ASTROPHYSICS

White holes: to be or not to be?

UNLIKE black holes, the white holes have received a lukewarm reception from relativists. Recently, however, a number of publications have focused attention on the existence, appearance and usefulness of white holes.

White holes are pockets in space where matter is being produced in an explosive manner. In this sense, the much-touted "big bang" Universe is the biggest white hole! However, in 1964-65, Y. Neeman, University of Texas, and I. D. Novikov of the Institute of Applied Mathematics, Moscow, USSR, independently suggested that the universe may not have been formed in one big bang, and there may have been a few portions of space where matter was created later. Thus, white holes could be manifestations of delayed *mini bangs*. In 1964, F. Hoyle, J. Faulkner and I showed that to an external observer, the light quanta emitted by the white hole in its initial stages will appear to be highly blueshifted. We suggested that white holes could serve as sources of high-energy particles and quanta desperately needed by astrophysicists to account for many astronomical phenomena. In 1975, K. M. V. Apparao and I discussed various astrophysical scenarios like exploding nuclei of galaxies, transient X-ray sources, gamma ray bursts, etc, where the concept of the white hole is useful. In a recent book (*White Holes : Cosmic Gushers in the Universe*), John Gribbin has discussed many applications of the white hole idea ranging from straightforward astrophysics to esoteric science fiction.

However, some theoreticians doubt whether white holes could survive. In 1974, D. M. Eardley argued that an

exploding white hole 'sees' the ambient matter in the universe highly (in fact, infinitely) blueshifted. This would mean that the expanding white hole surface would be quickly swamped by in-falling matter and radiation at such a rate that its force of explosion will be smothered. The result? The white hole would collapse and become a black hole. In 1976, K. Lake and R. C. Roeder of the University of Toronto, Canada, published a counter argument in which they showed that in the case of white holes arising from delayed mini bangs, the infinite blueshift could be avoided.

Recently, in *Nature* (**272,** 599), Lake has shown that certain types of white holes can survive and be observed in the Universe. These special white holes (which are called *grey holes*) do not expand beyond their Schwarzschild radius; they become black holes before breaking this barrier. (If a contracting object tries to emit outward signals, the Schwarzschild barrier does not allow these signals to come out; but, for an exploding object, this barrier is *not* insurmountable.) Lake also finds that such grey holes should have come into existence with almost *zero* delay.

However, in a subsequent paper (*Nature*, **278**, 449, 1978), Lake and Roeder have also found that such white holes will be bright only for a very short time after the initial explosion. This is because the light coming from the white hole not only comes along radial directions but also along non-radial ones. In fact, most of it comes along the latter directions; and for these, the Doppler blueshift is large for a very short time in the beginning. Thus, the authors feel that such white holes cannot be invoked to explain the observed explosions in galactic nuclei. It is not clear, however, whether this rules out other applications (of white holes) like gamma ray bursts.

This weakening blueshift of non-radial rays was, in fact, noted earlier by R. C. Kapoor, Indian Institute of Astrophysics, Bangalore, and me in January this year (*Astrophysics and Space Sciences*, **55,** 155). We found that this can lead to peculiar observable effects in the initial stages of a white hole explosion. Its angular size, for example, would appear to increase so fast as to give the impression of faster-than-light expansion.

The last word on white holes is still awaited.

J. V. NARLIKAR

[Dr. Narlikar is Professor of Astrophysics at the Tata Institute of Fundamental Research, Bombay.]