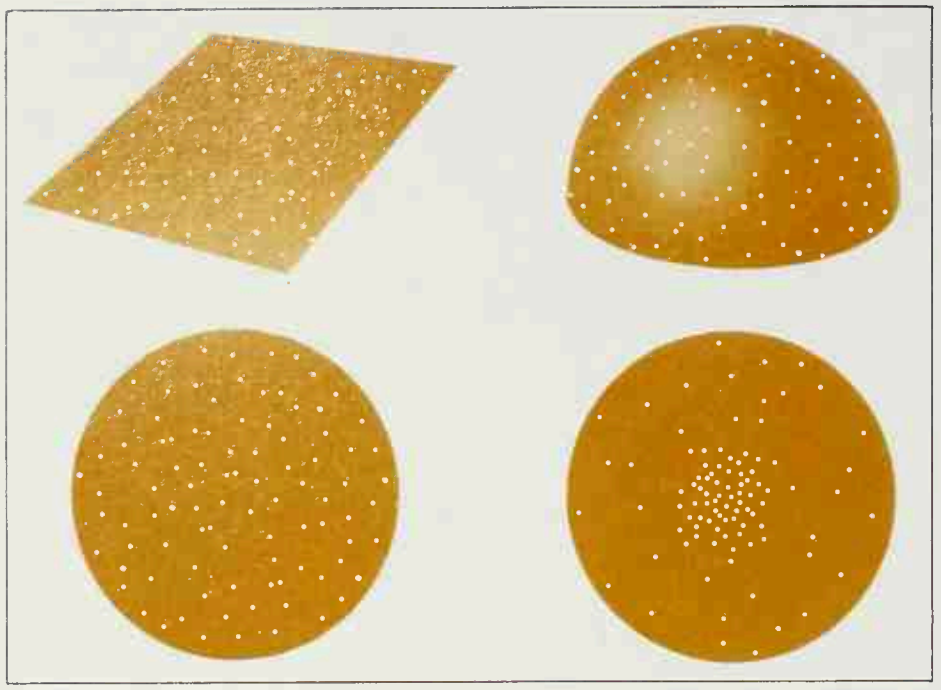

Fig 8·13
According to the shape of space and the model universe we choose, the number of sources we observe at great distances will be different.

the universe, can make predictions about the conditions in the very earliest instants following the Big Bang. Even at such an early stage – and we are talking of only 10^{-39} second after the Big Bang – it can be shown that the universe would have consisted of 10^{80} regions which could not have been causally connected (that is to say that none could have had any influence upon the others). The problem remains how to explain the fact that the relict radiation is so homogenous – to at least one part in 10 000. Some progress is being made with tentative theories – for example that known as the Inflationary Universe – which go some way towards meeting these obstacles They even indicate that our observable universe may be no more than a very tiny part of a much larger Big Bang universe, some 10^{60} times greater in volume!

Unanswered questions

There are still many unanswered problems. We may not know whether we live in an open (ever-expanding) universe or a closed one, but certainly cosmology seems to be an open-ended subject. There is, for instance, the problem of the nature of what are sometimes called Eddington's 'magic numbers'. Eddington, in the 1930s and early 1940s, pointed out that the ratio of the electromagnetic force between a proton and an electron divided by the gravitational force between these two particles was $0{\cdot}23 \times 10^{40}$, and also that the ratio of the radius of the (observable) universe divided by the radius of the electron was 8×10^{40}, two huge numbers that are of the same order of magnitude, while 10^{40} is approximately the square root of the number of particles (5×10^{79}) which the universe is thought to contain. Are these relationships nothing more than coincidences; or are we perhaps at that age in the evolution of the universe when they happen to coincide; or do these numbers remain the same all the time, and some other fundamental 'constants' (gravity, for instance) change? These magic numbers may have the most profound significance – or they may have none.

Another point which must be realized is that the hot big-bang theory is only concerned with the earliest stages of the formation of the universe as we now observe it. It does not tell us how the singularity from which the material poured came into being. In other words, the presence of a super atom is taken as our starting point. Such a question seems, on the face of it, to lie outside the realms of scientific enquiry; or perhaps the question has no meaning, for it implies an existence in time before the matter of the universe appeared and, in a space-time universe, space and time are inextricably linked – time would be formed when matter was formed and would have no previous existence.

Again, in curved space-time there is no 'outside' to the universe; space-time expands outwards as the universe evolves, but there is no outside space waiting there to receive it, just as there was no time ticking by waiting for the creation of the universe to begin. It makes no sense then to ask what lies outside the universe because the very question implies that one is thinking of something there already waiting to receive the galaxies as expansion proceeds. But there is the question of what is meant by the word 'universe'. By definition it signifies everything, 'the whole body of things and phenomena observed or postulated' (*Webster's Dictionary*) or 'the whole of created or existing things regarded collectively; . . .' (*Shorter Oxford Dictionary*). However, according to relativity there is a limit to the observable universe – we can never observe at distances where the speed of recession is equal to the speed of light – so there is the obvious question of whether our section of the universe is just part of something larger, more comprehensive. Is our expanding universe no more than one of many bubbles expanding outwards into a vaster universe? Such a suggestion has indeed been made by Narlikar, but although this is an imaginative idea, there seems at present no way of testing whether or not it could be so. The very suggestion pinpoints a danger – the danger of postulating a universe inaccessible to observation, for this is the path that leads to unbridled and unscientific speculation.

Fig. 8·14
A plot of observations using different model universes.