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Making Science that Really Explain Things

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Editorial

Current scientific discourse if full of mysterious and obscure concepts such as: dark energy, dark matter and inflaton fields. To be sure each term was invented for a good reason such as explaining galactic acceleration, the galaxy rotation curve or the homogeneity of the cosmic microwave background. Dark energy is the most accepted hypothesis to explain the observations indicating that the universe is expanding at an accelerating rate. The accelerated expansion was discovered in 1998, by two independent projects, the Supernova Cosmology Project and the High-Z Supernova Search Team, which both used distant type Ia supernovae as standard candles to measure the acceleration. The discovery was unexpected, cosmologists at the time expecting that the expansion would be decelerating due to the gravitational attraction of the matter in the universe. Three members of these two groups have subsequently been awarded Nobel Prizes for their discovery. Confirmatory evidence has been found in baryon acoustic oscillations and in analyses of the clustering of galaxies. Assuming that the standard model of cosmology is correct, the best current measurements indicate that the conjectured dark energy contributes 68.3% of the total energy in the present-day observable universe.

The mass-energy of the conjectured dark matter and ordinary (baryonic) matter contribute 26.8% and 4.9%, respectively, and other components such as neutrinos and photons contribute a very small amount. The density of the assumed dark energy ($\sim 7 \times 10^{-30}$ g/cm^3) is very low, much less than the density of ordinary matter or dark matter within galaxies. However, it comes to dominate the mass–energy of the universe because it is uniform across space. Two proposed forms for the assumed dark energy are the cosmological constant, representing a constant energy density filling space homogeneously, and scalar fields such as quintessence or moduli, dynamic quantities whose energy density can vary in time and space. Dark matter is a hypothetical type of matter distinct from baryonic matter (ordinary matter such as protons and neutrons) and neutrinos. Dark matter has never been directly observed; however, its existence would explain a number of otherwise puzzling astronomical observations. One of the most significant evidence for the need for the hypothetical dark matter was given by Vera Rubin and Kent Ford in the 1960s-1970s using galaxy rotation curves.

Rubin found that most galaxies must contain about six times as much dark as visible mass; thus, by around 1980 the apparent need for the conjectured dark matter was widely recognized as a major unsolved problem in astronomy. The name dark matter refers to the fact that it does not emit or interact with electromagnetic radiation, such as light, and is thus invisible to the entire electromagnetic spectrum. Although the conjectured dark matter has not been directly observed, its existence and properties are inferred from its gravitational effects such as the motions of visible matter, gravitational lensing, its influence on the universe's large-scale structure, on galaxies, and its effects on the cosmic microwave background.

But do we really explain things by inventing a new physical entity (matter, field or an empirical constant) for every experiment and observation that we make? Obviously this will make the scientific endeavor trivial and in fact redundant. It was William of Ockham (1285-1347) who explained what scientists should be doing by stating the now famous Ockham's Razor: "Plurality is not to be posited without necessity". In other words don't multiply complex causes to explain things when a simple one will do. This principle was reformulated in more modern terms by Albert Einstein (1879-1955) as follows: "It can scarcely be denied that the supreme goal of all theory is to make the irreducible basic elements as simple and as few as possible without having to surrender the adequate representation of a single datum of experience." (On the Method of Theoretical Physics, the Herbert Spencer Lecture, Oxford, June 10, 1933).

But what real hope is there for theoretical physics without dark energy, dark matter and inflaton fields? Perhaps one should look at general relativity and study the instabilities of the Friedman-Lemaitre-Robertson-Walker metric to explain galactic acceleration, retardation effects in weak gravitational fields to explain the galaxy rotation curve and unstable Euclidean metric solutions to explain the homogeneity of the cosmic microwave background. This may seem less exotic and require more mathematical calculations than the more fashionable solutions but perhaps will provide explanations to the observations in terms of the indispensable concepts of general relativity instead of the current ad-hoc invented terms.