POST-SCRIPT

Among the more recent developments in physics, there are two I wish to mention, even if briefly.

Dark matter and dark energy[13]

In the 1970's, astronomers found that spiral galaxies like our own Milky Way were spinning at such a fast rate that, long ago, they should have "wobbled out of control, … shedding stars in every direction." Since these galaxies have not done so, theorists have to speculate that each galaxy is cocooned by a halo consisting of some hypothetical invisible matter, which they call "dark matter." This kind of matter does not consist of the protons and neutrons of "normal" matter. It does not interact at all with electricity or magnetism, which is why it cannot be seen.

Later, another major oddity of the cosmos was discovered. To determine the rate of expansion of the universe as a whole, cosmologists compare how bright supernovae appear and how much the cosmic expansion has shifted the frequency of their light. By 1997, data had been accumulated on more that 50 supernovae. The data indicated that the supernovae were dimmer than anticipated. In 1998, after studying the data, two teams of researchers announced that they had independently reached an unexpected conclusion: the rate of expansion of the universe was not slowing down; it seemed to be speeding up. Some force was counteracting the pull of gravity which has acted to rein in the expansion of the universe since the Big Bang. This anti-gravitational force has been named "dark energy." One scientist has called it "the most profound mystery in all of science." It might not be dark. It might not be energy. The whole name just stands for something scientists don't understand.

The current view is that the universe is 74% dark energy, 22% dark matter and 4% ordinary matter. One theorist has remarked: "If you got rid of us, and all the stars and all the galaxies and all the planets and all the aliens and everybody, then the universe would be largely the same. We're completely irrelevant."

String theory[14]

Contemporary physics rests on the two pillars of General Relativity and Quantum Mechanics. The former "provides a theoretical framework for

[13] Based on the article "Out There" by Richard Panek in the New York Times of 3/11/07

[14] Based on Brian Greene's book "The Elegant Universe"

understanding the universe on the largest of scales: stars, galaxies, clusters of galaxies, and beyond to the immense expanse of the universe itself. The other … provides a theoretical framework for understanding the universe on the smallest of scales: molecules, atoms and all the way down to subatomic particles like electrons and quarks.” [1] Thus, General Relativity is the tool to study what’s large and very massive, whereas Quantum Mechanics is the tool to study what’s very small and light.

There are situations, however, where extremes of minuscule size and enormous mass coexist. Inside a black hole, for instance, a huge mass is crushed to a tiny size. At the moment of the Big Bang, the universe had its entire enormous mass concentrated in an extremely small size. Such situations require that both quantum mechanics and general relativity be brought to bear simultaneously. Their combination, unfortunately, yields nonsensical answers because the two theories are not compatible with one another.

Without success, Einstein spent the last thirty years of his life in the pursuit of “a so called unified field theory – a theory capable of describing nature’s forces within a single all-encompassing, coherent framework.”[2] Einstein’s unrelenting quest, which at the time came to be seen as quaint, if not quixotic, has been embraced by a new generation of theorists. Many physicists believe now that they have found such a framework in a theory that, *in principle*, can describe all physical phenomena. It is called “string theory.” It unifies the laws that govern the small as well as the large. String theory, however, is not yet a theory that has been completely worked out, experimentally confirmed, or fully accepted by the scientific community.

Between 1984 and 1986, more than a thousand papers on string theory were written by physicists from around the world. These papers conclusively showed that numerous features of fundamental particles - which had been painstakingly discovered over decades of research - emerged naturally and simply from the structure of string theory. Still, according to some experts, it could be decades or even centuries before string theory is fully developed and understood.

What is the basic idea behind string theory? As we saw in Chapter 18, physics tells us that all ordinary objects are made up of atoms, each consisting of a number of electrons surrounding a nucleus. The latter contains protons and nucleons, both of which consist of “up” and “down” quarks. Electrons and quarks are all viewed as being like points: they have no dimension and no internal structure. String theory, instead, tells us that each subatomic particle is <u>not</u> like a point without any size: it consists of a single extremely tiny one-dimensional “loop”. Like an infinitely thin rubber band, each particle contains a vibrating filament called a *string*. The length of a typical string is about a hundred billion billion (10^{20}) times smaller than an atomic nucleus.

According to string theory, the observed properties of fundamental particles reflect the various ways in which a string can vibrate. Each pattern of vibration of a string appears as a particular particle whose mass and charge are determined by the oscillation pattern of the string. The electron, for instance, is a string vibrating one way, the up-quark is a string vibrating another way, and so on.

Before string theory, the differences among the fundamental particles were explained, essentially, by saying that each type of particle was "cut from a different cloth". In string theory, each elementary particle is composed of a single string and all strings are absolutely identical. Differences between particle types are due to the fact that their respective strings vibrate in different patterns.

The basic idea behind string theory, as presented, can be misleadingly simple. Actually, string theory is a highly complex mathematical theory. Theorists have gradually discovered that string theory is not a theory that involves only one-dimensional strings. It contains also two-dimensional vibrating "membranes" and other more complex structures.

String theory offers a theoretical framework that claims to explain every fundamental feature upon which the whole universe is built. Accordingly, it is sometimes described as being potentially a "theory of everything (T.O.E.), or an "ultimate" or "final" theory, that is, a theory that is the foundation for all other theories without itself needing a deeper explanation.

In a more limited definition, a T.O.E. is a theory that can explain the properties of all the fundamental particles and all the forces by which these particles interact with one another. This, however, is not seen at all as a limitation by a "reductionist," who claims that, in principle, every aspect of reality can be described in terms of underlying physical principles involving fundamental particles. Thus, if we understand everything about these particles and their behavior, in principle, we understand everything, whether we are considering inanimate objects, living organisms, mental processes or even consciousness. A basic feature of reductionism is that some truths are less fundamental than others to which they can be *reduced.* Chemistry can be reduced to physics; microbiology, to chemistry

Many people strongly object to the reductionist's claim that "the wonders of life and the universe are mere reflections of microscopic particles engaged in a pointless dance fully choreographed by the laws of physics." [3] To these critics, Steven Weinberg, Nobel Laureate in physics, responds: "The reductionist world view *is* chilling and impersonal. It has to be accepted as it is, not because we like it, but because that is the way the world works." [4]

I do not believe this world view is capable of accounting for the workings of our mind, our thoughts, feelings, creativity or spirituality. I have presented my reflections in two self-published books, “The Virtual Universe – Philosophy, Physics and the Nature of Things,” and “Virtualism, Mind and Reality – An approach to Untangle the Consciousness Problem” (both available at amazon.com). I hope we can meet again in these books.

Matthew Raspanti

SOURCES AND REFERENCES [15]

Reference
- Encyclopedia Britannica (15th edition, 1990)

Major Sources
Textbooks (in approximate order of increasing difficulty):
- Jae R. Ballif and William E. Dibble, “Conceptual Physics” (John Wiley and Sons, 1969)
- Robert H. March, “Physics for Poets” (McGraw Hill Book Company, 1970)
- Leon N. Cooper, “An Introduction to the Meaning and Structure of Physics” (Harper and Row Publishers, 1968)
- William A. Blampied, “Physics: Its Structure, and Evolution (Blaisdell Publishing Company, 1969)
- Richard Feynman, Robert B. Leighton and Matthew Sands, “The Feynman Lectures in Physics (25-year Commemorative Issue), ” (Addison-Wesley Publishing Company, 1989)

Books for a more general public:
- Brian Greene, “the elegant universe – superstrings, hidden dimensions, and the quest for the ultimate theory” (W.W. Norton & Company, 1999)
- John Gribbin, “In Search of Schrodinger’s Cat,” (Bantam Books, 1984
- Tony Hey and Patrick Walters, “The Quantum Universe,” (Cambridge - University Press, 1987)
-Lloyd Motz and Jefferson Hane Weaver, “The Story of Physics” (Plenum Press, 1989)
- Time-Life Books Editors, “The Cosmos (Voyage Through the Universe Series” (Time-Life Books, 1989)
- Time-Life Books Editors, “Stars (Voyage Through the Universe Series” (Time-Life Books, 1989)

[15] Other sources are mentioned in the Notes section.

INDEX

NOTES

CHAPTER 3 - Laws of Motion

[1] Time magazine, 12/28/92 pg 42

CHAPTER 6 - Particles in Motion

[1] Erwin Schrodinger, "What is Life" and "Mind and Matter" (Cambridge University Press, combined reprint, 1967) pg 7

CHAPTER 9 - Electromagnetism

[1] Richard Feynman, Robert B. Leighton and Matthew Sands, "The Feynman Lectures on Physics", published in 1964 (Addison-Wesley Publishing Company, 1964, reprinted in 1989) Vol.II pg 1-1

[2] Feynman Vol.II pg 1-1

CHAPTER 12 - Special Relativity

[1] Feynman Vol.I pg 15-6

[2] Motz pg 248

CHAPTER 17 - Quantum Interpretations

[1] Richard Feynman, "The Character of Physical Law" (MIT Press 1967) pg 129

[2] Nick Herbert, "Quantum Reality" (Anchor Press, Doubleday, 1985) pg 45

[3] John Gribbin, "In Search of Schrodinger's Cat" (Bantam Books, 1984) pg 229

[4] Feynman Vol.III pg 1-1

[5] John Gribbin, "Schrodinger's Kittens and the Search for Reality" (Little, Brown & Co., 1995), pg 140

[6] Gribbin95, pg 142

[7] Gribbin95, pg 162

CHAPTER 19 - A Cosmic Perspective

[1] The section "The First 100,000 Years" is based mainly on "Voyage Through the Universe -The Cosmos" (Time-Life Books, 1989) pg 119-131

[2] "Voyage Through the Universe - Galaxies" (Time-Life Books, 1989) pg 61

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[1] Brian Greene, “The elegant universe” (W.W. Norton & Company 1999) pg 3

[2] Greene pg ix

[3] Greene pg 16

[4] Greene pg 17