Ettinger Journals

Glossary for Ettinger Journals

The Moon Enigma By Douglas B. Ettinger

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Glossary for the Moon Enigma and its solution:

- The Earth's Metamorphosis (EMM) Hypothesis
- The Collocation of Stars and Planets (CSP) Hypothesis
- The Supernova Seeding (SNS) Hypothesis

I. Table of Contents

II. Theories, Laws, Rules and Hypotheses

A. Collocation of Stars and Planets (CSP) Hypothesis

A proposal of how multi-star systems and stellar systems with planets develop certain orbital distances and velocities.

B. Kepler's Laws

Kepler's three laws describe the motion of the planets around the Sun by analyzing the astronomical observations of Tycho Brahe and the predictions of Copernicus' solar system.

C. Langrangian Points

These points represent a mathematical theory that predicts five positions in an orbital configuration where a small body only affected by gravity can be stationary relative to two larger bodies. The Trojan asteroids at L_4 and L_5 positions for the Sun/Jupiter system are an example.

D. Later Heavy Bombardment (LHB)

A period of time during the young solar system, about 3.9 to 4.0 billion years ago, when a large bombardment of asteroids on the inner planets, the Moon, and some outer planets' satellites occurred as measured by radiometric dating on the Moon and by crater counting methods.

E. Nebular Hypothesis

Describes how a giant molecular cloud gravitationally collapses to form a proto-star disk which in turn creates a star and suite of planets by means of accretion.

F. Newton's Laws of Motion

Supported by Kepler's Laws, Newton outlined the universal laws of motion which more accurately describe and predict the motions of celestial bodies .

G. Newton's Universal Law of Gravitation

This law describes the attractive force between celestial bodies.

H. Nice Theory

This fairly recent idea predicts the LHB by modeling the outward movement of Uranus' and Neptune's orbits to perturb inwardly the minor planets and comets of the Kuiper Belt thereby creating conditions for a close grouping in time for collisions.

I. Titius-Bode Rule

This rule uses a mathematical equation to predict the orbital distances of the planets from the Sun. The rule is not entirely accurate but was applied to find large asteroids in the Main Belt and Uranus.

J. Supernova Seeding (SNS) Hypothesis

A proposal of how the hot, charged, and magnetic plasmas of supernova remnants create next generation stars and planets using the seeds of magnetic, spinning orbs mostly composed of iron that are ejected from the final supernova explosion.

K. Moon Enigma

The Earth-Moon system is a long standing mystery that is not answered by the nebular hypothesis. Numerous ideas each with their own set of problems have been proposed over the past three centuries. The Apollo missions to the Moon produced more questions than answers about solving this enigma.

1. Co-accretion hypothesis

The Earth and Moon formed together from the accretion of a ring of material in the Sun's proto-star disk.

2. Earth's metamorphosis (EM) hypothesis

The subject and focus of this journal portrays a story that includes both a huge impact and a capture mechanism. The collision occurs in the asteroid Main Belt where Earth formed as a proto-planet. A Martian size impactor gorged the Earth, tilted its axis, changed its trajectory inward toward the Sun, and created the collisional debris known as the asteroid belt. The falling Earth increases its velocity and its centripetal force enough to begin orbiting again very close to the existing Moon's orbit. Over millions of years of Earth passing the slower, smaller Moon gravitational forces cause the Earth to slow to match the Moon's velocity, to move the Moon farther away to conserve angular momentum, and to synchronize their orbits. Debris from this major collision causes the Late Heavy Bombardment (LHB) period.

3. Fission hypothesis

The Earth with a much larger, original, accelerated rotation expelled material to form the Moon.

4. Giant impact theory

When the Earth and Moon were both proto-planetary bodies, the Moon struck Earth with a glancing blow and then was captured in an orbit around Earth. The resulting debris mostly fell back on the Moon. This idea is currently the favored hypothesis but took time for scientists to accept within their framework the inevitable large impact events of the early solar system. The difficulty with large impacts stems from the idea that more debris should occur rather than more accretion.

5. Lagrangian capture hypothesis

A recent idea is proposed that the Moon formed at one of the Lagrangian points, L_4 or L_5, for the Earth/Sun system and later was perturbed to move closer to Earth and be captured and/or have a collision.

6. Lunar capture

The completely formed Moon was captured by the gravitational field of the Earth which is virtually impossible as proven by the N-body problem for two bodies unless very specific conditions are chosen. The lunar capture for the EMM hypothesis does utilize very specific conditions, such as co-planar properties, closely matching velocities, and similar elliptical orbits.

7. 3753 Cruithne

This object is Earth's companion object which is not sharing one the Lagrangian points although it shows stability in its repeatedly changing orbits. This unique asteroid illustrates the means proposed in the EMM hypothesis for the synchronization of the Earth-Moon orbits.

"This asteroid occupies one of two regular solar orbits, one of them slightly smaller and faster than the Earth's orbit, and the other slightly larger and slower. The asteroid periodically alternates between these two orbits due to close encounters with Earth. When the asteroid is in the smaller, faster orbit and approaches the Earth, it gains orbital energy from the Earth and moves up into the larger, slower orbit. It then falls farther and farther behind the Earth, and eventually Earth approaches it from the other direction. Then the asteroid gives up orbital energy to the Earth, and drops back into the smaller orbit, thus beginning the cycle anew. The cycle has no noticeable impact on the length of the year, because Earth's mass is over 20 billion (2×10^{10}) times more than 3753 Cruithne." This previous quotation comes from Wikipedia.

If two unreal assumptions are made: that the Earth has no Moon and 3753 Cruithne for some reason matched the orbital velocity of Earth, then 3753 Cruithne would begin to orbit the Earth just like the Moon.

III. Birthing of Celestial Bodies

A. Accretion Model

Rings of denser matter occur as proto-star disk spirals inward which then accrete to form increasingly larger bodies that finally become planets.

B. Gravitational Collapse of Molecular Cloud

A giant molecular cloud (GMC) somehow develops a region of high density and is perturbed by supernova shock fronts to trigger a gravitational collapse of a large portion of a GMC. This is the basis of the nebular hypothesis.

C. Herbig-Haro (HH) Object

These objects are patches of nebulosity associated with newly born and T-Tauri stars. The objects are jets of H and He plasma that are emitted from the star's polar regions. This plasma normally recombines as it moves away unless it shocks some inter-stellar medium (ISM). The total mass of these jets is 1 to 20 Earth-masses.

D. Magnetic Spinning Orb (MSO)

Iron blobs ejected from the star's core during a supernova begin to spin and become highly magnetic via electromagnetic phenomena. The combination of these MSOs passing through other electrically charged plasma creates a disk that acts like a dynamo. This disk conducts huge amounts of currents composed of both positively charged and negatively charged fermions. The process is comparable to pushing an electromagnet through piles of iron filings. These MSO's are the seeds for star/planet formation referenced in the SNS hypothesis.

E. Proto-Planet

A new planet forming from a proto-planetary disk initiated primarily by electromagnetic phenomena.

F. Proto-Star

A new star forming from a proto-star disk that is collapsing onto a central, denser region. The star's core is initiated by a MSO and its electromagnetic properties. The disk around a proto-star acts similarly to a metallic disk used for Faraday's dynamo.

G. Proto-Planetoids

Smaller or minor planets and satellites forming from their own individual, much smaller collapsing disks.

H. Proto-Planetary Disk (Version 1)

The popular version is the phase of a proto-star's disk as it is forming planets through accretion.

I. Proto-Planetary Disk (Version 2)

This journal's version is the disk of materials that forms around a proto-planet during its formation

J. Proto-Star Disk

The disk of dust and gases that is falling inward to produce a proto-star and supposedly planets being accreted at certain orbital distances.

K. Solar System Objects

1. Asteroids

Debris or ejecta created by the collisions of larger bodies that is irregularly shaped and generally orbits the Sun; other asteroids or families of asteroids orbit other planets or share orbits which are called Trojan asteroids.

2. Comets

Debris or ejecta that orbits the Sun in long or short periods; these objects also come from collisions just like asteroids except they have volatiles that are vaporized and ejected to form easily seen comas and tails.

3. Irregular-shaped objects

Any inter-planetary object that was not formed by gravity into a spherical shape; these objects; asteroids, meteorites, and comets are all re-processed being created initially by collisions of larger bodies.

4. Meteorites

Asteroids that have collided with other planets and are observed and/or recovered.

5. Outer gas giants

The largest planets, Jupiter and Saturn, are composed mostly of hydrogen and helium.

6. Outer ice giants

Uranus and Neptune composed mostly of ices and rock.

7. Planets

Spherical objects having stable orbits around the Sun and generally having the properties of differentiated layers with cores and magnetic fields.

8. Planetisimals

Popularly referred to objects smaller than planetoids that were the building blocks of planets when first forming; for this journal planetisimals refer more generally to all solid matter that has existed or still exists that is in the range of size from dust particle aggregations to the size of planetoids.

9. Planetoids

Popularly referred to as any solar system body orbiting around the Sun; for this journal this term will only refer to all spherical minor planets, sometimes called dwarf planets; or any size body with planetary features that is in the process of being capture in an orbit during the solar (any star) system's formation.

10. Ring particles

A range of small-size particles composed of dust or ices that are captured and orbiting the outer planets; these particles are postulated to be collisional products of asteroids striking the outer planets' satellites.

11. Satellites

Any body that orbits a planet or any other smaller body; even small asteroids have satellites.

12. Terrestrial planets

The inner, rocky planets that possess little volatile materials and have only a thin or no atmosphere.

L. Supernova Seeding Process

The SNS process that this journal is supporting claims that the electromagnetic properties of ejecta from supernova and previous eruptions of the same star while still in a plasma state creates the conditions for birthing new stars and their planets. The final explosion produces ejecta of iron blobs that become magnetic spinning orbs (MSOs) that attract other plasma as it passes through the previous circum-stellar rings and slower shock fronts of expelled materials.

M. T-Tauri Star

As a proto-star begins fusion of hydrogen and helium in its central core due to its growing mass and size, radiation pressure drives strong stellar winds outward from the star's surface that arrests the inward falling of materials eventually heating and evacuating materials from the inner portions of the proto-star disk. This is the T-Tauri phase that directly precedes the star joining the Main Sequence.

IV. Planetary Evolution

A. Basaltic Crusts

Created by the initial or primary differentiation of mantle materials such as oceanic crusts and the Moon's lowland marias.

B. Continental Drift

Earth's super-continents breaking apart and moving slowly apart and then moving together again repeating this cycle several times.

C. Crustal Development

The hardening of the outer surfaces of terrestrial planets and satellites due to heat loss from radiation and convection transfers which may occur several times due to the introduction of additional thermo-energy from later heavy and numerous impacts.

D. Differentiation – Primary

Separation of the lighter elements and compounds because gravity forces them to float to the surface thus creating crusts, mantles, and very dense liquid and/or solid cores at the center.

E. Differentiation – Secondary

Separation of the lighter elements and compounds that become mixed into an already differentiated mantle by the introduction of later impactors having these volatile materials.

F. Granitic Crusts

Created by secondary differentiation after impactors with volatile materials mix with the original mantle materials that flow outward from the crater onto or displacing the already existing basaltic crust.

G. Hot Spots (Geological)

A special type of volcanism that randomly occurs globally under oceanic, continental crusts, and even at plate rifts, that have no connection to volcanoes caused by the subduction zones resulting from tectonic plate collisions.

H. Impacts and Cratering

Surface disturbances seen on celestial bodies with hardened surfaces created by either asteroids, comets, possibly minor planets, and collisional debris created by other nearby collisions.

I. Lava Flows

Molten material that escapes to the surface either by volcanoes or the upwelling of mantle materials within large impact basins like the mares on the Moon. If a thin crust is penetrated by enough impactors ,mantle materials can ooze to the surface and cover a large area creating a flat table-like surface. On Earth sufficiently large lava flows created islands above oceanic crusts, mountain ranges on continental crusts, and new oceanic crusts at global rifts. The Earth's Metamorphosis (EMM) hypothesizes that a huge collision created a large opening in the surface crust for a mixture of Earth's mantle and volatiles from the impactor to flow outward and create the original continent, the grandest of lava flows.

J. Magnetic Field Evolution

As molten materials crystallize they record direction and strengths of magnetic fields that may come from both external and internal sources. Generally, the internally generated fields developed by rotating liquid iron cores are the strongest and vary in direction and strength over time.

K. Plate Tectonics

The motion and interaction of large sections of crust on the surface of Earth; very little tectonic processes exist on other solar system bodies.

L. Residual Heat

Most celestial bodies have hot and even molten cores created by residual heat from the collapse of accreted materials during their creation, the hydrostatic pressure due to a large column of mass bearing on the central core, and the heat generated by radioactive decay of fissionable elements, some having half-lives older than the age of the solar system.

M. Terrestrial Planet Evolution

This process describes why the inner, rocky planets either never possessed or lost most of their accreted volatile materials.

N. Tidal Forces

The interacting force of gravity between two close celestial bodies causing rotational slow-down and in some cases, tidal locking of the smaller body. These forces create tides, lateral surface movements, and heat.

O. Volatile Outer Shells

Due to the differentiation process the lighter elements and compounds percolate to the surface and gather to create gaseous atmospheres, liquid seas, and/or solid, frozen outer layers; the phase of this matter depends on the combination of residual heat, solar heating, and atmospheric greenhouse affect; the longevity of these volatile materials depends on the strength of the gravitational field due to the mass of the body.

P. Volcanism

The method of how lighter volatiles trapped under the crustal regions escape to the surface; the primary differentiation process percolated the primordial volatiles globally. Later bombardments brought other volatiles that became embedded inside mantles to later escape via volcanism or secondary differentiation. The movement and sinking of one tectonic plate under another in subduction zones also traps volatiles under the crust that eventually escape by means of volcanism.

V. Star Types

Stars have significantly different lifetimes and different endings based on their masses. Lifetimes can vary from hundreds of billion years to a few million years – the more massive the shorter their lives.

A. Categorized By Size

1. Super-massive stars

- Stars > 250 $M_\odot$ become photodisintegration SNs or hypernovae. These stars are only predicted and are not directly observable.
- Stars < 250 to 130 $M_\odot$ become true pair-instability SNs.
- Stars < 130 to 100 $M_\odot$ become partial pair-instability SNs that convert to Type Ib or Ic SNs.
- Stars < 100 to 60 $M_\odot$ become Type Ib or Ic SNs preceded by Luminous Blue Variable (LBV) and Woff-Rayet (WR) phases.

2. Massive stars

- Stars < 60 to 20 $M_\odot$ become Type II SNs preceded by a WR phase.
- Stars < 20 to 9 $M_\odot$ become normal Type II SNs.

3. Stars producing Type Ib, Ic, and II SNs

Nine to 130 $M_\odot$ that explode to become either a neutron star, black hole, or some other compact remnant; if the compact remnant has 10 to 25 $M_\odot$ it will become a black hole.

4. Non-supernova stars

Stars less than 9 $M_\odot$ enter a normal red giant phase that changes to a planetary nebula with a central white dwarf remnant.

5. Large blue-white (O, B, and A Harvard Class)

Greater than or equal to 1.5 $M_\odot$; 0.73 % of all main sequence (MS) stars.

6. White dwarfs (F-Class)

1.04 to 1.5 $M_\odot$; 3 % of all MS stars.

7. Yellow dwarfs (G-Class)

0.8 to 1.04 $M_\odot$; 7.6 % of all MS stars.

8. Orange dwarfs (K-Class)

0.45 to 0.8 $M_{\odot}$; 12.1 % of all MS stars.

9. Red dwarfs (M-Class)

Greater than 0.08 to < 0.45 $M_{\odot}$ (star cannot fuse helium); 76.5 % of all MS stars.

10. Brown dwarfs

Greater than 13 Jupiter masses (deuterium can be fused.) to < 0.08 $M_{\odot}$ (temperature is not high enough for nuclear fusion).

11. Planets

Less than 13 Jupiter masses or 0.0125 $M_{\odot}$.

12. Compact star remnants

These objects are small for their masses and are at the end point of stellar evolution. As a star exhausts all it fuel the gas pressure can no longer support the column of weight and the star collapses to a denser state.

- **White dwarfs (0.6 to 1.4 $M_{\odot}$)** -Dwarfs are degenerate matter made of larger atomic nuclei pushed together within a sea of electrons.
- **Neutron stars (1.35 to 2.0 $M_{\odot}$)** -The increasing weight causes most of the electrons to react with protons and form neutrons. A neutron degeneracy pressure supports the star from further collapse.
- **Exotic stars (2 to 10 $M_{\odot}$)** - These stars are composed of something different than normal fermions. A certain degeneracy pressure (or some type of quantum property) prevents complete gravitational collapse.
- **Black holes (10 to 25 $M_{\odot}$for stellar remnants)** - As the mass of the compact remnant continues to increase the star's central pressure can no longer counter-balance gravity and a catastrophic collapse occurs where no energy or light can escape.

B. Main Sequence

Any star that is normally fusing fuel inside its core after its proto-star phases and before it evolves into a red giant phase or variable star phase due to using all the fuel for one or more core burning processes. This main sequence is defined by a band on the Hertzsprung-Russell diagram. This diagram categorizes other smaller populations of stars.

C. Population I

Includes the Sun and are luminous, hot, and young. They are concentrated in the disk of spiral galaxies especially the spiral arms. These youngest stars have the most metallacity and come from the heavy element formation of previous supernovae. This population is only 2 % of the entire population.

D. Population II

Are stars that are older, less luminous, and cooler tending to be found in globular clusters, nuclei of spiral galaxies, and in elliptical galaxies. These older stars have fewer heavy elements and are metal poor.

E. Progenitor Stars

Remnant stars that previously created a CSM from novae, supernovae, SN imposters, and massive stellar winds and eruptions by stars in their variable phase.

F. Supernova Imposters

Stars that appear to explode like supernovas but are only shedding massive outer layers leaving behind a core remnant that is still evolving.

VI. Star Evolution

As a star continues to fuse or burn its elements in the central core in various stages it sheds its outer layers until either a helium flash and red giant phase or a final supernova explosion occurs.

A. Core Burning Processes Inside Stars

As a star becomes older it consumes its fuel in various stages that supposedly produce onion-like layers of different elements around the different burning cores.

1. Hydrogen burning without the CNO cycle

Fusing H and He for the original primordial stars that had no heavy metals such as C, N, or O.

2. Hydrogen burning via the CNO cycle

Fusing H and He inside stars more massive than the Sun that have metals.

3. Helium burning via the triple-alpha process

A set of nuclear fusion reactions by which three He-4 nuclei (called alpha particles) are converted to carbon.

4. Carbon burning process

Fusing carbon to form the main products of Ne, Na, Mg, and Al.

5. Neon burning process

Fusing neon to form the main products of O and Mg.

6. Oxygen burning process

The fusing of oxygen to form the main products of Si, S, Ar, and Ca.

7. Silicon burning process

The fusing of silicon to form nickel, cobalt, and iron where nickel and cobalt rapidly decay into iron.

B. Helium Flash of Core

For stars greater than 0.5 and less than 2.25 solar masses the core consumes all its hydrogen and runaway fusion of helium occurs due to degeneracy or quantum mechanical pressure and not thermal pressure supporting gravitational collapse. The degeneracy pressure finally stops contraction, makes the core hotter, thereby initiating the red giant stage of a smaller star.

C. Hypernovae

The final explosion of a star exceeding 250 more times the mass of the Sun in which photodisintegration is a major factor. Photodisintegration due to its energy absorbing effect reduces pressure and temperature of the star's core and leads to the formation of a black hole with possible jets emitting higher metals into the universe.

D. Luminous Blue Variable (LBV) Stars

Very bright, blue, supermassive, variable stars that exhibit long slow changes in brightness during substantial mass loss events and are extraordinary rare. Typical examples are S Doradus, Eta Carinae, and P Cygni.

E. Novae

Nuclear explosion in a star caused by accretion of hydrogen on the surface of a white dwarf from a companion star. A white dwarf can have multiple novae over time. If the Chandrasekhar limit of mass is exceeded than a Type Ia SN occurs.

F. Nucleosynthesis (Stellar)

processes internal to the star that create all the synthetic elements of the universe after the Big Bang elements are produced.

G. Pair-Instability Supernova

A supernova that occurs when pair production of free electron and positrons in a collision between atomic nuclei and energetic gamma rays, reducing thermal pressure inside a super-massive star core. The pressure drop leads to a runaway thermonuclear explosion that blows the star completely apart without leaving behind any remnant. Pair-instability can only happen in the mass range from about 130 to 250 solar masses with low metallacity such as is common with Population III stars.

H. Photodisintegration

High energy gamma rays interact with atomic nuclei which emit subatomic particles. Single protons or neutrons are effectively knocked from the nuclei by incoming gamma rays. This process creates fission, the opposite of fusion and is energy absorbing.

I. Radiation Pressure at Star's Surface

Begins to strip off outer layers for stars $> 40\ M_{\odot}$ and expulsion rates limit star with metallacity to sizes of $\leq 120\ M_{\odot}$.

J. Red Giant Phase

Smaller stars from 0.5 to 10 $M_\odot$ during end of life expand their outer layers during the end of hydrogen consumption within the core.

K. Stellar Winds and Eruptions

Stars near end of life expel large amounts of material from their surface either by steady, slower winds or by more violent, faster global eruptions.

L. Supernovae

Stars that explode at the end of their lives usually leaving behind a supernova remnant such as a neutron star or black hole.

1. SN imposters

an explosive event that appears to be a supernova but leaves behind a normal or variable star which is having pre-supernova violent eruptions.

2. Type Ia

A supernova resulting from a binary with a white dwarf star accreting mass from a companion star which reaches the Chandrasekhar limit of about 1.4 solar masses before exploding.

3. Types Ib and Ic

Supernovae of progenitor stars that have most of their outer envelopes stripped due to strong stellar winds and violent eruptions and are preceded by Wolf-Rayet stars. Type Ibs are stripped mostly of their hydrogen layer whereas Ics are stripped mostly of both layers of H and He.

4. Type II

Supernovae that are aging massive stars that ceased generating energy from nuclear fusion and suddenly undergo gravitational collapse becoming either neutron stars, black holes, or dwarf stars, or other compact object.

M. Wolf-Rayet (WR) Stars

Evolved massive stars that are over 20 solar masses initially and are losing mass rapidly by means of strong stellar winds and/or randomly violent eruptions.

1. WC type

A sequence of WR star with broad emission lines of He, C and O.

2. WN type

A sequence of WR star with broad emission lines of He and N.

3. WO type

A sequence of WR star with broad emission lines of He, C, and 3 or more isotopes of O.

VII. Interstellar Mediums (ISMs)

A. Circum-Stellar Medium (CSM)

Matter ejected from a star and surrounding it in various rings or shock fronts created by either stellar winds, eruptions, or major explosions including the final supernova.

1. Planetary nebulae

Matter surrounding a star created by a nova and/or the dispersion of the red giant phase.

2. Supernova remnant (SNR)

Matter surrounding a progenitor star remnant created by a supernova or its imposter.

B. H I Regions

Interstellar clouds composed of neutral atomic hydrogen with temperatures about 100^{o} K.

C. H II Regions

Large, low density clouds of partially ionized hydrogen around 8000^{0} K. where star formation is known to take place. Spiral arms and irregular galaxies contain these regions whereas elliptical galaxies have hardly any.

D. Interstellar Medium (ISM)

Matter that exists between the star systems in galaxies.

1. Cold neutral medium (CNM)

ISM composed of neutral atom of hydrogen displaying HI 21cm line emission between 50^{0} and 100^{0} K.

2. Warm ionized medium (WIM)

ISM composed of ionized hydrogen emitting Hα and is greater than 8000^{o} K.

3. Warm neutral medium (WNM)

ISM composed of neutral hydrogen atoms displaying a HI 21cm line emission between 6000^{o} to $10{,}000^{o}$ K.

4. Hot ionized medium (HIM)

Typically coronal gas at 10^{6} to 10^{7} degrees K. with both ionized hydrogen and metal. X-ray emission display absorption lines of highly ionized metals.

E. Molecular Clouds

A type of interstellar cloud at 10^{0} to 20^{0} K. whose density and size permits the formation of molecules, most commonly molecular hydrogen (H_2). Molecular hydrogen is difficult to detect by infrared and radio observations, so the molecule most often used to determine the presence of H_2 is CO (carbon dioxide).

1. Bok globules

Isolated gravitationally bound small molecular clouds, 2 to 50 $M_{\odot}$, resulting in formation of new stars and star clusters found in H II regions of the galaxy.

2. Giant molecular clouds (GMC)

Assemblage of molecular gas at $10^2 - 10^3$ parts/cm^3, 50 to 300 light years in diameter, and at 10^o to 20^o K.

3. Pillars of Creation

Columns of molecular clouds being dispersed by and penetrating various shock fronts of supernova or severe eruptions of stars.

F. Nebulae

Interstellar clouds of dust, hydrogen, helium, and other gases both ionized and neutral.

1. Dark nebulae

Clouds that are opaque and absorbing radiation.

2. Emission nebulae

Clouds that are emitting light from nearby or internal stars or proto-stars.

3. Planetary nebulae

The remains of novae and red giants.

4. Proto-disk nebulae

A cloud of material, sometimes a disk structure, which is collapsing to form a proto-star.

5. Supernova remnants

The remains of ejecta surrounding a supernova.

VIII. Galaxies

A. Circum-Galactic Medium (CGM)

Halo stars that are much older with lower metallicities and non-observable matter.

B. Dark Matter

The majority of mass that makes up galaxies and interacts gravitationally but is not directly observable.

C. Dwarf Galaxies

a**A**relatively small grouping of stars about 1/100 the size of the Milky Way that are about 100 parsecs across and generally orbit large galaxies.

D. Elliptical Galaxies

Giant, generally elliptical shapes of old stars, considered to be the first type of galaxy.

E. Galactic Streams

Streams of matter, mostly cold hydrogen that connect galaxies that have either collided or had close encounters. One such stream is the Magellanic connecting the Large Magellanic Cloud with the Milky Way.

F. Globular Clusters

Large clusters of stars that are old and metal poor which surround the perimeters of both elliptical and spiral galaxies.

G. Inter-Galactic Medium (IGM)

Matter that exists between clusters of galaxies.

H. Irregular Galaxies

A type of galaxy that is not readily classified into any particular scheme such as the Milky Way's neighboring Magellanic Clouds.

I. Spiral Galaxies

Large groupings of stars in the shape of a thin disk with spiral arms and a central bulge. These are the younger star-forming galaxies.

J. Lenticular Galaxies

An intermediate form having properties of both elliptical and spiral types.