CHAPTER 23

SigChar T

Explanations For LSB Dwarf Galaxies' Low Star Formation Rates (SFRs) And For Massive Galaxies' Very High SFRs

If the diameter of an LSB dwarf galaxy disk is smaller than the "hollow" core of its dark matter halo, the number of dark matter halo protons entering the galaxy to ignite or feed stars would be low or very low. This would occur because the dark matter protons near the DM halo's core, being farther away from the galaxy disk, would not be subjected to the full magnitude of the galaxy's much higher magnetic field strength. Therefore, the dark matter halo protons would not experience large synchrotron radiation losses and their flow into the enclosed LSB dwarf galaxy disk would be minimal. See Chapter 15 (SigChar L) and references *4* and *17*.

The author believes that LSB dwarf galaxies and starless dark galaxies probably have this smaller-galaxy-disk/larger-halo-core relationship.

The author also believes that an LSB dwarf galaxy or starless galaxy could evolve into a star-creating galaxy as the galaxy disk grows in size, over time, through hydrogen accretion until the disk becomes equal to or larger than the "hollow" core of its DM halo. This hydrogen would have been formed by slowed protons linking to electrons created by decaying muons, formed microseconds earlier by proton collisions with dust, photons, and/or hydrogen molecules.

The author further believes that the Milky Way is of this overlapping disk-halo type because it is generally believed that the dark matter mass penetrating into the Milky Way is of the same order of magnitude as the ordinary matter mass of the Milky Way, and that our galaxy is a confirmed star-forming galaxy with a medium level SFR. See Chapter 7, SigChar D.

An unusually large, massive galaxy could significantly overlap the dark matter halo's "hollow" core, leading to a very high SFR. Such a massive galaxy's disk would be reaching deep into the dark matter halo, thereby interacting with higher energy relativistic DM protons and thus creating a very active high star formation region. However, if this

SFR is too high, the replenishment hydrogen being supplied by the dark matter halo and the galaxy could be insufficient to maintain the SFR, which could fall rapidly to lower levels after a period of time. For the Milky Way and LSB dwarf galaxies, the replenishment hydrogen could be adequate to maintain their SFRs for much longer periods of time than for large, massive galaxies.

One well-known LSB dwarf galaxy is DDO154, also known as NGC 4789A and UGC8024, which contains a very large amount of atomic hydrogen gas and has a very large ratio of dark matter to ordinary matter but, for some reasons, has a very low star formation rate. Another LSB dwarf galaxy of this type with a huge disk of rotating atomic hydrogen gas, UGC 5288, was studied with a radio telescope by Liese van Zee of Indiana University using the NSF VLA telescope and reported on in a press release dated January 10, 2005, entitled, "Dwarf Galaxy Gives Giant Surprise."

Another possible reason these two dwarf galaxies have low SFRs is that they may have a shortage of molecular hydrogen, even though they have adequate amounts of atomic hydrogen. The empirical Schmidt law illustrates the importance of molecular hydrogen over atomic hydrogen in SFRs, as described in Chapter 53. In LSB dwarf galaxies with small disks, fewer and lower-energy relativistic DM protons would be bombarding the hydrogen atoms, thereby lowering the hydrogen ionization rate and the hydrogen molecule forming rate in these galaxies. On the other hand, in spiral galaxies the atomic hydrogen may be converted much faster into molecular hydrogen through the ionization of as much as 50% of the atomic hydrogen by the bombardment with high energy relativistic dark matter protons.

As will be explained in subsequent chapters, collisions of the relativistic protons with large collision cross section molecules will generate large numbers of muons, which can form muonic ions with molecules of hydrogen and helium that can catalyze hydrogen fusion reactions and thus create stars.

On February 18, 2005, Astronomy magazine published an article by Ken Croswell entitled, “The first dark galaxy?” in which astronomers from Britain (Cardiff University in Wales), Australia, France, and Italy stated:

> A [rotating] cloud of gas in the Virgo cluster may be the first dark galaxy ever found. … The mysterious object has one-tenth the Milky Way's mass but consists of hydrogen gas and dark matter -- with no detectable stars.

Yet, its mass-to-blue-light ratio is at least 10 times that of the Milky Way. The researchers' astro-ph/0502312 paper is entitled, "A Dark Hydrogen Cloud in the Virgo Cluster."[23]

On December 1, 2004, the University of Virginia announced the discovery of a galaxy, named I Zwicky 18, that existed as a galaxy in an embryonic state as a cold gas cloud of hydrogen for billions of years and "went through a sudden first starburst only about 500 million years ago." The news release is entitled, "Hubble Uncovers a Baby Galaxy in a Grown-Up Universe." The researchers' astro-ph/0408391 paper is entitled, "Deep Hubble Space Telescope/ACS Observations of I Zw 18: a Young Galaxy in Formation."[24]

It is possible that the disk of this galaxy was smaller in diameter than the "hollow" core of its DM halo for billions of years until they finally overlapped after the galaxy disk grew in size through accretion of hydrogen and helium derived from its DM halo during those billions of years.

CHAPTER 26

SigChar W

How The First-Generation Stars May Have Been Ignited Without Dust Or Molecular Hydrogen

The European Southern Observatory (ESO) published an article about starburst galaxies on November 18, 2004, entitled, "Stellar Clusters Forming in the Blue Dwarf Galaxy NGC 5253." The researchers' astro-ph/0411486 paper is entitled, "The Star Cluster population of NGC 5253."[26] The following two excerpts from the ESO article provide some insight into the level of challenge presented to someone seeking an explanation for primordial star formation:

> Star formation begins with the collapse of the densest parts of interstellar clouds, regions that are characterized by comparatively high concentration of molecular gas and dust like the Orion complex and the Galactic Centre region. Since this gas and dust are products of earlier star formation, there must have been an early epoch when they did not yet exist.

The next paragraph continues:

> But how did the first stars then form? Indeed to describe and explain 'primordial star formation' without molecular gas and dust is a major challenge in modern astrophysics.

There are several possible explanations for primordial star formation (formation and ignition of the first stars) utilizing only atomic hydrogen and the relativistic proton dark matter theory/cosmology. Let us begin with the simplest.

Molecular hydrogen is needed for star formation. It is known that a mixture of 50% hydrogen ions and 50% neutral hydrogen atoms will form molecular hydrogen much faster than would neutral hydrogen atoms alone. Therefore, the bombardment/ionization of a galaxy's atomic hydrogen gas by the relativistic protons from the dark matter halo should facilitate the formation of hydrogen molecules on the surface of the enclosed galaxy, provided that no more than, say, 70% of the atomic hydrogen is ionized. The ideal ratio probably would be 50% hydrogen ions and 50% atoms to maximize the number of hydrogen ion-atom pairs to merge into molecules.

Another possible explanation for primordial star ignition utilizing only atomic hydrogen and the relativistic proton dark matter theory/cosmology involves four steps:

1. The relativistic dark matter protons and associated helium nuclei colliding with compressed interstellar clouds of hydrogen and helium atoms would generate muons that could create muonic atoms of hydrogen and of helium.

2. The muon orbits around the protons and helium nuclei are very small because the muons weigh 207 times as much as electrons. Therefore, the positive coulomb charges of the nuclei are well shielded by the closely orbiting negative muons, making the muonic atoms have a very low effective coulomb charge and thereby enabling them to collide with one another.

3. The colliding muonic atoms of hydrogen and helium could form muonic molecular ions with either two protons or one proton and one helium nucleus. These two types of ions are being orbited by only one muon since the net coulomb charge is so low that a second muon would not attach. By this means, muonic molecular ions are formed.

4. Subsequent bombardment of the muonic molecular ions by relativistic dark matter protons with energies of about 10^{15} eV and by high-velocity helium nuclei should be capable of triggering hydrogen fusion reactions and the ignition of new stars from the muonic molecular ions.

The author's star ignition and hydrogen fusion theory is based upon astronomical data that each 10^{15} eV cosmic ray proton striking the Earth's atmosphere produces perhaps hundreds to one thousand muons. See Chapter 27 (SigChar

X). (The cosmic ray protons actually produce pions which rapidly decay into muons which, in turn, decay less rapidly into electrons, etc., in a number of microseconds.)

For a number of decades, muons have been known to catalyze hydrogen fusion reactions by forming muonic molecular ions comprised of a proton plus a helium nucleus or deuterium or another proton orbited by a muon.[27,28] Muons are also known to catalyze multiple fusion reactions since they are not destroyed in the nuclear fusion process. A Google search for “muonic hydrogen fusion” leads to dozens of website references.

Star-related hydrogen fusion might have been feasible in the early Universe since relativistic dark matter protons were probably multitudinous and had energies much more than a thousand times higher than what can be achieved with man-made accelerators today. Also, catalytic muons were being produced in enormous quantities, and hydrogen/helium muonic molecular ions evolved as collision targets for the dark matter relativistic protons and helium nuclei spiraling into a galaxy from its dark matter halo.

An alternative explanation for primordial star formation is based upon the theory behind the starburst galaxy phenomenon, which is described in Chapter 46. It is known that the vast majority of starburst galaxies involve merging spiral galaxy clusters. According to the relativistic proton dark matter theory/cosmology, merging spiral galaxy clusters would subject the hydrogen in the galaxy disks to bombardment by protons from the galaxy clusters' DM halos with energies more than 10 times higher than protons from the bombarded galaxy's own DM halo. Such a higher energy proton bombardment should create more muons, muonic atoms, and muonic ions and would subject the latter to higher energy collisions, thereby facilitating hydrogen fusion and ignition of first-generation stars.

Three different methods of creating the first-generation stars have been presented. Depending upon conditions throughout the early Universe, any one of them could be favored in some space and at some time and possibly all three methods were involved in the early epoch.

The relativistic protons in dark matter halos have sufficient energy to trigger hydrogen fusion in galaxies. The website of the Princeton Plasma Physics Laboratory-Tokomak Fusion Test Reactor (http://www.pppl.gov/projects/pages/tftr.html) reports that by 1997 the Tokamak Fusion Test Reactor [for fusion of hydrogen isotopes] achieved a world record "plasma temperature of 510 million degrees centigrade -- the highest ever produced in a laboratory, and well beyond the 100 million degrees required for commercial [hydrogen] fusion." Note that in a 510 million degree plasma, the average kinetic energy of the plasma particles would be far below the kinetic energy of many galaxy-orbiting relativistic protons in the dark matter halo around a spiral galaxy.

The catalytic capability of muons in hydrogen fusion nuclear reactions has been known for about fifty years. In 1956, at the Los Alamos Meson Physics Facility and at U.C. Berkeley, Luis W. Alvarez and H. Bradner discovered the hydrogen-fusion-catalytic capability of the mu-meson, now called the muon, with the help of Edward Teller. They discovered that incoming muons were able to catalyze nuclear fusion between a proton and a deuterium nucleus (one proton and one neutron). Apparently, the muons were aiding the two types of nuclei to come close enough together for quantum tunneling to allow them to fuse, *even at room temperature.*

This nuclear fusion process was never commercialized because the proton bombardment energy required to produce the necessary muons was so great and the helium produced in the reaction captured so many muons (a principal source of energy loss) that the nuclear fusion process was very inefficient and impractical. However, this same or related process may be practical for creating hydrogen fusion in stars because of the extremely high energies of the multitudinous cosmic ray protons available in the Universe to bombard the muonic ions to trigger fusion and also to generate up to one thousand muons per bombarding proton, thereby overcoming and negating the muon-absorption-by-helium problem.

See SigChar J, K, and also see SigChar X, which discusses the role of the muons. In addition, see SigChar O regarding collisions of the relativistic dark matter protons with dust, photons, and hydrogen.

The thee above-described star formation methods 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.

Relativistic Proton Dark Matter May Be The Source Of The Stars, Planets, And DNA Changes:

Relativistic proton dark matter may be the source of sunlight, starlight, the stars, planets, and DNA changes throughout the Universe. In this chapter, we have learned that proton dark matter probably feeds hydrogen fuel to all the galaxies and that it ionizes atomic hydrogen, thereby forming hydrogen molecules faster. The proton dark matter also creates muons that catalyze hydrogen fusion nuclear reactions, and it bombards and triggers hydrogen-based muonic ions that ignite the stars. Through these four functions, the relativistic dark matter protons seem to have created all the stars and, therefore, all the planets in the Universe.

CHAPTER 27

SigChar X

How The Later Generations Of Stars May Have Been Ignited Utilizing Both Dust And Molecular Hydrogen

In Chapter 26, SigChar W, note in the ESO article that the star formation regions "are characterized by comparatively high concentration of molecular gas and dust."[26] The question is, how are the hydrogen molecules and dust utilized to facilitate star formation?

It has been known for decades that when high energy cosmic ray protons strike the Earth's atmosphere, they generate muons. The Stanford SLAC website reports that a count of muons arriving at the Earth's surface from one cosmic ray proton collision totaled about 1,000 muons. For the purposes of this book, it is estimated that a 10^{15} eV proton collision in the Earth's atmosphere would generate hundreds of muons and as many as one thousand muons.

It is well known that negative muons have the same negative charge as the electron, weigh about 207 times as much, and can form muon-orbiting protons as atoms or as ions. It is also known that a muon can orbit one proton, forming an atom, or it can orbit a proton-proton pair or a proton-helium nucleus pair, forming a molecular ion with the muon closely orbiting the pairs because of its high mass, thereby, for example, pushing the proton and helium nucleus closer together or pushing two protons closer together. It is believed that if one of these two protons were replaced by deuterium or helium, hydrogen fusion could result, generating enormous amounts of energy, but the muon would be ejected unscathed to be able to catalyze additional similar fusion reactions until the muon decays into an electron.[27,28]

With the large flux of muons and electrons created by relativistic dark matter protons and helium nuclei bombarding the dust particles, helium, and hydrogen, and with the large flux of dark matter relativistic protons and helium nuclei passing through the region, a variety of particle collisions and particle configurations are feasible in this high-velocity muon-electron-proton plasma to trigger hydrogen fusion. For example, high-velocity, high-collision-cross-section helium nuclei being orbited by one muon, possibly could collide with a pair of protons being orbited by one muon, thereby triggering hydrogen fusion. The success of the fusion triggering action would depend upon how well the negative muons shield the positive coulomb charges of the nuclei involved so as to reduce the opposing coulomb forces sufficiently to permit high collision velocities of the charged-shielded nuclei.

Another hydrogen fusion mechanism, mentioned in the previous chapter, involves collisions with galactic hydrogen by relativistic protons and helium nuclei departing from the dark matter halo, so as to form muonic molecular ions. This step would be followed by the relativistic DM protons and high-velocity DM helium nuclei bombarding the newly formed muonic molecular ions containing either two protons or one proton and one helium nucleus, so as to trigger hydrogen fusion.

TABLE 1

RECAP

Galaxy-Orbiting Relativistic Protons Are Expected To Have Signature Characteristics (SigChar) Related To The Following Subjects:

PART I – Signature Characteristics A - X

SigChar A	Dark Matter (DM) Proton Energies
SigChar B	The Milky Way's Magnetic Fields
SigChar C	Larmor Radius Equation
SigChar D	The Milky Way's Dark Matter Halos And Proton Energies
SigChar E	Paths Of Protons
SigChar F	Proton Streams Creating Magnetic Fields
SigChar G	Proton Flux And Kinetic Energy In Halos
SigChar H	Proton Relativistic Mass Losses From Synchrotron Radiation
SigChar I	Magnetic Bulges Leading To Increased Synchrotron Radiation From Protons
SigChar J	Why Dark Matter Halo Protons Enter Their Enclosed Galaxy And Lose Relativistic Mass
SigChar K	Protons/Helium Nuclei Collisions With Hydrogen Clouds
SigChar L	Linearly Rising Rotation Curves Indicating LSB Dwarf Galaxy DM Halos Are "Weakly Centrally Concentrated" (i.e., "Hollow")

TABLE 1

(Continued)

SigChar M	An Explanation For The Two "Knees" And "Ankle" Of The Cosmic Ray Energy Spectrum
SigChar N	Proton Synchrotron Radiation Losses And Proton Collision Losses Possibly Could Lead To An Accelerating Expansion Of The Universe
SigChar O	Radiating DM Halo Protons Become Cosmic Ray Protons
SigChar P	Long, Large, DM Filaments Creating Galaxy Clusters
SigChar Q	Mature Galaxies In A Young Universe
SigChar R	Conservation Of Angular Momentum
SigChar S	No DM Cusps In Nuclei Of Galaxies
SigChar T	Explanations For LSB Dwarf Galaxies' Low Star Formation Rates (SFRs) And For Massive Galaxies' Very High SFRs
SigChar U	The Relativistic Energy Of All The Protons In The Universe May Provide The Energy For The Accelerating Expansion Of The Universe
SigChar V	Linking Relativistic Dark Matter And Dark Energy
SigChar W	How The First-Generation Stars May Have Been Ignited Without Dust Or Molecular Hydrogen
SigChar X	How The Later Generations Of New Stars May Have Been Ignited Utilizing Both Dust And Molecular Hydrogen

CHAPTER 38

Cosmic DM Mystery #10

LSB Dwarf Galaxies Have Low Star Formation Rates

Relativistic Proton Dark Matter Particles Could Create A Starless Galaxy Or An LSB Dwarf Galaxy With Low Star Formation Rates

See SigChar A, B, C, D, E, G, J, L, M, and T.

The author believes that the diameter of a galaxy disk embedded within the "hollow" core of a dark matter halo can be larger, smaller, or the same size as the inner diameter of the "hollow" core. Based upon the Milky Way, it is estimated that the galactic magnetic field strength of spiral galaxies is perhaps in the range of 2,000 times higher than the extragalactic magnetic field surrounding the dark matter halo of a spiral galaxy.

The low star formation rates for starless dark galaxies and LSB dwarf galaxies can be explained if the galaxy-orbiting relativistic protons in the dark matter halo are normally utilized either to ignite the hydrogen fusion nuclear reaction of new stars or to provide proton or hydrogen fuel to galaxies for its stars. It would follow that the low star formation rate could occur if the galaxy disk diameter is smaller than the DM halo "hollow" core diameter and, therefore, the relativistic protons in the dark matter halo near the "hollow" core would not be subjected to the full magnitude of the much higher magnetic field of the enclosed galaxy. In this case, the resultant synchrotron radiation losses of the relativistic dark matter halo protons would be smaller than normal, thereby reducing the number of $1x10^{16}$ eV protons that would move from the dark matter halo into the galaxy to facilitate the formation of stars.

The "hollow" core of the dark matter halo of the Milky Way was created at an earlier time, when the Milky Way's disk was much smaller than it is today. At that earlier time, orbiting DM protons with energies much less than $3x10^{15}$ eV would lose a significant portion of their kinetic energy through synchrotron radiation energy loses and leave the core region of the dark matter halo, thereby enlarging the diameter of the "hollow" core.

CHAPTER 41

Cosmic DM Mystery #13

Dark Matter, Hydrogen, Helium, And Muons Create Stars

Relativistic Proton Dark Matter Particles Could Ignite Hydrogen Fusion Reactions Of First-Generation Stars Using Only Hydrogen And Helium Atoms, And Of Second-Generation Stars Using Hydrogen Molecules, Helium, And Dust As Well

See SigChar A, K, W, and X and consider Chapters 26 and 27 as being integral with this chapter.

Star Ignition Using Hydrogen Atoms:

It is known that dwarf galaxies having a large amount of atomic hydrogen and dark matter may exhibit a subnormal star formation rate. Also, many astrophysicists believe that "to explain primordial star formation without molecular [hydrogen] gas and dust is a major challenge in modern astrophysics."[26] See Chapter 26 (SigChar W) and also reference *26.*

Yet, astrophysicists know that primordial star formation did take place. The author believes that the relativistic proton dark matter theory/cosmology offers several possible explanations for the formation of the first stars, utilizing only atomic hydrogen. Let us begin with the simplest.

It is known that a mixture of 50% hydrogen ions and 50% neutral hydrogen atoms will form molecular hydrogen much faster than would neutral hydrogen atoms alone. Therefore, the bombardment/ionization of the atomic hydrogen gas in a spiral galaxy by the relativistic protons from the dark matter halo should facilitate the formation of hydrogen molecules in the galaxy, provided that no more than, say, 70% of the atomic hydrogen is ionized. The ideal ratio would be 50% hydrogen ions and 50% atoms to maximize the number of hydrogen ion-atom pairs to merge into molecules.

As another explanation under the relativistic proton dark matter theory/cosmology, primordial star ignition utilizing only atomic hydrogen might have occurred through the following four steps:

1. Galaxy-orbiting relativistic dark matter protons and associated helium nuclei colliding with compressed interstellar clouds of hydrogen atoms and helium atoms

would generate muons, which in turn would create muonic atoms of hydrogen and of helium with muons replacing the electrons.

2. Muons in muonic atoms orbit the protons and helium nuclei at much smaller radii than electrons because the muons weigh 207 times as much as an electron. Therefore, the positive coulomb charges of the nuclei are well shielded by the closely orbiting negative muons, making the muonic atoms have a very low effective charge and thereby enabling them to collide with each other.

3. The colliding muonic atoms of hydrogen and helium form muonic molecular ions with either two protons or one proton and one helium nucleus. These two types of muonic molecular ions are being orbited by only one muon since the net coulomb charge is so low that a second muon typically would not attach. By this means, muonic molecular ions are formed.

4. Subsequent bombardment of the muonic molecular ions by relativistic protons with energies of about 10^{15} eV and by the large relativistic helium nuclei should be capable of triggering hydrogen fusion reactions and the ignition of new stars from either one or both types of the muonic molecular ions. Also, high-speed collisions between the muonic molecular ions themselves could also participate in the hydrogen fusion nuclear reactions.

The author's star ignition and hydrogen fusion theory is based upon astronomical data that each 10^{15} eV cosmic ray proton striking the Earth's atmosphere produces hundreds to perhaps one thousand muons. See SigChar X. (The cosmic ray protons actually produce pions that rapidly decay into muons that, in turn, decay less rapidly into electrons, etc., in a number of microseconds.)

For a number of decades, muons have been known to catalyze hydrogen fusion reactions by forming muonic molecular ions comprised of a proton plus a helium nucleus or deuterium or another proton orbited by a muon.[27,28] Muons are also known to catalyze multiple fusion reactions because they are not destroyed in the nuclear fusion process. A Google search for “muonic hydrogen fusion” leads to a number of website references.

Star-related hydrogen fusion might have been feasible in the early Universe since relativistic dark matter protons were probably multitudinous and had energies much more than a thousand times higher than what can be achieved with man-made accelerators today. Also, catalytic muons were being produced in enormous quantities, and hydrogen and helium muonic molecular ions evolved as collision targets for the dark matter relativistic protons and high-velocity helium nuclei spiraling into a galaxy from its dark matter halo. See SigChar J, K, W, and X.

There is also the possibility that some primordial star formation can be attributed to the merging of early galaxy clusters, thereby forming starburst galaxies. See Chapter 46.

Star Ignition With Hydrogen Gas Molecules And Dust Would Generate Even More Muons:

The relativistic proton dark matter and accompanying relativistic helium nuclei could enter into collisions with the molecular and atomic hydrogen and helium gas and with dust particles in the enclosed galaxy. The higher collision cross sections of the dust and molecules, compared to those of the atoms, could lead to a significantly higher rate of muon formation, which in turn could facilitate and expedite star formation. That is, the larger volume of muons would replace more electrons in the hydrogen and helium atoms, in the hydrogen and helium molecules, and in the hydrogen/helium molecules. This would lead to the formation of more muonic ions with a muon orbiting two protons or a proton-helium nucleus pair, pushing them closer together and creating a collision target for the bombarding relativistic protons and high velocity helium nuclei arriving from the cored dark matter halo.

Subsequent bombardment of the larger volume of muonic molecular ions by relativistic protons with energies of about 10^{15} eV and by the high-velocity helium nuclei should be capable of triggering a higher rate of hydrogen fusion reactions and a higher rate of ignition of new stars from either one or both types of the muonic molecular ions. Also, high-speed collisions between the muonic molecular ions themselves also could participate in the hydrogen fusion reactions.[27]

As discussed in Chapter 26, the catalytic capability of muons in hydrogen fusion nuclear reactions has been known for about fifty years. In 1956, at the Los Alamos Meson Physics Facility and at U.C. Berkeley, Luis W. Alvarez and H. Bradner discovered the hydrogen-fusion-catalytic capability of the mu-meson, now called the muon, with the help of Edward Teller. They discovered that incoming muons were able to catalyze nuclear fusion between a proton and a deuterium nucleus (one proton and one neutron). Apparently, the muons were aiding the two types of nuclei to come close enough together for quantum tunneling to allow them to fuse, *even at room temperature.*

CHAPTER 46

Cosmic DM Mystery #17
Starburst Galaxies Form Via Merging Galaxy Clusters

The Merging Of Spiral Galaxy Clusters Create Starburst Galaxies That Exhibit Star Formation Rates (SFRs) As Much As 50 Times Higher Than The SFRs Of Spiral Galaxies

See SigChar G, J, K, S, T, W, and X.

The author designates the above-titled phenomenon as the 17th Cosmic DM Mystery of the Universe, which then leads to the rhetorical question: What type of dark matter particle could cause, expedite, facilitate, or explain the starburst galaxy phenomenon?

Starburst galaxies show evidence of a transient increase in star formation rate by a factor as much as 50. Most starburst galaxies are associated with merging spiral galaxy clusters. The starburst phenomenon may be galaxy-wide or limited to a region of the galaxy such as the galaxy nucleus.

An excellent source of basic astronomical information about starburst galaxies is a six-page article, "Starburst Galaxies"[39] by astronomer William C. Keel of the University of Alabama, posted on the University of Alabama's website: http://www.astr.ua.edu/keel/galaxies/starburst.html.

Starburst galaxies, with SFRs rising by as much as a factor of 50, are created when two clusters of spiral galaxies merge. Starbursts are associated with spiral galaxies that have been disturbed from their steady-state condition. The starbursts are usually confined to a few hundred parsecs from the nucleus of a spiral galaxy, although some starbursts occur throughout the galaxy disk. Large quantities of dust are also associated with starburst galaxies as well as the blue stellar emission from the young stars. Much of the star formation appears to be associated with very compact star clusters of about one hundred million stars in a region of a few parsecs in diameter near the galaxy nucleus.

A majority of spiral galaxies that are found in close pairs, known as *interacting* galaxies, demonstrate an increase in SFRs from about 30% to is as much as 100%.

The four preceding paragraphs describe the principal features and characteristics of starburst spiral galaxies and interacting spiral galaxies. The next step is to utilize this information in conjunction with the relativistic proton dark matter theory/cosmology to extract a plausible explanation for the starburst phenomenon.

In the dark matter halo around a normal spiral galaxy, the lowest energy relativistic protons are close to and penetrate the surface of the enclosed galaxy, while the more than an order of magnitude higher energy relativistic protons would be orbiting at the outer diameter of the dark matter halo at radii more than an order of magnitude greater than those in close proximity to the galaxy. Therefore, there is normally no interaction between a galaxy's hydrogen atoms and molecules and the highest energy relativistic protons in the outer diameter of its dark matter halo.

However, if two spiral galaxies along with their relativistic dark matter halos are interacting or merging, the highest energy relativistic protons in the dark matter halo of one galaxy could bombard the hydrogen atoms and hydrogen molecules of the other galaxy. Further, if two spiral galaxy *clusters* are merging, the ultra-high energy protons orbiting the galaxy *clusters*, if disturbed from their steady-state orbits, can smash into the hydrogen atoms and molecules of individual spiral galaxies. The enormous number of muons generated by these UHECR collisions would be capable of catalyzing the hydrogen fusion reactions associated with the well-known starburst galaxy phenomenon.

If these last two paragraphs are not fully understood, it is suggested that the SigChar references at the beginning of this chapter be reviewed. SigChar T describes a low star formation rate dwarf galaxy where there is a physical gap between the galaxy disk and the "hollow" core of the halo, leading to a low star formation rate. It also explains how a normal star formation rate is associated with the disk of a spiral galaxy overlapping its dark matter halo "hollow" core, thereby permitting more and higher energy relativistic protons to enter the galaxy and generate muons where the hydrogen atoms and molecules are located. Applying these same concepts to closely situated interacting pairs of spiral galaxies, it is not surprising that their star formation rates rise about 30% to 100% above those of normal spiral galaxies.

Why should starburst galaxies have a factor of 50 higher star formation rate compared to the 30% to 100% rise for close and interacting pairs of spiral galaxies? There may be two reasons. Starburst galaxies are usually formed from the merging of two spiral galaxy *clusters*. The ultra-high energies of DM relativistic protons in the DM halo of a galaxy *cluster* are probably about 30 times higher than those in a DM halo of a single spiral galaxy. (See Chapter 50.) These ultra-high energy DM protons orbiting galaxy *clusters* have the potential to produce very high SFRs. Also, there should be a large reservoir of hydrogen atoms and molecules to ignite into stars near the spiral galaxy nucleus because gravitational tidal forces will move such slow-moving atoms and molecules toward the gravitationally attractive black hole over millions to billions of years.

The hydrogen atoms and molecules near the nucleus of a spiral galaxy would not normally participate in new star formation. Photographs of spiral galaxies typically exhibit the blue color of a new star formation at the outer periphery of those galaxies in the spiral arms. Therefore, it would not be surprising that in a starburst galaxy involving merging galaxy *clusters*, the ultra-high energy protons from the galaxy cluster's dark matter halo could be perturbed from their normal circular orbits because of magnetic field distortions and, thus, could smash into a spiral galaxy straight through to its hydrogen-rich nucleus to ignite new stars. Star ignition could occur through the creation of muons near the galaxy nucleus, followed by particle collisions involving hybrid muonic molecular ions comprised of protons and helium nuclei. Also facilitating this starburst process is the ionization of some of the atomic hydrogen gas in the galaxy nucleus by the ultra-high energy dark matter protons, which speeds up the formation of hydrogen *molecules* and thereby raises the SFR, as explained in Chapters 26 and 41.

This chapter provides a plausible explanation for the starburst galaxy phenomenon, designated Cosmic DM Mystery #17, that cannot be explained by the 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 53

Cosmic DM Mystery #24

Schmidt Law: SFR Vs. Surface Hydrogen Molecular Density

One Of The Mysteries Of Observed Isolated Spiral Galaxies Has Been The Empirical Schmidt Law Correlation Between Star Formation Rate And The Average Molecular Hydrogen Surface Density On Kiloparsec Scales, Even In Regions Dominated By Atomic Hydrogen. The Schmidt Law Has A Power-Law Index Of Correlation Or Slope In The Range Of 1.3 To 1.5. At High Gas Densities, The Schmidt Law Is Very Consistent From Galaxy To Galaxy But Does Break Down Below A Threshold Surface Density Level.

See Chapters 23, 26, 27, 31, 41, 46, and 48 and References *46* (astro-ph/0303240, "On the Origin of the Global Schmidt Law of Star Formation") and *47* (astro-ph/0508054, "Star Formation in Isolated Disk Galaxies. II. Schmidt Laws and Star Formation Efficiency of Gravitational Collapse").

The author chooses the Schmidt law for isolated spiral galaxies to be the 24th Cosmic DM Mystery of the Universe. That raises the question: What type of dark matter particles could cause, facilitate, expedite, or explain the Schmidt law for isolated spiral galaxies?

The Schmidt law appears to have some distinctive characteristics:

1. It is a power law with a slope (of 1.3 to 1.5) almost half way between a linear and a square law correlation.

2. Although the law is a strong function of the average molecular hydrogen surface density, it does not seem to be affected by the level of surface atomic hydrogen.

3. At high levels of molecular hydrogen surface density, the law is consistent from galaxy to galaxy.

4. The empirical Schmidt law uncovered a molecular hydrogen surface-density-feature correlation as distinct from a volume-density-feature correlation.

5. The law breaks down and therefore is not valid below a low molecular hydrogen surface density threshold level.

6. The law does not apply to starburst galaxies, which normally involve merging galaxy clusters and therefore are not isolated spiral galaxies.

Using the relativistic proton dark matter theory/cosmology, we will now seek a plausible explanation for the Schmidt law. Success in doing so will confirm that *dark matter* *relationism* is applicable to the Schmidt law, which is the subject of Cosmic DM Mystery #24.

A review of Chapters 26, 27, 31, and 41 should provide the background information necessary to understand the star formation and hydrogen fusion process associated with the relativistic proton dark matter theory/cosmology.

The relativistic proton dark matter theory/cosmology's star formation process for an isolated spiral galaxy involves four steps, as follows:

1. Relativistic protons with energies at or below 10^{16} eV depart from the dark matter halo in closest proximity to the spiral galaxy and move into the galaxy as a result of proton energy losses from synchrotron radiation losses and collisions with CMB photons, helium, hydrogen, and dust.

2. When these relativistic protons collide with the hydrogen molecules near the spiral galaxy's surface, they generate pions that quickly decay into muons that decay less quickly into electrons. Hundreds to one thousand muons can be generated by each 10^{15} eV proton.

3. These large quantities of muons then collide with the hydrogen molecules near the surface of the spiral galaxy as well as with the estimated one-in-twelve helium molecules present on the galaxy surface. As a result,

muonic hydrogen ions and muonic hydrogen-helium ions are created near the galaxy surface.

4. The relativistic protons arriving at the spiral galaxy surface after the muonic ions are formed, bombard the muonic hydrogen ions and the muonic hydrogen-helium ions, thereby initiating hydrogen fusion reactions. (Note that these bombarding protons are about 1,000 times more energetic than man-made relativistic protons.)

It should be noted that the dark matter halo is also providing replenishment hydrogen fuel to the galaxy as the slowed protons entering the galaxy will capture some of the enormous quantity of electrons being generated by the decaying muons. Also, it is known that muons usually catalyze multiple hydrogen fusion reactions during their short lifetime since they are not destroyed in the nuclear fusion process and, therefore, would be in plentiful supply even though they decay rapidly into electrons.

Drexler first published this hydrogen fusion star ignition theory on April 22, 2005 on the Physics arXiv in astro-ph/0504512.[37] This star ignition theory is based upon and relies on the relativistic proton dark matter theory and its related cosmology. We will now apply Drexler's star formation/ignition theory to the characteristics of the

Schmidt law to determine whether Drexler's theory provides a plausible theoretical basis and explanation for the empirical Schmidt law.

Why should the Schmidt law be a power law? Note that the star forming/ignition process involves four steps, two of which involve relativistic proton bombardment. That is, the higher the average hydrogen molecular surface density, the more muons will be created per bombarding proton. Then, for a given number of muons created, the higher the hydrogen molecular surface density, the more hydrogen and helium molecules at the surface will be converted into muonic ions. Finally, the arriving relativistic protons bombarding the muonic ions will create a level of star formation in proportion to the surface density of muonic ions. Thus, the posited star formation process should have, and appears to have, a somewhat stronger than linear correlation with the average molecular hydrogen density on the surfaces of isolated spiral galaxies, which at the least would imply a low-level power law.

The author believes this chapter provides a plausible theoretical basis and explanation for the empirical-Schmidt-law phenomenon defined by Cosmic DM Mystery #24. This is an indication that *dark matter relationism* is applicable to Cosmic DM Mystery #24.

Why doesn't the presence of atomic hydrogen affect the correlation of the Schmidt law? First of all, the level of muon creation for atomic hydrogen would be much lower than that for hydrogen molecules, which have a larger collision cross section to the relativistic proton/helium nuclei bombardment. Also, in the atomic-hydrogen case, the muons created will not produce the large numbers of muonic ions required for hydrogen fusion since there would be relatively small numbers of hydrogen molecules, helium molecules, and hydrogen-helium molecules present near the galaxy surface to convert to the muonic ions.

These star formation phenomena defined by Cosmic DM Mystery #24 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 54

Cosmic DM Mystery #25

Mass-And-Time-Dependent SFR Graphs For Field Galaxies

The Two-Part Mystery Of Recently Observed Star-Forming Galaxies Is That Large, Massive Galaxies Form Stars Early And Rapidly, But Eventually Their Star Formation Rates Fall Rapidly, Whereas Small Galaxies Form Stars Slowly Over Longer Time Scales And Their Star Formation Rates Decline Slowly Over Longer Time Scales

See Chapters 23, 26, 27, 28, 31, 41, 46, and 48.

For the 25th Cosmic DM Mystery of the Universe, the author chooses the discovery that time-dependent star formation rates differ significantly for massive star-forming galaxies compared to small star-forming galaxies. This raises the question: What type of dark matter particles could cause, facilitate, expedite, or explain the mass-and-time-dependent SFR phenomena exhibited by massive star-forming galaxies and by small star-forming galaxies?

Mass-dependent SFR phenomena for star-forming galaxies were reported on December 18, 2005 in a research paper, astro-ph/0512465, "The Mass Assembly History of Field Galaxies: Detection of an Evolving Mass Limit for Star Forming Galaxies,"[48] by Kevin Bundy, Richard S. Ellis, et al. A similar subject was presented on January 9, 2006 at the AAS 207th meeting in Washington, D.C., in a talk entitled, "Mass-dependent star formation histories of field galaxies in the EGS" by Kai G. Noeske, which was reported in a January 9, 2006 University of California at Santa Cruz news release entitled, "Large survey of galaxies yields new findings on star formation."[49]

The above-referenced paper and news release provide the following information about the SFR as a function of star-forming galaxy mass and as a function of time:

- Massive, undisturbed, star-forming galaxies form stars early and rapidly.
- Small, undisturbed, low mass star-forming galaxies form their stars more slowly and over longer time scales than the massive galaxies.
- Both massive and small star-forming galaxies exhibit a decline in star formation rate over time, but the fall of the

SFR for the massive galaxies is much more rapid and begins much earlier.

- Astronomical studies of large galaxy clusters representing billions of years of star formation history demonstrate a "downsizing signal." This means a "downsizing" pattern in space and time, in which the sites of the most active star formation shift over time in a large galaxy cluster from its massive galaxies in the early epochs to its low mass galaxies during later epochs.

- The fading of star formation rates over time appears to be consistent with galaxies exhausting their hydrogen gas, rather than for any other causes.

These mass-and-time-dependent SFR phenomena seem to be explainable by these paragraphs from Chapters 28 and 23:

From Chapter 28: Under the top-down theory of galaxy formation, galaxies form and grow through the accretion of hydrogen and protons from a relativistic proton DM halo into its "hollow" core and onto its enclosed proto-galaxy. The galaxy disk enclosed within a DM halo may be larger or smaller than the relativistic proton DM halo's "hollow" core diameter. If the galaxy disk is smaller, the galaxy should exhibit a low SFR; and if the disk is much larger, such a massive galaxy should exhibit a very high SFR. The decline of SFRs over time would be very small for small galaxies because their DM halos could provide adequate replenishment hydrogen to compensate for the hydrogen consumption of its stars. However, for large massive galaxies with their very high SFRs, the replenishment hydrogen from the DM halos could be inadequate, subjecting the SFRs to declines over time that are large and rapid.

From Chapter 23: An unusually large, massive galaxy could significantly overlap the DM halo's "hollow" core, leading to a very high SFR. Such a massive galaxy's disk would be reaching deep into the DM halo, thereby interacting with higher energy relativistic protons and thus creating a very active high SFR region. However, if this SFR is too high, the replenishment hydrogen being supplied by the DM halo could be insufficient to maintain the SFR, which could fall rapidly to lower levels. For the Milky Way and LSB dwarf galaxies, the replenishment hydrogen from the DM halo could be adequate to maintain their SFRs for much longer periods of time than for large, massive galaxies.

Regarding the paragraph from Chapter 23: Note that the initial high SFR of the large, massive galaxy is probably directly related to the amount the star-forming galaxy's disk overlaps the inner diameter of the DM halo's "hollow" core.

However, note in Chapter 56 that Dr. Mark Wilkinson of Cambridge University was quoted on 6 February 2006 as saying, "No matter what size, how bright, or how many stars they contained -- all the galaxies seemed to be sitting in roughly the same amount of dark matter."[50] Professor Gerry Gilmore of Cambridge made a similar statement at the time. This somewhat similar size of DM halos for "all the galaxies" could cause a hydrogen replenishment problem for the high SFR massive galaxies, leading to the early decline of their SFRs.

A plausible explanation has been provided for the mass-and-time-dependent SFR phenomena described by Cosmic DM Mystery #25. The explanation uses the same relativistic proton dark matter theory/cosmology used to explain the LSB dwarf galaxy star formation phenomenon, the Schmidt law, the starburst galaxy star formation phenomenon, and the formation of new blue stars in the spiral arms of galaxies. The author looks forward to the use of his theory/cosmology by others to solve Cosmic DM Mysteries #26, #27, #28, etc.

TABLE 3

RECAP

Decoding The Cosmos Via DM Relationism And By Solving The Cosmic DM Mysteries

PART II – Cosmic DM Mysteries #1 - #14

#1 Spiral Disk Galaxies Have Spherical Dark Matter Halos
#2 Accelerating Expansion Via Conserving DM Momentum
#3 Hydrogen Derived From DM Cosmic Ray Protons
#4 Magnetic Fields Derived From DM Cosmic Ray Protons
#5 Intersecting DM Filaments Create Galaxy Clusters
#6 Mature Galaxies Discovered In The Very Early Universe
#7 Dark Matter Spherical Cored Halos Have "Hollow" Cores
#8 Source Of Spiral Galaxies'/Halos' Angular Momentum
#9 No Central Dark Matter Cusp Found In Spiral Galaxies
#10 LSB Dwarf Galaxies Have Low Star Formation Rates
#11 LSB Galaxies Have Inclining Star Rotation Curves
#12 Galaxy Hydrogen Is Replenished From Halo Dark Matter
#13 Dark Matter, Hydrogen, Helium, And Muons Create Stars
#14 Earthbound Cosmic Ray Protons Depart From 4 Locations

PART III – Cosmic DM Mysteries #15 - #25

#15 Astrophysical Emergence Of Dark Matter Halos, After Eons
#16 UHECRs Arrive At Earth From Galaxy Superclusters
#17 Starburst Galaxies Form Via Merging Galaxy Clusters
#18 UHECR Protons Via Starburst Galaxies/Merging Galaxies
#19 Blue Stars In Spiral Arms Vs. Red Stars In Galaxy Nucleus
#20 Magnetic Field, DM Proton Energies Set Galaxy Halo Size
#21 Different Dark Matter For Small Galaxies And For Clusters
#22 800 Galaxies Detected, Less Than 1.2 Billion Years Old
#23 Fine Balance Between Dark And Baryonic Matter In Spirals
#24 Schmidt Law: SFR Vs. Surface Hydrogen Molecular Density
#25 Mass-And-Time-Dependent SFR Graphs For Field Galaxies