The Major Mysteries of Orthodox Cosmology

Cosmology is the study of the entire universe as a physical system. Those who study cosmology are cosmologists. Today's cosmologists (2009) address three major problems: (1) Why is the universe expanding at an accelerating rate? (2) What is dark matter? And (3) What is dark energy?

The short answers are:

(1) The universe is not expanding at an accelerated rate. (2) "Dark matter" is the difference between gravitational mass and baryonic mass. And (3) Dark energy is the difference between the energy of baryonic mass and that of gravitational mass. Clearly, these cryptic answers require some elaboration. Let us consider them in order.

Accelerated Expansion?

The accelerated expansion of the universe is an inference drawn from the fact that the most distant galaxies "are fainter than they should be". First of all, how does one know how faint they should be? Actually, it is not the galaxies themselves which are unaccountably faint but certain objects within distant galaxies which are unaccountably faint. These objects are supernovae of type Ia. They are stars (white dwarfs) which have evolved by a well-understood aging process to a limiting mass (1.41 solar masses, the Chandrasekhar limit) beyond which they can no longer be white dwarfs. They have been growing by accretion of matter shed by their companion in a double star system. If they no longer can be a white dwarf, what can they be?

Answer: **a supernova of type Ia, a star which explodes violently in a process of self-annihilation**, creating for a few days or weeks the most luminous single kind of object in the universe. Since the conditions which lead to this kind of supernova are always identical, their maximum luminosities and behavior are nearly identical. Their apparent faintnesses therefore imply their distances.

But there is another distance indicator. It is the Doppler shift in the supernova's spectrum, the same kind of Doppler shift used by television weathermen to detect the approach or departure of storms. In the 1920's and 30's, American astronomer Edwin Hubble discovered that **the Doppler shift in the spectra of galaxies, always to longer wavelengths (a red shift), was proportional to a galaxy's distance**. For the most distant galaxies, this distance is less than the faintness distance. Which should be adopted and why? What is the explanation of the discrepancy?

Orthodox cosmologists have adopted the greater faintness distance, implying that the most distant galaxies have receded faster than the nearer ones. This means that the expansion of the universe is accelerating. Or is it? **Could the faintness of distant type Ia supernovae have an entirely different explanation?** It could.

Attenuation

A galaxy receding at a speed which is a substantial fraction of the speed of light (186,000 miles per second), is subject to an effect called **attenuation**. Light from the galaxy in one second or from a supernova within the galaxy in one second is strung out over more than 186,000 miles simply because the galaxy is rapidly receding. Therefore only the first 186,000 miles of such a light beam will be received at the earth in one second; the remainder will follow in the next second. Consequently, the source (the galaxy as a whole or the supernova within the galaxy) will fail to be credited with the same brightness as if it had not been receding rapidly. This effect is called attenuation. Though attenuation occurs in any receding source, it is undetectably small except in those sources receding at a substantial fraction of the speed of light, such as a distant galaxy. In short, it is not greater distance but attenuation which is the cause of the additional faintness of remote supernovae of type Ia.

Dark Matter

Let us consider next what dark matter may be. First, what is the evidence for its existence? In the 1970's, astronomer Vera Rubin of the Department of Terrestrial Magnetism measured the velocities of stars on the outskirts of the Milky Way and other galaxies. These velocities were far greater than the velocity at which they would have escaped if they had been held to their respective galaxies only by the visible matter (baryonic matter). The implied excess matter, six times the baryonic matter but not in otherwise detectable form, was termed "dark matter". The excess energy attributed to dark matter was termed "dark energy". If dark matter could be identified, dark energy would also be.

Somewhat surprisingly, **a clue is provided by the planet Mercury**. This little planet, the nearest to the sun, is governed in its motion by the sun, of course, but it follows an orbit which is perturbed by such things as the attractions of the other planets, the material of the sun's equatorial bulge, etc. Together, these perturbations advance the position of Mercury's perihelion (point nearest the sun) by 531 seconds of arc per century. This is 43 seconds of arc (a very small amount) less than the actual observed advance. Einstein's theory of general relativity was the first to account for this discrepancy. This success earned Einstein and his theory immediate acclaim and established his theory of general relativity as the ultimate expression of a theory of gravitation.

How did Einstein's theory differ from Newton's? It said that Mercury and the other planets followed orbits which were paths of minimum length in a spacetime which was possessed of a curvature induced by the mass of the sun. **Such an explanation does not readily convey a sense of causation**. How is a mathematical (geometrical) characteristic induced by the presence of the sun? General relativists shun such questions.

A better answer is suggested by the very equation for the relativistic effect. The effect is shown to be proportional to the arithmetic mean of the gravitational potential energies at perihelion and at aphelion divided by c^2. Here is evidence that **Mercury's mass varies** a trifle between its maximum and minimum distances from the sun. **A planet whose mass changes according to its position in its orbit could not be expected to follow quite the same orbit as one whose mass remained constant. Special relativity provides a physical cause for a physical effect.** It is an historic irony that the first success of Einstein's general theory of gravitation was due to the relativistic mass-energy equivalence of which he made no use.

Dark Matter and Dark Energy

N**ot only is the mass of Mercury increased very slightly by the attraction of** the sun, but **the mass of the sun is increased by the gravitational attraction of Mercury**. Suppose now that Mercury were replaced by a star similar to the sun. Its effect on the sun would be the same as the sun's effect on it, namely a small increase in mass due to the gravitational energy generated by their mutual gravitational attraction. This would still be a very small amount, but far more than the amount generated by Mercury. Now suppose that there were two stars, ten stars, a hundred stars, a million stars,...etc. The sun's increase in mass would be proportionately greater. How much greater? The amount needed to account for the velocities of stars on the outskirts of our and other galaxies is a factor of very nearly six. This "additional" mass, generated by gravity and due to the mass-energy relation, is invisible "dark matter". The additional kinetic energy of the "dark matter" is the "dark energy".

Of course, the stars are generally much farther from each other than the sun is from Mercury, hence of lesser effect, but in a galaxy or a globular cluster **their enormous numbers more than compensate for their greater separations**. This is why only galaxies of billions of stars or globular clusters of millions of stars exhibit "dark matter".