beamed down from his heavenly abode as a delegate to the meeting he would certainly have been amazed at the progress made in the field. Whether he would have approved of the developments is another matter.

Take the subject of gravitational waves, for example. Do they exist? The question was not resolved unambiguously during Einstein's lifetime. In his autobiographical work, *Quest: The Evolution of a Scientist*, his long time colleague Leopold Infeld describes an episode in Princeton when Einstein thought he had proof that these waves don't exist. It was an important result, if true. Infeld went through Einstein's complicated proof and found another much simpler one, which greatly pleased Einstein. However, the next day Infeld discovered an error which vitiated the proof! And when he called on Einstein the next day to acknowledge his mistake, Einstein admitted that he too had found a mistake in his own proof. Since Einstein had already arranged to give a seminar on what would have been a great discovery, at the seminar, he went through his proof and in the end showed the audience where his mistake was.

A Challenge

Today's relativists are confident that the waves exist. There is even an indirect proof of their existence. Observations of the pulsar PSR 1913+16 show that it is part of a double star system. The period with which the two stars go round each other is slowly decreasing, because their orbit is shrinking. This happens exactly at the rate that general relativity predicts, on the assumption that the binary star system is losing energy through gravitational radiation. But can the radiation be detected directly? This is a challenge that takes us to the frontiers of present technology. When a pebble is thrown in a pool of water, the water level rises and falls as a water wave progress outwards. When a gravitational wave passes through space and time it changes its geometry ever so slightly. The spatial distances will accordingly undulate. Sophisticated equipment is needed to detect such changes which are as minute as a change of one centimetre in a distance several million million times the distance between Mumbai and Delhi.

Seems a hopeless task? Not so to a small band of scientists busy constructing laser interferometers which beam narrow and precise laser rays back and forth between mirrors over distances of around a kilometre or more. For precision, the laser beams have to travel through pipes in which a very high grade vacuum is created. And the system has to be protected from seismic disturbances which are continually taking place in the earth. Two detectors in Europe, one in Japan and a double detector in the United States are vying with one another in the race to receive the first gravitational wave signal from space. Cautious optimism suggests that this may happen at the turn of the century. Nor would it be easy to locate that signal against the background noise. Scientists at IUCAA are carrying out the mathematical exercise of signal processing that will be needed when D-Day arrives.

Great Discovery

Moving from the high-tech experiment to a high level exercise in abstract speculation, the most significant discovery of this century is the realisation that the laws of motion and force originating from Isaac Newton, so successful in describing nature, do not work in the micro-world of atoms and molecules and subatomic particles. A new system, the quantum theory, provides the modus operandi of describing their behaviour. But can the law of gravity, first given by Newton and later improved upon by Einstein, be adopted to the quantum world? At the Pune conference, this issue received considerable attention. For, the holy grail of unification of all forces of nature into a single entity will continue to elude scientists until, as they say, 'gravity is quantised'. Except that nobody knows for sure what it means. Einstein said that gravitational effects manifest themselves through the geometry of space and time. In a quantised theory, the notions of an evenly distributed space and continually flowing time have to change. How should we describe it?

The present marketplace for quantum gravity parades such exotic goods as 'strings' in 11 dimensions and 'loops' of all kinds. Our intuitive feel of space and time obviously makes no sense when one is talking about less than a million-million-million-million- million-million-millionth part of a second! What does it matter to us mortals whether space and time are continuous entities or whether they are discrete on such a tiny scale? But for theorists, in search of an overall consistency and completeness on the part of nature, these issues are very relevant. And that is why several of the best brains are trying to figure out the answer.

Isaac Newton, who started it all with his inverse square law of gravity was asked, what lies beneath the law. Why indeed does nature have an inverse square law? His reply was *Non fingo hypotheses*, that is, 'I do not frame hypotheses'. Newton was concerned more with the applicability of the law to natural phenomena than with speculations about its foundations. I think he would have reacted positively to the search for gravitational waves, seeing in them a culmination of his experiments in optics.

Einstein, on the other hand was concerned with the epistemological issues not only about quantum mechanics, but also about unification of basic forces. He spent the latter part of his life on the trail when the rest of the physics community did not think a search for unification worthwhile. Now the present craze for unification. Strange, how fashions change, even in science.

Human Mind

To offset this heavy dose of gravity, the conference organisers had arranged a public lecture by Roger Penrose, eminent relativist and author of *Science and the Mind.* Penrose highlighted his point of view that there are aspects of human mind that lie beyond the powers of the best possible computer. He developed a circular interaction between abstract mathematics, physics of the real world and the thought processes of the human brain. The organisers had made a serious miscalculation of the speaker's popularity, with the result that several hundred enthusiasts had to be turned away as there was no space for them in the auditorium, the largest Pune could offer. While sympathising with the disappointed and angry persons who could not hear an excellent talk, I cannot help feeling optimistic about a society that can generate so much spontaneous enthusiasm for an intellectual feast.