SMOOTHING OUT THE UNIVERSE

The expansion of the universe appears to be going smoothly despite some recent suggestions of odd behavior

BY DIETRICK E. THOMSEN

Since the classic work of Edwin Hubble and others in the early decades of this century, cosmologists have accepted the notion that the universe is expanding. The big cosmological question has been whether the expansion will continue endlessly. Given that the force of gravity attracts all the bodies in the universe to each other and that it is the only force acting over cosmological distances, it must be slowing the expansion. For decades, astronomers have argued (with generally insufficient evidence one way or the other) whether the gravitational deceleration is strong enough to stop and reverse the expansion eventually or not.

In the last couple of years two sets of observations have given the argument a couple of unexpected wrenches. The first was a series of observations of distant galaxies that seemed open to the interpretation that the expansion was lopsided rather than isotropic as everyone had always assumed (SN: 8/18-25/73, p. 115). The second, and perhaps even more shocking, was a determination that seemed to show that the expansion was actually accelerating (SN: 5/3/75, p. 285). At the Eighth Texas Symposium on Relativistic Astroyphysics, held in Boston in December, an astronomer associated with each of those operations reported conclusions that take less radical options in interpreting the evidence.

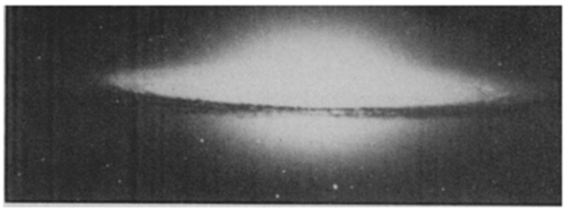
Beatrice Tinsley of Yale University spoke on the question of accelerating universal expansion. In the observations involved with this sort of question, astronomers study the redshifts of the light from distant galaxies. It is generally accepted that the redshifts arise from relative velocities of recession from the observer (that is, us). (The fact that all the other galaxies we see appear to be receding from us is one of the main reasons to believe in an expanding universe.) To check whether the rate of expansion has changed over the eons or not, astronomers look at the most distant and therefore most ancient galaxies. In doing this they are looking back in time to see how things were moving eons ago, and this is then compared to evidence from nearby galaxies, which tell how things have been moving in recent times.

When this was first done by the group with whom Tinsley was involved it appeared that the deceleration factor was very nearly zero. Then an evolutionary correction added to the data made the factor negative, indicating that an acceleration had been going on.

To compare the redshift data, one needs independent estimates of the distance of the galaxies, and for this the brightness of the galaxies is used. The observers pick a class of galaxies that they can plausibly argue have the same or virtually the same intrinsic brightness. Then their apparent brightness will give a measure of their distance. However, because looking at distant galaxies is looking into the past, one must correct for galactic evolution over time. It was generally assumed that galaxies grow fainter as they age because the stars in them evolve from bright young things to dimmer older bodies. So when a plausible correction for stellar evolution was made in the figures, it appeared that acceleration was going on.

To account for a universal acceleration meant bringing back into the cosmological equations a term originally put in by Einstein, the so-called cosmological constant. When Einstein considered the cosmological effects of his general relativity, the discovery of the evidence for universal expansion lay some years in the future. Einstein, like other scientists at that time, believed in a static universe. Because gravity acts to pull the universe together, Einstein had to add a term to the equations to hold the universe static. This cosmological constant, as it is called, could represent some repulsive force acting over cosmological distances or some other constraint that counteracted gravity. When Hubble's work showed that the universe is not static, Einstein gleefully threw out the cosmological constant. He had never liked it because it spoiled the aesthetics of the equations. Now, after a time when it seemed the cosmological constant would have to be resurrected, it can safely be buried again.

The reason is new evidence about the evolution of galaxies. It appears now that the brightest galaxy in a cluster of galaxies (and these were the ones used in the survey) can swallow up nearby galaxies from time to time. This tends to increase the brightness of the swallowing galaxy, counteracting the dimming effect of stellar evolution. When allowance is made for this, the acceleration disappears, and we are back to a decelerating universe, which, in Tinsley's opinion, is probably decelerating too slowly ever to reverse motion and collapse.



Vera C. Rubin of the Carnegie Institution of Washington is a member of a group that surveyed a sample of galaxies to discover if there was any difference in the redshift-recession-speed-distance relation in different parts of the sky. They found in fact that there was such a difference between galaxies in two halves of the sky. Such a difference is open to the interpretation that the expansion of the universe is lopsided, which would give cosmologists a new and difficult effect to explain. (An expansion that is the same in all directions is easiest and simplest to explain mathematically and physically.)

Rubin now says that further investigation has led her and her co-workers to adopt an alternate explanation, namely our galaxy and the group of galaxies it belongs to are moving at a rate of 500 kilometers per second toward a point in the direction (as seen from earth) of the constellation Virgo. This is a motion in addition to the general expansion of the universe.

The adoption of this conclusion comes from studying the differences between the redshift-distance relation for nearby and distant galaxies in both halves of the sky. If the basic difference is due to lopsided expansion of the universe, it will affect the apparent recession velocities of near and distant galaxies in equal proportion. If the difference comes from an extra motion of our galaxy, it will affect the apparent recession velocities of nearer galaxies more than farther ones, because we will be catching up to the nearer ones faster. That is indeed what Rubin and her co-workers find in their latest data, so they opt for a peculiar motion of our galaxy. She admits that the figures determined do not agree with those derived from the other way of determining a motion of our galaxy, looking for it against the microwave background radiation that pervades the universe, but she argues that there are ways to solve that disagreement.

Another disagreement comes from Jean-Pierre Vigier of the Paris-Meudon Observatory in France, who has interpreted the anisotropy in redshift-distance relations as a kind of tired-light effect. He argues, and he can show sky maps to support his claim, that the light from the galaxies that seem systematically redder than they should be comes through a part of the universe more densely packed with matter than the light from the other group of galaxies. Vigier argues that the light passing through the denser matter somehow loses energy in the stronger gravitational field of the denser matter—this would be an entirely new physical effect—and thereby becomes redder. Vigier insists on his interpretation in spite of Rubin's new evidence and interpretation. Equally, she refuses to accept his.

In either case, a lopsided expansion is out of consideration, and that together with the disappearance of the apparent acceleration factor puts us back in the more smoothly moving universe we used to think we had. ☐