PART II

CHAPTER 29

Cosmic DM Mystery #1
Spiral Disk Galaxies Have Spherical Dark Matter Halos

Relativistic Proton Dark Matter Particles Could Form Spherical DM Halos Around Spiral Galaxies And DM Halos Around Galaxy Clusters

See SigChar C, D, E, G, L, N, and Chapter 44.

The author believes that the dark matter halos around spiral galaxies have roughly defined outer diameters and “hollow” core diameters determined by the galactic and extragalactic magnetic field magnitudes and the energy spectrum of the relativistic protons. The kinetic energies of the protons orbiting spiral galaxy *clusters* are probably about 30 times higher than those orbiting spiral *galaxies*, as determined by the Larmor Radius equation, the cosmic ray proton energy distribution at the Earth, the magnetic field strength, and the size of a galaxy cluster compared to the size of a spiral galaxy disk. (See Chapter 50.)

Also, the author believes that the outer diameter and core diameter size of dark matter halos are not significantly affected by the amount of galaxy mass enclosed, since electromagnetic forces are tens of orders of magnitude greater than gravitational tidal forces.

Astronomical data indicate that dark matter forms enormous spherical halos around spiral galaxies, which extend outward from the galaxy to 10 to 20 times the radius of the galaxy disk. The morphology of the spherical DM halos could be affected by the protons' coulomb forces.

The author believes that dark matter halos around spiral galaxies and around their galaxy clusters are created by a phenomenon the author calls *astrophysical emergence*, also referred to as *emergent evolution*. The footnote paragraph near the end of Chapter 28 briefly describes this phenomenon, and Chapter 44 is entirely devoted to *astrophysical emergence*. The author is not aware of any literature references that apply the principle of *emergence* to the formation of galaxies or dark matter halos.

CHAPTER 31

Cosmic DM Mystery #3

Hydrogen Derived From DM Cosmic Ray Protons

Relativistic Proton Dark Matter Particles Could Be Transformed Into Low-Velocity Hydrogen, Protons, Or Proton Cosmic Rays

See SigChar O, W, and X.

Low-velocity hydrogen and protons and relativistic cosmic ray protons are all prevalent in galaxies. The most logical source of all three of these types of this ordinary matter would be relativistic dark matter protons that had lost kinetic energy through synchrotron radiation and/or collisions with dust, photons, helium, or hydrogen.

When relativistic protons in a dark matter halo give up some kinetic energy through synchrotron radiation or through collisions with dust, photons, or molecules or atoms of hydrogen or helium, they decelerate into slower moving relativistic protons. When the kinetic energies of some of the relativistic protons in the Milky Way's dark matter halo are reduced much below $3x10^{15}$ eV, their synchrotron radiation losses accelerate and their kinetic energy, relativistic mass, and radius of curvature of their spiral orbits decline. The reduced-kinetic-energy relativistic dark matter protons then depart the dark matter halo and move into the enclosed galaxy and eventually plunge into star systems as hydrogen or as cosmic ray protons.[12]

Let us see how hydrogen could be created. Relativistic dark matter protons and helium nuclei colliding with compressed interstellar clouds of hydrogen and helium atoms should generate muons. It is estimated that each 10^{15} eV cosmic ray proton striking the Earth's atmosphere produces perhaps hundreds to one thousand muons. They actually produce pions that rapidly decay into muons that, in turn, decay less rapidly into electrons in a number of microseconds. The electrons are thus produced in large numbers per relativistic proton and, therefore, should be available in quantity to combine with the decelerating protons to form hydrogen.

CHAPTER 34

Cosmic DM Mystery #6

Mature Galaxies Discovered In The Very Early Universe

Relativistic Proton Dark Matter Particles Could Create Large, Mature, Spiral Galaxies Less Than 2.5 Billion Years After The Big Bang

See SigChar Q.

Relativistic protons could create large, mature, spiral galaxies less than 2.5 billion years following the Big Bang if galaxy clusters are created via the top-down theory of crashing, intersecting, dark matter filaments followed by galaxy formation from the dark matter remnants, as indicated in the previous chapter. Then, galaxies would form and grow through the accretion of hydrogen and protons from the relativistic proton dark matter remnants, onto proto-galaxies.

The recent discovery of the existence of mature galaxies only about 2.5 billion years after the Big Bang[20,21,22] (and confirmed by the Carnegie Observatories on March 10, 2005)[35,36] can be explained using the relativistic proton dark matter theory/cosmology. This top-down theory of galaxy formation involves relativistic protons that create and combine with electrons to form the galactic hydrogen, but it raises questions about the cold dark matter bottom-up theory of galaxy formation, which involves only very slow-moving, weakly interacting, non-baryonic particles.

The above references *20* and *21* are articles in the July 2004 issue of Nature, entitled, "A high abundance of massive galaxies 3 - 6 billion years after the Big Bang" and "Old galaxies in the young Universe." The Carnegie Observatories had announced in a news release on March 10, 2005[35,36] that:

> Astronomers have found distant red galaxies -- very massive and old -- in the universe when it was only 2.5 billion years post Big Bang.

This news would imply that these old red galaxies were formed very much earlier as new blue galaxies.

Also supporting the relativistic proton dark matter theory is the discovery, reported in Chapter 51, of 800 young galaxies located 12.5 billion light years away, that were born about 1.2 billion years after the Big Bang.

CHAPTER 36

Cosmic DM Mystery #8
Source of Spiral Galaxies'/Halos' Angular Momentum

Relativistic Proton Dark Matter Particles Could Provide Angular Momentum To Spiral Galaxies And Their DM Halos

See SigChar C and R.

Galaxy-orbiting relativistic protons creating magnetic fields via the astrophysical dynamo effect eventually will achieve a steady-state, dynamical configuration with significant angular momentum, which can be transferred to a spiral galaxy and its dark matter halo under the Law of Conservation of Angular Momentum. Spiral galaxies embedded within or overlapping the "hollow" cores of dark matter halos (essentially orbiting proton streams) represent one such steady-state configuration with a high angular momentum.

The cold dark matter theory does not offer any explanation as to the role or roles of slow-moving, non-baryonic, weakly interacting WIMPs in providing angular momentum to either the spiral galaxies or their dark matter halos. This could imply a lack of a link or coupling between WIMPs and DM halos.

CHAPTER 48

Cosmic DM Mystery #19
Blue Stars In Spiral Arms Vs. Red Stars In Galaxy Nucleus

The Spiral Arms Of Spiral Galaxies Contain Many Hot Blue And Blue-White Stars Less Than One Million Years Old, And In The Galaxy Nucleus There Are Red Stars About Five Billion Years Old

See SigChar A, C, D, G, J, T, W, X, and Chapters 31 and 38.

The author designates the above-stated phenomenon as the 19th Cosmic DM Mystery of the Universe, which raises the rhetorical question: What type of dark matter particle could cause, expedite, facilitate, or explain the creation of the one-million year-old blue and blue-white stars in the spiral arms at the outer diameter of a spiral galaxy, which also has five-billion-year-old red stars located near the galaxy nucleus?

A study of face-on photographs of spiral galaxies clearly shows the many blue and blue-white young stars in the spiral arms at the outer periphery of spiral galaxies. A photograph of the Andromeda galaxy, M31, can be found on the cover of this book. Photographs directed toward the nuclei of spiral galaxies at red wavelengths show old red stars that are estimated to be five billion years old (for Galaxy M81).

These star colors and their locations are widely known. Although there may be generally accepted explanations for the location of the newborn blue and blue-white stars in the spiral arms at the outer periphery of spiral galaxies, the author has not been able to find any published explanation for this preferred star-birth location. This specific star-birth location is not explained by the mainstream theory of star formation where clouds of hydrogen collapse, anywhere in a galaxy, under their own weight and are heated, through compression, to hydrogen fusion temperatures. The mainstream star formation theory provides no clues why spiral galaxies should form their new stars in the spiral arms.

Why are the blue and blue-white stars being formed at the outer diameter of the spiral galaxy disks M81and M31 rather than elsewhere? Could the spherical dark matter halos surrounding spiral galaxies such as M81 and M31, the Andromeda galaxy, play a role in igniting new stars in them?

Let us briefly review the steps in achieving new star formation in an isolated spiral galaxy according to the relativistic proton dark matter star formation theory. This review also explains why the stars forming in an isolated spiral galaxy, surrounded by a relativistic proton dark matter halo, would be located near the outer diameter of the galaxy disk, where the spiral arms are located:

1. An isolated spiral galaxy is surrounded by a spherical dark matter halo comprised of galaxy-orbiting relativistic protons following almost-circular spiral paths determined by the proton kinetic energies, the local orthogonal magnetic field, and the Larmor Radius equation.

2. Since a spiral galaxy is normally producing stars, its disk must be overlapping the "hollow" core diameter of the dark matter halo. (Spherical dark matter halos surrounding spiral galaxies have "hollow" cores, as explained at the end of Chapter 38.) Relativistic protons near the "hollow" core would lose kinetic energy over time from synchrotron radiation losses and eventually would plunge into the enclosed spiral galaxy and bombard the atomic and molecular hydrogen gas closest to the galaxy surface.

3. The bombarding of the hydrogen gas primarily near the surface by the relativistic protons will produce a number of significant effects. By ionizing some (50% would be optimum) of the atomic hydrogen, the conversion of

> atomic hydrogen to molecular hydrogen would be accelerated. The protons bombarding the resulting molecular hydrogen would create large numbers of muons, which would catalyze hydrogen fusion reactions. The bombarding protons (and accompanying high-speed helium nuclei) also would trigger nuclear fusion reactions and the ignition of new stars by colliding with the muonic ions created earlier by reactions of muons with the hydrogen and helium.

This scenario provides a plausible explanation for the birth of blue and blue-white stars in the spiral arms near the surfaces of spiral galaxies, as defined by Cosmic DM Mystery #19.

The dark matter relativistic protons also may be performing another role. On one hand, the muons they create can catalyze the hydrogen fusion reaction, thereby igniting new blue and blue-white stars. In addition, the protons add hydrogen to the enclosed galaxy, which can facilitate future star formation and to cause the galaxy to grow by accretion.

The idea of galaxy growth through accretion of baryons provided by the galaxy's dark matter halo is a relatively new idea and, therefore, requires some support from astronomical data. One example that provides such support is the

Andromeda galaxy, M31, whose disk seems to have enlarged by accretion by a factor of three over billions of years. See astro-ph/0504164 entitled, "On the accretion origin of a vast extended stellar disk around the Andromeda galaxy."[41]

There is a related point that should be considered. Five billion years ago, the red stars near Andromeda's nucleus might have been blue stars at the outer diameter of a then-much-smaller galaxy. Did the galaxy disk grow in diameter by accretion since then?

A study of 2,800 stars outside Andromeda's disk by the authors of astro-ph/0504164, led to the discovery that these stars were not in the halo of the disk, but actually in an extension of the galaxy disk. From a study of the velocities and directions of the stars in the extended disk, researchers have ruled out the possibility of an earlier merger with another galaxy to explain the tripling of the disk diameter. This would leave hydrogen accretion as the primary source of growth, by a factor of three, in the diameter of the Andromeda disk. The author believes that Andromeda's dark matter halo could have provided the necessary hydrogen or protons for galaxy disk growth as posited by the relativistic proton dark matter theory/cosmology; however, astro-ph/0504164 does not suggest that.

Additional astronomical support for new star formation taking place primarily at the outer periphery of spiral galaxies is found in the empirical Schmidt law that posits that the SFR of isolated spiral galaxies is highly correlated with their average *molecular hydrogen surface density.*

See Chapter 53, which links the Schmidt law to the relativistic proton dark matter theory/cosmology and thereby provides (1) a plausible explanation for the Schmidt law, (2) support for the relativistic proton dark matter theory and cosmology, and (3) support for Cosmic DM Mystery #19, the formation of new stars in the spiral arms near the surfaces of spiral galaxies.

The star formation phenomena defined by Cosmic DM Mystery #19 cannot be explained by the generally accepted mainstream theory of star formation where clouds of hydrogen molecules collapse anywhere in a galaxy under their own weight and are heated through compression to hydrogen fusion temperatures.

CHAPTER 51

Cosmic DM Mystery #22

800 Galaxies Detected, Less Than 1.2 Billion Years Old

Report Of Over 1,000 Clumps Of Dark Matter, With Most Harboring Several Newborn Galaxies, 12 Billion Light-Years Away. On December 21, 2005, Japanese Astronomers Reported That Clumps Of Dark Matter Are The Nursing Grounds For 5, 000 Newborn Galaxies About 12 Billion Light-Years Away. A Single Nest Of Dark Matter Can Nurture Several Young Galaxies. About 800 Of The Galaxies Are 12.5 Billion Light-Years Away And, Therefore, Were Born Less Than 1.2 Billion Years After The Big Bang.

See SigChar O, P, Q, and W.

The above-indicated astronomical data and the December 21, 2005 research report entitled, "Young Galaxies Grow Up Together in a Nest of Dark Matter"[44] represent the work of researchers at the Space Telescope Institute, the National Astronomical Observatory of Japan, and the University of Tokyo.

The author of this book chooses the above-reported multiple-galaxy nurseries to be the 22nd Cosmic DM Mystery of the Universe, which raises the question: What type of dark matter particles could form enormous clumps of dark matter in the early Universe only 1.2 billion years after the Big Bang, could nurture several young galaxies simultaneously, and could also play a role in their initial galaxy formation? The galaxy-orbiting relativistic proton dark matter seems to have several necessary characteristics to satisfy the requirements of Cosmic DM Mystery #22.

First of all, owing to their velocities, relativistic proton dark matter particles could have formed a very large number of widely distributed, enormous clumps of dark matter within 1.2 billion years after the Big Bang. That is, their relativistic velocities enable them to quickly distribute the dark matter over a very wide area. More specifically, with the filamentary dark matter structure moving at, say, 90% of the speed of light along, say, a circular path, the protons could have encompassed a circular area of dark matter clumps with a diameter of roughly about 300 million light-years, by the end of the 1.2-billion-year evolutionary period.

Secondly, relativistic proton dark matter can form several new galaxies within each of the widely distributed, very large clumps of dark matter by means of the top-down galaxy formation process, which is an integral part of relativistic proton dark matter theory/cosmology. This takes place in several steps. Protons that are slowed through synchrotron radiation and collisions, combine with electrons to form hydrogen, the basic ingredient of galaxies. (These electrons were created when the relativistic protons collided with hydrogen and helium atoms and molecules, with dust and with photons to create pions initially, which rapidly decayed into muons that then decayed into electrons.)

This formation of hydrogen from decelerated protons and electrons is a key step in the formation of the new galaxies within the dark matter clumps. By this means, the dark matter clumps can accrete hydrogen onto the enclosed proto-galaxies, causing them to grow. The fact that several newborn galaxies are located in a single clump of dark matter provides an image of a top-down galaxy formation process, where the dark matter clump forms first and the galaxies form afterward within it and grow by the accretion of protons and hydrogen, derived from dark matter protons converted to hydrogen.

Finally, relativistic proton dark matter can form stars in the newborn galaxies by bombarding the hydrogen and helium atoms and molecules with high-velocity protons to generate muons, which then form muonic atoms, molecules, and ions. In turn, these muons, muonic ions, molecules, and atoms can catalyze hydrogen fusion reactions and can trigger the birth of new stars by the subsequent proton/helium nuclei bombardment. See Chapter 26, SigChar W, which discusses the first-generation star formation process.

Based upon the above, relativistic dark matter protons appear to meet the requirements defined by Cosmic DM Mystery #22. They have the relativistic velocities to cause the rapid distribution of dark matter over regions hundreds of millions of light-years in size; they can create atomic hydrogen for use in forming galaxies; they can facilitate hydrogen molecule formation through ionization of some of the atoms; and they also can form and ignite stars by creating muons, then muonic ions, and then subjecting the muonic ions to high-velocity proton/helium nuclei bombardment. Meeting these requirements is an indication that *dark matter relationism* is applicable to Cosmic DM Mystery #22.