The sun was a red giant 4.6 billion years ago - the planets were born from the solar wind of the red giant sun.

Abstract

How the solar system formed, is a puzzle that challenged scientists for many centuries. The current accepted theory is the Solar Nebula Hypothesis originated by Kant and Laplace in the 18th century. In reference 1 it was suggested that the sun energy source is not fusion but magnetic fields from the center of the galaxy. The Solar nebula Hypothesis cannot coexist with a sun powered by magnetic fields. As shown on reference 4, those magnetic fields create mass that slowly increase the mass of the sun. The sun is growing not from dust from the interstellar space but from synthesis of new particles in the sun interior. The sun and the planets formed separately, the sun came first and then the planets follow.

In the standard solar model stars are turned into red giants when the hydrogen in their core is depleted and the energy production stop. Stars do not work on fusion, but on magnetic fields, so they turn into a red giant when their energy supply from the magnetic field is stopped. Stars that have a very long Maunder minimum, for tens of million of years, in which their stellar cycle is weak, will turn into a red giant.

The exoplanet search programs found that stars with planets have higher metallicity compared to stars without planets. The metallicity of a star depends on its mass. Massive stars have higher pressure and temperature in their core that increase the fusion rate of heavy elements. Stars with planet, that show higher metallicity, had higher mass in the past that created the high metallicity. They went through a significant mass loss that decreased their mass but did not change the high metallicity. Those stars significant mass loss occur when they turned into red giants. Red giants have strong stellar wind that disperses the star outer layers into interstellar space. This stellar wind creates comets that form planets around the star. The high metallicity of the sun indicates that it was a red giant. The solar planets where born from the solar wind of the red giant sun. The solar system shows many evidences in support of an ancient red giant sun.

The energy calculation in reference 4 suggests that stars are slowly growing by converting the energy from the magnetic fields to mass. The gradual mass increase indicates that more massive stars are also older, so according to the standard solar model there is a mix up between older and younger stars. Older stars are not the smaller stars like red dwarfs but the heavier stars like blue giants. The idea that stars are slowly growing from small sizes, and the fact that the latest exoplanet search programs found large number of exoplanets, leads to the conclusion that stars originate from planets. The development steps leading to the creation of stars from planets include: growth of the planet by cold accretion of comets and asteroids; separation of the planet from the star; magnetic ignition of the planet when it reaches the size of a brown dwarf; and growth of the star by conversion of the energy from the magnetic fields to mass.

Introduction

The sun energy source is magnetic fields that propagate in the galactic disk from the supermassive black hole at the center of the Milky Way galaxy. The hypotheses that the energy source of stars is fusion of hydrogen and other light elements caused the development of incorrect stellar evolution and planet formation. The evolution of stars according to the Standard Solar Model and the formation of planets according to the Solar Nebula Hypothesis will be described shortly together with the flaw and inconsistencies of those theories. The stars are believed to originate from the collapse of dust and gas clouds of the interstellar space, first into stellar nebula and then into a young star or protostar. The birth of new stars is taking place in areas of dense clouds of gas and dust like the Orion nebula that accommodate many O and B type stars.

The evolution of stars depends on their mass. Low mass stars, with mass below 0.5 the sun mass, have low luminosity and will burn their fuel for hundreds of billion of years. When the star consume its fuel, it will collapse into a white dwarf directly if it is of very low mass, or will turn first to a red giant and then to white dwarf.

Medium mass stars like the sun will burn their fuel for about 10 billion years. It first burns the hydrogen and fuses it into helium. The helium accumulates and sinks to the core, so the mass of the core increase by the heavier helium. The helium and hydrogen layers above the core compress and their temperature increase. The hydrogen fusion is then continuing in higher rate that increase the star luminosity. Further contraction causes the helium in the core to start fusion by the triple alpha process to create carbon atoms. When the helium is depleted the star turn into a red giant, it loses much of its mass to stellar winds and then turns into a white dwarf.

Massive stars will burn their fuel very fast and will develop a layered structure where at each layer different elements will fuse. In the outermost layer hydrogen will fuse, then in the layer below it helium, then carbon, neon, oxygen, silicon and at the core iron will sink. Iron cannot fuse further to other elements because it is in the lowest energy state. At the end of its life the massive star will explode in supernova to create a neutron star or a black hole.

This evolution also determine the stellar ages, low mass stars like red dwarfs are considered of old age since they consume their fuel very slowly and will take hundreds of billion of years to consume all their fuel. Blue giants are considered to have young age since they will deplete all their fuel in several million years. Areas in the galaxy where blue giants are found like in the Orion nebula are considered a place of young stars and birthplace for new stars.

The planets orbit around the sun in the same direction and also the spin of the planets or their rotation around their axis is generally in the same direction. This uniformity in the orbit and rotation led to the development of the Solar Nebula Hypothesis in the 18th century by Immanuel Kant, and Pierre-Simon Laplace. This hypothesis suggests that a giant molecular cloud contracted and flattened by its rotation to form a protoplanetary disk. The fast contraction increased the temperature of the disk and formed a hot protostar at the center of the protoplanetary disk. The high temperature of the protostar started a fusion reaction, in which the hydrogen was fused into helium to supply energy to keep the star shining for billion of years. The formation of the planets is from the dust left after the formation of the sun. This dust stuck together by electrostatic forces to form first small bodies and then comets that grew by accretion of further material, those merge together through collisions to from the planets.

There are many problems and contradictions to the solar nebula hypothesis. First, there is the problem of the angular momentum; the planets hold 99% of the solar system angular momentum, so the sun holds only a small part of it. If the solar system collapsed from a dust cloud, then the sun should conserve this angular momentum and hold larger portion of the angular momentum. Also, observations of dust clouds like those in the Orion nebula show that the density of those clouds is too low to enable the cloud to collapse. In order for the cloud to collapse there are thresholds known as the Jeans radius and the Jeans mass that only if the cloud exceed them it will continue to collapse. There are no clouds of such high density, so they cannot collapse according to the solar nebula hypothesis. Another point that contradicts the solar nebula hypothesis is that there is no observational evidence of protoplanetary disks that form blue giants. Blue giants can be fifty time more massive then the sun so there protoplanetary discs should be a gigantic structures. Such structures are not observed anywhere despite an extensive search. The blue giants should have a short life so a large number of those protoplanetary disks should be observed.
Observations of exoplanets also undermine the solar nebula hypothesis. There are observations of planets that circle neutron stars and there are many planets with high eccentricity.

The latest observations of exoplanets revealed hundreds of planets orbiting other stars. The first exoplanet was observed in 1995 by Michel Mayor and Didier Queloz of the University of Geneva orbiting the star 51 Pegasi. Later, research groups were assembled like University of California Planet Search Project and The Geneva Exstrasolar planet Search Programs. Those groups found more then 400 planets. The detection methods of planets are limited and usually find only large planets with small radius orbits, so the planets found so far are only small fraction of the total number of planets. Overall, planets are common and found in large number in the Milky Way. The total number of planets in the Milky Way could be of the order of tens or hundreds of billions.

In references 1, 2, 3, 4 it was shown that the energy source of the sun and other stars is not nuclear fusion. The stellar cycle originate from magnetic fields in the galactic disk. The stellar cycle is not generated in the star interior but is induced by the galactic disk. The galactic disk spread eddies of magnetic fields through the galactic disk and supply energy to the stars. The source of the magnetic fields eddies is the supermassive black hole at the center of the galaxy. Matter is constantly falling forcefully in relativistic speeds to the supermassive black hole where it produces magnetic fields by the dynamo effect. The source of the matter that fall to the supermassive black hole is the stars. The stars by their stellar winds, coronal mass ejection and supernova release matter to the galactic disk that later reach the supermassive black hole. In this way the stars feed the supermassive black hole with matter and the supermassive black hole feeds the stars with magnetic fields. This creates an energy cycle in the galaxy that produces new matter and energy. The number of stars in the galaxy increase and this leads to spawning of new galaxies through globular clusters. According to this theory the stars convert energy to mass as was shown in reference 4. Since the stars constantly produce mass they grow larger. The stars are growing along the Hertzsprung-Russell diagram. The stars start as brown dwarfs and constantly grow along the main sequence.

The fact that the exoplanet search programs showed the large number of planets and that many of them reach a considerable size of up to 12 Jupiter masses shows that the planets are the first stage in the development of stars. There is continuity in the mass of planets and stars, and objects of all masses are observed in the galaxy. Small objects like planets, brown dwarfs and red dwarfs are found in large numbers. This continuity in mass, support the idea of gradual growth by magnetic fields - from planet to brown dwarf to red dwarf and to a high mass star. Above the size of a brown dwarfs the star is growing by converting energy from the magnetic fields to mass, below the size of a brown dwarf the planet is growing from cold accretion by absorbing falling dust, micrometeorites, meteorites, comets and asteroids.

The fact that stars grow by converting the energy from the magnetic fields to mass, invalidate the solar nebula hypothesis. The stars are not born to a fixed mass but grow slowly. This is similar to living things on earth that grow slowly by collecting energy in the form of food. The stars are doing the same thing; they grow slowly by collecting energy in the form of magnetic fields.

There is a mix up between young stars and old stars

According to the standard solar model the source of the sun energy is fusion of hydrogen to helium. According to this model the sun and other stars carry internally within them their fuel, and slowly consume it to produce their heat and luminosity. In this view stars are like candles; when they burn, they slowly consume the wax and get shorter. Knowing the size of the star can give estimate to the amount of fuel or energy the star carry. Also, the luminosity of the star indicates the amount of energy the star consumes. Combining those two factors, the fuel it carries and the consumption rate, it is possible to estimate the maximum age of the star. It turn out that small stars like red dwarfs that their luminosity is week can have much longer lives then blue giants of spectral type O and B. The blue giant luminosity is so high that they suppose to finish their fuel in tens of millions of years. The red dwarf on the other hand can live for hundreds of billion of years. Therefore, whenever a group of blue giant stars is observed, it is believed that the stars are of young age simply because they die young and never reach an old age. For red dwarfs it is always believed that they are old. The metallicity of stars is also believed to effect the age of the stars. The metallicity of the universe is believed to increase from supernovae that disperse heavy elements to the interstellar space, so as time passes the metallicity of the galaxies and universe is increasing. According to this idea, the higher metallicity of young O and B stars compared to older and smaller stars is the result of the age difference. Red dwarf that usually come with low metallicity are regarded old, reflecting the low metallicity of the universe long ago at their birth.

Hertzsprung-Russell diagram shows the luminosity of the stars versus their spectral class or color. Plotting many stars on this diagrams, for instance, stars from the Hipparcos catalog shows that most stars are found along a curve called the main sequence that elongate from a low luminosity and red spectra to high luminosity and blue spectra.

According to the solar nebula hypothesis the stars are created by large clouds of gas and dust, that when contracted, reach very high temperature that enable fusion to start. Under the Solar Nebula Hypothesis the stars fall to the main sequence in a predetermined mass, their mass is staying roughly the same during their life. The stars also occupy the same point on the Hertzsprung-Russell diagram until they turn into a red giant.

However, the Standard Solar Model is incorrect and the Solar Nebula Hypothesis that relies on the standard solar model is also deficient. The stars energy source is not fusion but magnetic fields from the center of the galaxy. Stars gain their mass by converting energy to mass, so more massive stars require more energy and more time to collect this energy, therefore more massive stars are more likely to have older age. This is similar to biological life on earth; a small puppy is younger then a fully grown dog. In both stellar evolution and biological life, larger size means older age.
In reference 4, it was shown that the energy supplied the sun can be calculated from the magnetic fields of the solar cycle as measured by the probe Ulysses. The energy that stars receive from magnetic fields can be calculated with the following formula derived in reference 4.

$$P = 1.89 \cdot 10^{-3} \cdot T^{3/2} \cdot \left(\frac{\Delta Bstar}{\Delta t}\right)^2 \cdot R^5 \qquad (1)$$

Where:

P - Is the energy per time or power that the star absorbs from the magnetic fields.
T - Is the star temperature at 0.7 of its radius.
Bstar - Is the magnetic field of the stellar cycle.
R - Is the star radius.

Most energy that the star absorbs is converted to mass according to Einstein formula:

$$E = MC^2$$

It is found that the sun is producing about 10^11 Kilogram per second of new mass. This means that stars are slowly growing by producing new mass. The stars are climbing along the Hertzsprung Russell diagram, they start with low mass as a brown dwarf and slowly gain mass. As they grow, their luminosity is increasing and their spectral class is changing to be of shorter wavelength. The more massive the star is, the older its age, as it took longer time to produce its mass from the magnetic fields.

Dividing the mass of the star by the rate it produces new mass can give a rough estimate of the star age. Doing this calculation for the sun gives an age of 550 billion years (Reference 4). As long as the magnetic fields keep supplying energy to the star it will keep on shining. Most stars will live for a very long life and die when the magnetic fields stop supplying energy for a long period. The star will then turn into a red giant and then to a white dwarf or a neutron star. It requires extreme conditions of no energy supply to cause a star to die, so stars will rarely die. The fact that stars rarely die drives the expansion of the universe. Stars are constantly added to the universe and only small fraction of them ever dies. This leads to creation of new galaxies and the rapid expansion of the universe.

The age of the stars depends on their surroundings. In the Milky Way galactic bulge there are stronger magnetic fields than in the Milky Way galactic disk. Therefore, a star in the galactic bulge will grow faster then a star in the galactic disk. The stars in the galactic bulge will on average reach a larger mass then a star in the galactic disk, since the stronger magnetic fields will enable them to sustain a larger mass. If you take two stars of equal mass one from the galactic bulge and one from the galactic disk, the chances are that the star from the galactic bulge will be younger since it grew faster.

The turnoff point in the Hertzsprung-Russell diagram of globular clusters is not determined by the age of the cluster. Every globular cluster has a heavy object in its center like an intermediate sized black hole or a group of neutron stars that produces energy for the globular cluster. The stars in the globular cluster emit gas and dust by their stellar wind that is collected by the black hole. The fall off material to the black hole create magnetic fields that spread to the stars in the globular cluster. The globular cluster is also receiving both gas and magnetic fields from the nearby galaxy. The turnoff point of the H-R diagram of the globular cluster is determined by the amount of energy in the form of magnetic fields that is available to the globular cluster. Globular clusters that get strong magnetic field and a lot of energy form their black holes will shine forcefully and will have higher turnoff point. Globular clusters with weak energy source will produce red dwarfs and its larger stars will turn into red giants. Few of the globular cluster - and only those with strong energy source - will evolve slowly into dwarf galaxies. The globular cluster with strong energy source will produce more stars and grow bigger to the point that they will be repelled from the main galaxy and form a new dwarf galaxy. The repulsion force is created by magnetic fields and it is similar to the repulsion between a superconductor and a magnet.

Stars originate from planets

There are observations of opaque disks circling many stars that seem to validate the idea of protoplanetary disks and formation of the solar system by the solar nebula hypothesis. The Infrared Astronomical Satellite IRAS and the Hubble space telescope were used to observe many of those disks. There are photos of those disks, for instance, in the Orion nebula and of star HR 4796A that show clearly a disk circling a star. However, according to the solar nebula hypothesis dust and gas should fall to the central star and extensive quantities of inflowing matter should be detected. Those inflows, if existed, could be easily detected with a spectrometer. In the stars with the opaque disk, however, inflows are rarely observed and the dust and gas show outflows instead. Even in T-Tauri stars there are no inflows of matter but only outflows. The fact that matter is not falling to the star but instead is flowing away from the star suggests that those disks are not protoplanetary disks but debris disk. Those debris disks are from matter ejected by the central star or captured from a neighboring stars. Some of the disks could be the result of a collision between planets, or between large asteroids or comets in the stellar system that disperse dust and small rocks, similar to what is found in the solar system asteroid belt. The disk around the star Vega is an example of a debris disk. The stars eject matter by their stellar wind and in some stars, like blue giants and red giants, the stellar wind is much stronger then the sun solar wind and this strong stellar wind eject matter that is condensing around the star. The Orion nebula has many blue giants that eject large quantities of dust and gas that reach the smaller stars in the Orion nebula. The blue giants in the Orion nebula eject fast and massive stellar winds that collide with the stellar wind of smaller stars. This creates bow shocks around the smaller stars from collision of the opposite stellar winds. Therefore, many of the images of the Orion nebula protoplanetary disks are bow shocks created by stellar winds.

In references 1 and 4 it was shown that the sun energy source is not fusion. Instead, it was suggested that the supermassive black hole at the center of the galaxy propagate magnetic eddies to the galactic disk that heat the stars. The sun receives this energy in the form of the solar cycle. The magnetic field polarity of the sun is changing every 11 years and this change induces electric current that by ohmic heating supply energy and heat to the sun. The magnetic fields of the sun are found to be open. They do not emanate from one pole and loop to the other pole; instead they stretch far into the Galaxy. The heat produced by the magnetic fields increase the speed of particles inside the sun. This leads to high speed collision between particles and like in a particle accelerator the collisions create new particles. This way, new particles are added to the sun and the mass of the sun increase. In reference 4 the amount of energy the sun absorb form the magnetic fields was calculated, and conversion of this energy to mass gives the growth rate of the sun to be about 10^11 kilogram per second. This calculation reveals the source of the stars mass, and the fact that they slowly grow by themselves from the energy they absorb from the magnetic fields. The solar nebula hypothesis is therefore rejected as the source of the star mass and star birth, so it can be replaced with a theory that rely on gradual growth from energy supplied by the magnetic fields. In stellar system like the solar system the creation of the star must be separated from the creation of the planets to give a dualistic origin. The star is created first and grows gradually from the magnetic fields to reach a considerable mass. Then the planets, under the influence of the star gravity, are slowly growing from accretion of nearby objects and matter. The material that is used to build planets is coming from the stellar wind ejected by the same central star and by nearby stars.

The idea that stars are born from planets is based on the latest observations of exoplanets conducted by the exoplanet search programs. There are 400 exoplanets found so far. The leading observation techniques, the use of spectroscopic wobbling and flyby shedding, limit the finding only to massive planets. Definitely there are many planetary systems with less massive planets that will be discovered with improved probes like the Kepler telescope. The amount of planets in the galaxy is therefore very large and is comparable to the number of stars. Some of the exoplanets found are very big of the size of 10 or higher Jupiter mass as shown in figure 4. Planets of 10 Jupiter mass, or higher, are just below the minimum mass of a Brown Dwarf of 13 Jupiter mass. Those 10 Jupiter mass planets therefore represent the evolutionary link between planets and stars or brown dwarfs. (The term "10 Jupiter mass planet" will henceforth represent the largest planets that are an evolutionary link between planets and a brown dwarf.) There are also observations of brown dwarfs that are also found in large numbers. In the galaxy there are planets in large number, 10 Jupiter mass planets in large numbers, brown dwarfs in large numbers and the red dwarfs are the most abundant stars. There is a continuum of objects in all the masses from planets to stars and in large numbers. This continuum leads to the idea that all the objects from planets to stars gradually grow, and that stars are born from planets (Figure 1).

Dust will first clump in space due to electrostatic forces. The dust wanders around freely, so there is collisions and friction between the dust particles that stick them together by electrostatic attraction. This was shown with experiments on the space shuttle done by NASA, especially the Cosmic Dust Aggregation Experiment – CODAG. Collision, and particularly of icy objects will also contribute to the growth of larger bodies. When small gravels containing ice collide, the ice will melt from the impact and then freeze again to hold the two objects together. This tendency of dust and gravel to stick together leads to formation of larger objects like comets. With the Deep Impact mission, a large impactor was slammed into comet Tempel 1, to find that the comet contains debris of various composition loosely held together. Another process that enables growth of small objects is cementation. Mixture of water, ice, dust and gravel can be hardened by chemical reaction between the dust and the water. The loosely packed object will then turn into a solid rock that will stand impacts in space.

As objects grow in size their gravity increase and they collect more material and comets from their vicinity that will create object of considerable size. Large objects in the Kuiper belt like Pluto and Eris, are collection of rocks, ices and debris from the Kuiper belt. Those dwarf planets were cold accreted during along time. The large cold accreted objects are then captured by planets and the central star to create moons and new planets. There are many examples of captured moons in the solar system, for instance Neptune moon Triton. Large objects or asteroids captured by the star will form planets and will start to collect matter from asteroids and comets, meteors, and micrometeorites. The planet will gradually cold accrete material and will grow in size. Planets collect much more material due to their orbit around the star. The planet moves around the star, so it sweeps material from larger area. It also collects material from asteroids and comets falling to the central star. The amount of material the planet accretes is therefore proportional to the mass of the central star the mass of the planet and the orbit perimeter. Higher Orbital velocity will decrease the accretion rate since objects moving at high speed are less likely to be influenced by the gravitational force. The outer planets in the solar system have higher accretion rate then the inner planet since their Orbital velocity is slower and they sweep larger area due to the large radius of their orbit. Therefore, the outer planets grow faster then the inner planets.

Planets are growing much faster when they rotate around a central star and not free floating in space. The growth of object to a considerable size is possible without a central star but it will take much longer. Such free floating planets are observed in the Galaxy, for instance in the Orion nebula. Those free floating planets will be much likely to collide with other objects or be captured by nearby star. In the stellar system while orbiting a central star the planet will grow very fast until it will reach the size of 10 Jupiter mass planet. There are even observations of objects in the size of brown dwarf circling a main star. One of these observations is the Object GI229B which shows a brown dwarf orbiting a star of type M. Not all planet will grow continually, some will be destroyed by collision with other planets, and some might fall to the central star. In summary, for a planet to evolve into a star it first must be part of a stellar system and orbit a central star; free floating planets are less likely to evolve into a star and will take much longer to do so.

Some areas in the galaxy are known as stellar nurseries. Those areas like the Orion nebula contain both massive stars like O and B type blue giants and huge clouds of dust and gas. It turn out that the stellar nurseries according to the Solar Nebula Hypothesis are also the stellar nurseries according to this theory. The massive stars in the stellar nurseries are the catalyst that creates new stars. This is for the following reasons: First, the massive stars eject powerful stellar wind; this stellar wind is then cold accreted to create the mass of the planets and help them grow quickly. Second, the massive stars with their strong gravity can pull and tug on nearby stellar systems. This will disintegrate the stellar systems and release the planets or 10 Jupiter mass planets from their central star and eject it into space. Third, the area of the massive stars is saturated with strong magnetic fields. Those strong magnetic fields can supply energy to the brown dwarfs and help them grow by converting energy to mass.

The dust and gas in the stellar nurseries is not what created the massive stars. It is the opposite; the massive stars by their powerful stellar winds create the dust and gas clouds. Over billions of years those gas and dust clouds grow to a huge size that dwarfs the stars that created them.

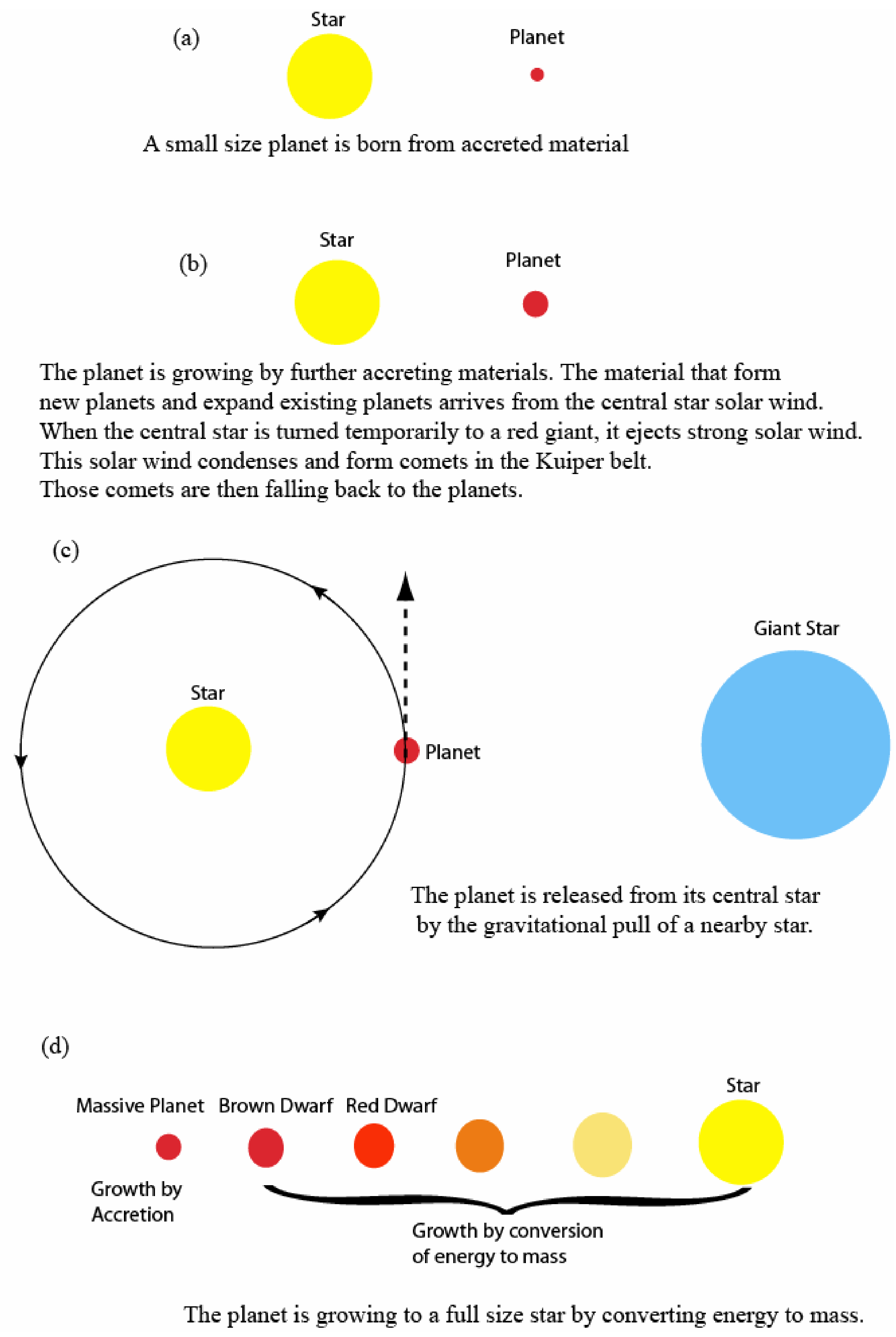
The Milky Way galactic bulge and the galactic arms are areas of rapid star birth. Those areas have strong changing magnetic fields that increase the luminosity of the stars in those areas. The strong changing magnetic fields increase the mass ejected by the stars through their stellar wind and by that help to create new planets that grow quickly to stars.

The planets around stars can grow to a considerable size in the stellar systems and as observation shows reach the size of 10 Jupiter mass planets (Figure 4). In order for the planet to grow into a separated star it need to be ejected from the stellar system. The main way the planet is released from the central star is a gravitational pull from a nearby star. The area of the stellar nurseries is very crowded and contains stars in close proximity. This help to release the planets as one star can get close to a nearby stellar system and cause a disturbance that will cause a planet from the stellar system to be ejected into outer space (Figure 3). The area of stellar nurseries like the Orion nebula contains many free-floating planets and brown dwarf that show that ejection of a planet from a stellar system is common in those areas. A large 10 Jupiter mass planet can develop a large magnetosphere; this magnetosphere will interact with the stellar wind in a way that a repulsion force will be created between the star and the planet that will help to separate the planet from the star. Not all planets will get separated from their central stars and this will create a binary star. In a binary the distance between the star and the planet will increase from the interaction of the stellar wind and the magnetosphere but they will maintain their original configuration and circle each other. Binaries are very common in the galaxy and this support the idea that planets are growing into stars. A stellar system composed of a central star and a planet can easily turn into a binary if the planet grows to a star.

In order for a planet to grow into a star, mass must be added to the planet at all stages of its evolution. At all points of its growth, from a planet to a 10 Jupiter mass planet to a brown dwarf to a red dwarf and then to a full star, mass is added to the planet that cause it to continually grow (Figure 1). At the beginning of its life the planet is growing from accreting material from its surroundings. This material comes in the form of comets, meteorites, asteroids and micrometeorites that are attracted by gravity to the planet. There is the example of comet shoemaker-levy 9 that fell to Jupiter in 1989 that demonstrates the growth of a planet from accreting material. As will be shown in next sections, the material that falls to the planets and increases their mass is coming mainly from the central star that the planet encircles. The central star stellar wind ejects material to the far regions of the stellar system. Those regions are like the Kuiper belt and Oort cloud of the solar system. The stellar wind is condensed at those regions and create comets and asteroids that later fall to the planets. The comets and asteroids fall to the planets mainly through the ecliptic plane so the outer planets receive most of the material while the inner planets receive smaller portion. At the last stage of its evolution, when the star is fully grown, it gains mass by converting the energy of its stellar cycle magnetic fields into energy as was shown in reference 4.

At some point of its evolution, as the planet grows, the source of its mass is changed from accretion to conversion of energy to mass. Brown dwarfs are the point where the star growth switches from accretion to conversion of energy to mass. At sizes below that of a brown dwarf the growth of the planets rely on accretion and at sizes above that of a brown dwarf the star convert energy to mass. The red dwarfs are the most common star in the galaxy and about 80 percent of all stars are red dwarf. The red dwarfs constitute a large portion of the galaxy mass. Certainly all the hefty mass of the red dwarfs cannot be from accretion. Therefore, the point where stars begin to produce their own mass must be below the red dwarf size and around the brown dwarf size. Brown dwarfs are also producing their own light or luminosity so they must have an energy source that produce heat - the magnetic fields of their stellar cycle.

The point where the planet starts to produce its mass by converting energy to mass depends on the region of the planet. Near blue giant at stellar nurseries there are powerful changing magnetic fields that will heat even a planet like a 10 Jupiter mass planet. The point where the planet will start to produce its own mass at those areas will be when the planet is in the size of a 10 Jupiter mass planet and not a brown dwarf. Stronger magnetic fields will ignite a lower mass planet.



A small size planet is born from accreted material

The planet is growing by further accreting materials. The material that form new planets and expand existing planets arrives from the central star solar wind. When the central star is turned temporarily to a red giant, it ejects strong solar wind. This solar wind condenses and form comets in the Kuiper belt. Those comets are then falling back to the planets.

The planet is released from its central star by the gravitational pull of a nearby star.

The planet is growing to a full size star by converting energy to mass.

Figure 1 – The growth of a star from a planet. The star starts its life as a small planet around a star. (a) The planet is born from cold accretion of material like large comets and asteroids. (b) In its trajectory around a star the planet accrete more material. This material is mainly from the stellar wind ejected by the central star or nearby stars. The stellar wind is condensed far from the star to form comets. The comets, then, under

the influence of the star, return to the stellar system and are captured by the planet gravity. As the planet is growing it can reach a size ten times the mass of Jupiter. (c) The planet is released from its central star by the pull of a nearby star mainly in areas of high density of stars like the Trapezium cluster in the Orion nebula. (d) When the planet reaches the size of a brown dwarf it grows from conversion of energy to mass and climb slowly along the main sequence.

The electrical resistance of a conductor depends on its cross section. Thicker conductor will have a smaller resistance. This is also true for the stars. The changing magnetic fields induce currents inside stars. The amount of energy the star absorbs depends on the resistance of its internal plasma layers. For a small planet the cross section that conducts electricity is small so the resistance is high and the energy it absorbs is small. As the planet grows to the size of a brown dwarf the cross section of its internal layer is larger so the resistance is low and the energy absorbed is high. This way as the star grows it will absorb more energy and some of this energy will be converted to mass.

As the star produces mass its size grow and it absorb more energy from the changing magnetic fields. Both the luminosity of the star and its spectral type evolve. Its color is shifting from red to orange to yellow to blue and its luminosity is increasing substantially. Plotting the absolute magnitude of a star against its spectral type as it evolve and gain mass will give a graph identical to the main sequence of the Hertzsprung-Russell diagram. During its life the star will follow the main sequence along the H-R diagram, it will start on the lower right corner as a brown dwarf and red dwarf and will proceed to the upper left side as its mass increase. Plotting thousands of stars in the H-R Diagram gives the graph of the evolution of a single star, because the many stars population contain stars at all masses at all stages of the star evolution. In figure 2 there is a graph of the absolute magnitude against spectral class of a single star as it grows and evolves. The shape is similar to an H-R Diagram. The star evolution starts at the lower right corner when the star is a planet. At this point the spectrum of the planet is infrared with long wavelength so the spectral type is extending sharply to the right corner. The infrared luminosity of the planet is very low so the absolute magnitude is near zero. As the star reach the size of a brown dwarf, it starts to receive energy from the magnetic fields and convert energy to mass, so its absolute magnitude is rising and it starts to emit light in the visible spectrum. The star evolution is then continuing along the main sequence as its mass increase and its spectral class and absolute magnitude evolve accordingly.

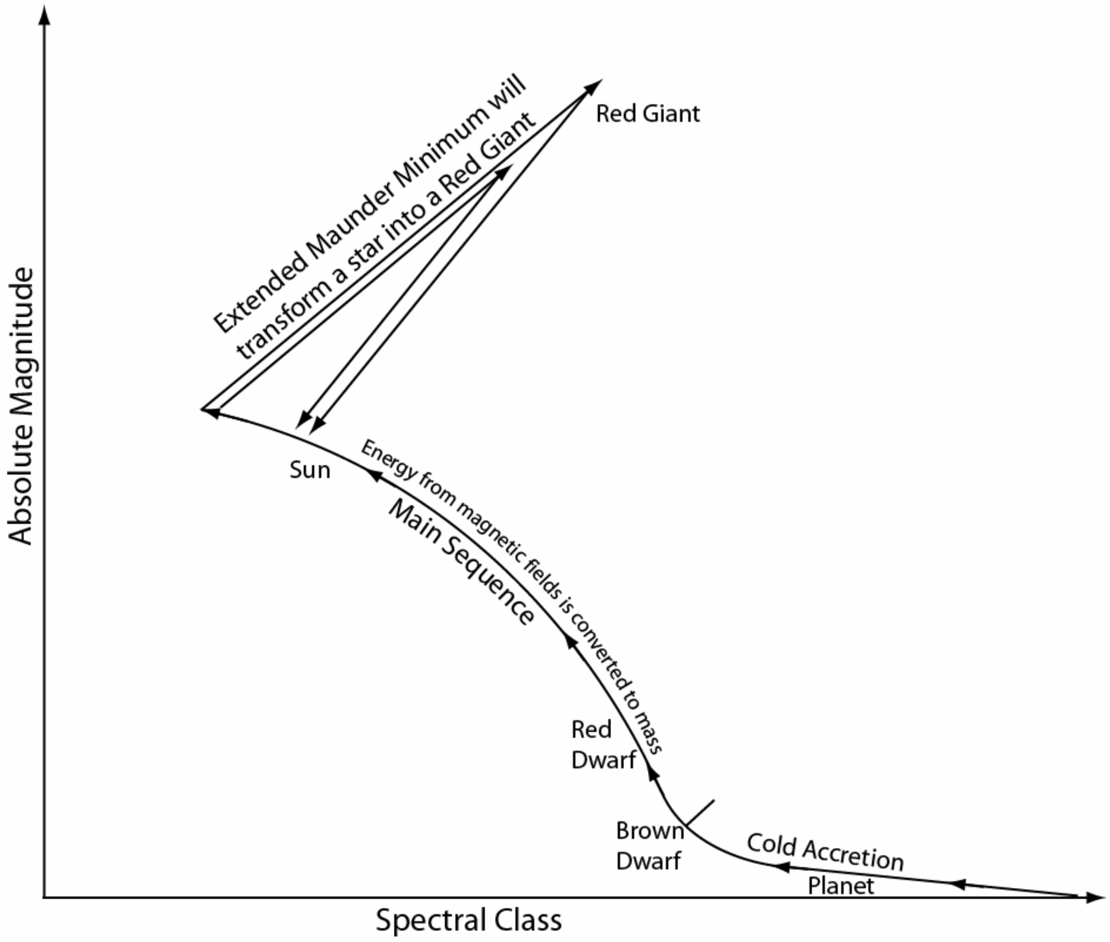


Figure 2 - The Hertzsprung-Russell diagram not only describes the distribution of the stars population, but it also shows the evolution of a single star as it mass and luminosity increases by conversion of energy from magnetic fields to mass. This is a schematic view of the growth of a single star in the coordinates of its spectral type and absolute magnitude. The star starts its life as a small planet at the lower right corner of the diagram. It slowly grows from cold accretion of comets and asteroids. When the planet is near the size of a brown dwarf it is ejected from the stellar system by a gravitational pull from a nearby star. At the size of a brown dwarf the star develop a stellar cycle and it is heated from the magnetic fields of the stellar cycle. Some of the energy absorbed from the magnetic fields is converted to mass, so the brown dwarf star is slowly getting bigger. The star will continue to grow by conversion of energy to mass and it will climb along the Main Sequence of the H-R diagram until it will be a full size star like the sun. The star will then fluctuate between a red giant star and the main sequence throughout its eternal life. The star will turn into a red giant after an extended Maunder minimum that will stop the energy supplied to the star. The sun was also a red giant. In the red giant state the sun ejected strong stellar wind that caused the sun to lose mass. The solar system planets were created when the sun was a red giant and its strong solar wind ejected material that later coalesced into the planets.

While the star keep absorbing changing magnetic fields and converting the energy to mass, the star will continue to grow. Different regions of the galaxy propagate changing magnetic fields of different strength. The Milky Way galactic bulge will have stronger magnetic fields then the Milky Way galactic disk and the Milky Way galactic disk will have stronger magnetic fields then the Milky Way galactic halo. Each of these regions will enable the star to reach a certain size depending on the strength of the magnetic fields. Stronger magnetic fields will enable the stars to grow larger so the stars in the galactic bulge will be on average larger then the stars in the galactic disk and the stars in the galactic disk will be larger then the stars in the galactic halo. The star will stop growing when the changing magnetic fields will weaken and will supply energy only to cover the stars energy consumption on luminosity and stellar wind without supplying further energy to cover conversion of energy to mass. The star energy supply decline when the stellar cycle and the associated magnetic fields will be weaker and of lower amplitude and the star will have disruption in the stellar cycle similar to the Maunder minimum the sun had in the seventeenth century.

Figure 12 shows the growth of a star mass as a function of time in two areas of the galaxy. The blue line represents a star growing at the Milky Way galactic bulge and the yellow line show the growth of a star at the Milky Way galactic disk. The star starts growing from the lower left corner and as time pass it evolve and proceed to the right. The star growth is at first exponential since it depend on the fifth power of the star radius as shown by Equation 1. The galactic bulge is closer to the supermassive black hole at the center of the Galaxy then the galactic disk. Therefore, the galactic bulge has stronger magnetic fields. The stronger magnetic fields supply more energy to the galactic bulge stars so they can grow faster than stars at the galactic disk. The stars at the galactic bulge can reach higher mass than stars on the galactic disk. The stars stop growing when the energy received from the magnetic fields is smaller then the energy lost to the star luminosity and to the stellar wind. Massive stars in an area of weak magnetic fields will receive stellar cycle of low amplitude and there will be interruption in the stellar cycle like the Maunder minimum. Extended Maunder minimum of tens of million of years will cause the star to transform into a red giant. In the state of a red giant the star has a strong stellar wind that will cause the star to lose portion of its mass. In an extended Maunder minimum the stellar cycle will not stop completely for a long time, instead, it will have smaller amplitude and frequent short interruption. At an equilibrium point, when the magnetic fields in the region cannot support further growth, the star will transform back and forth from a main sequence star to a red giant. The star mass will fluctuate but will not show a clear growth trend. In figure 12 the blue line represents a star in the galactic bulge. This star on average will reach a higher mass then a star in the galactic disk represented by the yellow line.

The magnetic fields can supply a limited amount of energy. When this limit is exceeded some stars will receive less energy and stop growing. This scenario can be compared to a city connected to a single power station. If the city consume more energy then what the power station can supply then some neighborhoods in the city will be temporarily cut from the electricity. Those neighborhoods can be reconnected to the electricity only if other neighborhoods are disconnected. Similarly, when there is not enough energy to all the stars in a specific region some stars will suffer from Maunder minimum and will turn into red giants.

In figure 2, the star climb along the main sequence until the region of the star cannot support further growth of the star. The star will then have weaker stellar cycle with frequent interruption. The energy supply to the star will be diminished and after tens of millions of years the star will cool down and will transform into a red giant with a spectral class of longer wavelength. The star will also expand and will have higher luminosity. In the H-R Diagram the star will enter the red giant branch. Longer interruption in the stellar cycle will cause the star to enter deeper into the red giant branch. This is shown in Figure 2 with two red giant transitions that one is deeper and longer then the other. The stellar cycle can return to produce higher energy and the star will return to the main sequence. The star can fluctuate back and forth between a main sequence state and a red giant state. These fluctuations will control the star mass. In a main sequence state the star will gain mass and in a red giant state the star will lose mass. When a star transform into a red giant, it loses mass to strong stellar winds. After the red giant transition, the star returns to the main sequence and emerge with lower mass, smaller radius and lower luminosity of longer wavelength. Those transitions to red giant will continue during the entire life span of the star. The stars keep moving in the galaxy and can migrate from one region to another. Star in the galactic disk when far from the plane of the galactic disk is more likely to turn into a red giant. A star that was in the galactic arm and then leaves the galactic arm is also likely to turn into a red giant.

The star will continue to live if the magnetic fields will supply enough energy to keep it hot and luminous. The star will die when its stellar cycle will stop and the star will not receive energy for a very long time. The star will then turn into a red giant for a long time without returning back to the main sequence. The star will lose much of its mass in strong stellar wind, will create a circumstellar envelope and will collapse into a white dwarf. The death of a star is a rare event and the majority of the red giants will return back to the main sequence. The galaxy continues to produce energy and disperse it in magnetic fields in the galactic disk. So stars will die only if they get into a position where they cannot get this energy for a long time. Generally, stars will live forever and will never die. Therefore, there are much more newborn stars than dying stars, so the number of stars in the galaxy is always rising and the galaxy is always growing. The fact that stars are eternal and never die also controls the behavior of the universe. The number of stars in the universe is constantly rising. This leads to the birth of new galaxies and to the fast expansion of the universe.

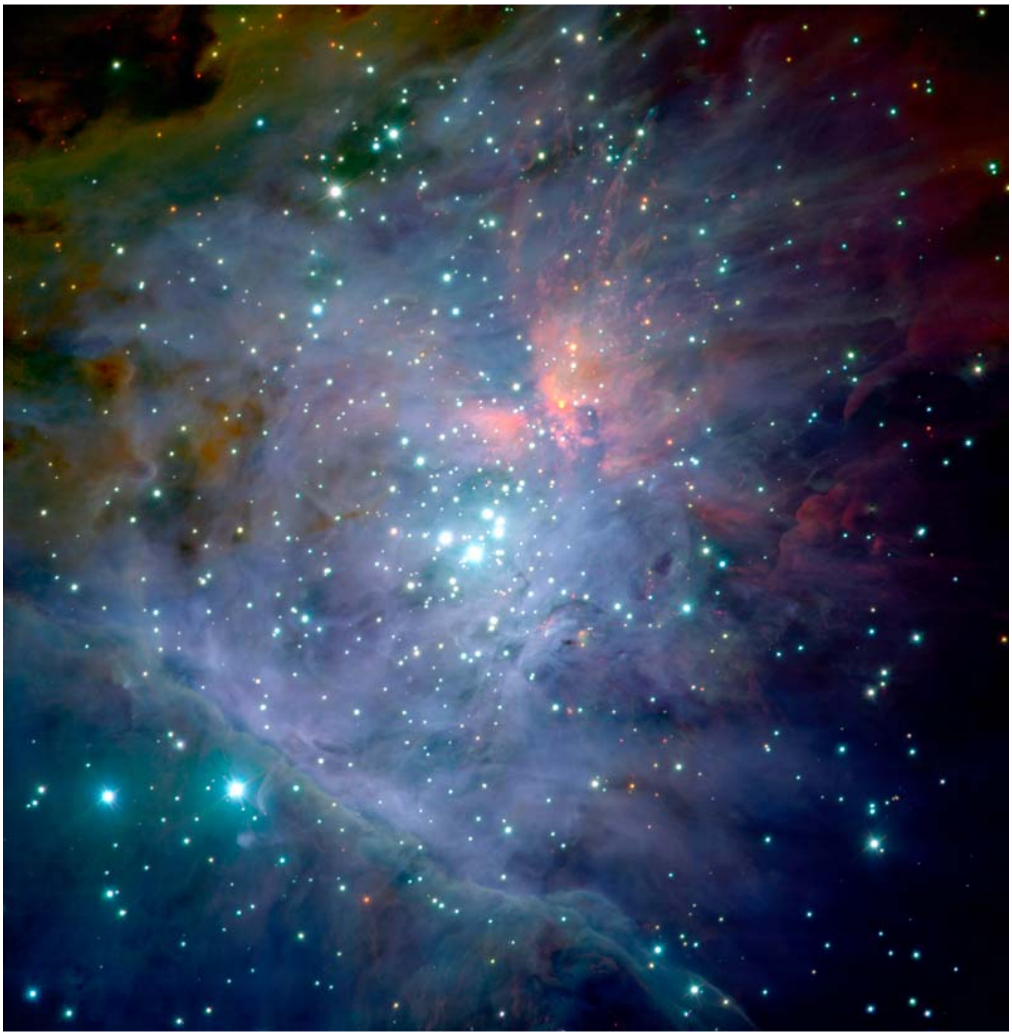


Figure 3 – This is a picture of the Trapezium cluster in the Orion nebula. The stars density in the Trapezium cluster is very high so the stars are close to each other. For a planet to turn into a star it needs to be detached from its central star. In clusters like the Trapezium the high density of stars means that stars exerts strong gravitational forces on nearby stars. Those gravitational pulls and tugs between the stars cause the planets to be released from their central stars. There are observations of free floating planets in the Orion nebula that confirm that planets are released from their central stars. The exoplanet search programs find many exoplanets with high eccentricity and with orbits very close to the central stars. Some of the high eccentricity exoplanets were captured from free floating planets. Other explanation to the high eccentricity exoplanets is a gravitational pull from a nearby star.

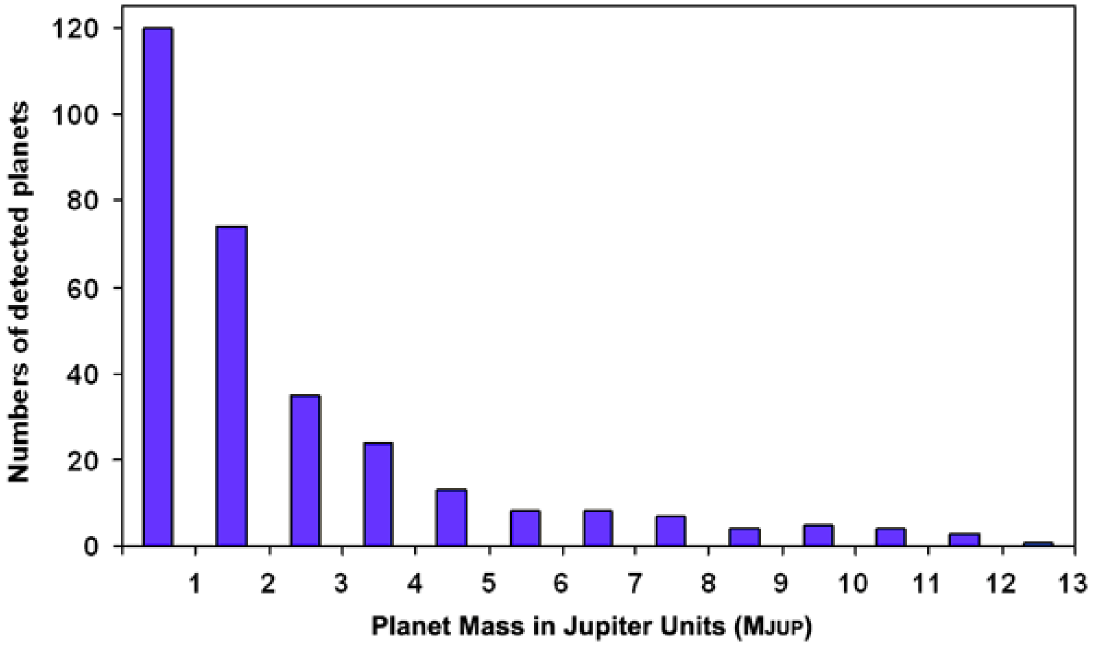


Figure 4 – Exoplanets mass distribution shows that there are planets with large mass above 10 Jupiter masses. Stars are born from planets so there is a continuum in the size of objects from planets to stars. Objects of all stages of the star evolution are found in the galaxy. The exoplanet search programs revealed that planets are common in the galaxy. There are many observations of large planets above 10 Jupiter mass that provide the link between planets and brown dwarfs. There are also many observations of brown dwarfs, and red dwarfs are the most common star in the galaxy. So clearly there is a continuum, and objects of all sizes, between planets and stars, are easily found in the galaxy. (From the Exoplanets Encyclopedia http://exoplanet.eu/).

The high metallicity of stars with planets

Stars produce their own mass. The changing magnetic fields associated with the stellar cycle supply energy to the star. This energy is converted to mass and new particles are created. The stars creates baryons or nucleons like neutrons and protons in baryon-synthesis process to form hydrogen atoms. The stars also fuse hydrogen to produce helium and heavier elements like carbon and oxygen in nucleosynthesis process. Stars fuse elements heavier then iron. For elements lighter then iron the fusion supply energy to the star and for elements heavier then iron the fusion absorb energy from the star. Therefore, the fusion of elements lighter then iron heat the star, while the fusion of elements heavier then iron cool the star. The energy to fuse elements heavier then iron is coming from the magnetic fields of the stellar cycle. The stars are not born from clouds of gas and dust as predicted by the Solar Nebula Hypothesis, but grow gradually by converting energy to mass. Therefore, the abundance and metallicity of stars is determined by internal processes in the stars. The stars create their own abundance and metallicity. At its birth the star is a planet and it is growing by accreting material. When it reaches the size of a brown dwarf it start to grow by converting energy to mass. So, only a small fraction of the star mass is coming from outside. The star mass can be divided into mass that was accreted at the star birth and to mass that was converted from energy and produced by the star itself. The accreted mass in each star is about the mass of a brown dwarf, while most of the mass is created internally. If the sun is about 1000 times heavier then Jupiter, and a brown dwarf is about 20 times heavier then Jupiter, then 2% of the Sun mass is accreted while the rest is from conversion of energy to mass. The accreted material has composition that roughly resembles that of Jupiter.

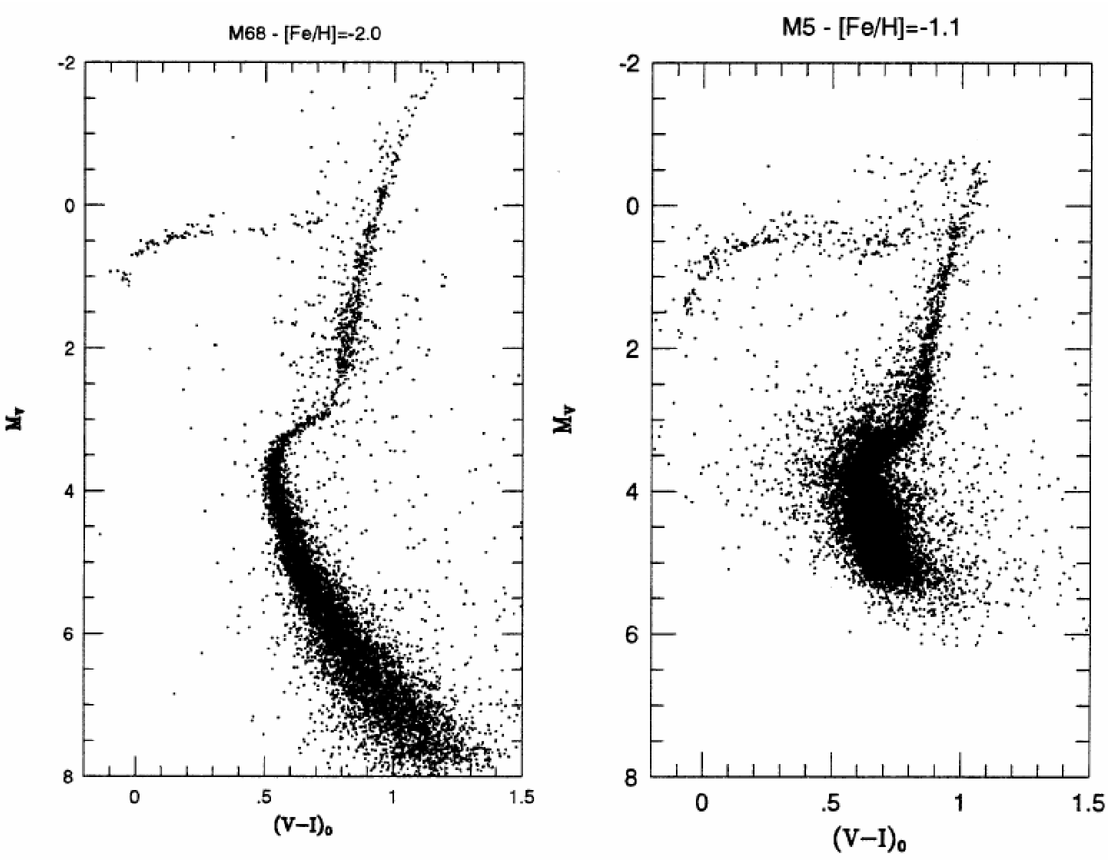
The stars in the Milky Way are divided to population I stars found in the Galactic disk and in the Galactic bulge and population II stars found in the Galactic halo. The population I in the disk and bulge are metal rich while population II in the halo is metal poor. The Milky Way halo contains stars of low luminosity and low mass, mainly red dwarf. The Milky Way bulge and disk contain more luminous and massive stars like K, G and F stars. The more massive stars show higher metallicity (Figure 7). This is clear from O and B stars that show the highest metallicity of all stars. Previously it was suggested that more massive stars are older. So, the O and B stars are both massive and old. The metallicity of stars depends on their mass and also on their age, since older stars are also more massive. The stars create their own metallicity and more massive stars have higher metallicity. The reason that more massive stars have higher metallicity is because the temperature and the pressure at their core are higher than in smaller stars. The high pressure and temperature ease the fusion of metals, so they are created at faster rate. The fact that more massive stars have higher metallicity can also be demonstrated with star clusters (Figure 5). Cluster M5 has stars more massive then the stars of cluster M68. Cluster M5 also shows higher metallicity then cluster M68.

The changing magnetic fields that supply energy to the stars are stronger in the Milky Way Galactic disk and Galactic bulge then the magnetic fields in the Milky Way Galactic halo. This is reflected in the mass and metallicity of the stars. Stronger changing magnetic fields will supply more energy and will enable the stars of population I to grow faster, larger and develop higher metallicity then those of population II.

Stars could live for a very long time and are basically eternal (Reference 4). So, if metals are always fused, why there are no stars with extreme super-metallicity? The reason is that stars also split atoms. There is a balance between the fusion of atoms and splitting or decay of atoms. As the star metallicity rise to a high values, the rate of splitting atoms is equal to the rate of fusing atoms, so no new metal atoms are created and the metallicity stay unchanged (similar to a chemical equilibrium). It can be said that the rise in the metallicity stop when there is saturation or equilibrium of the metal elements.

The exoplanet search programs revealed that stars with planets have higher metallicity than star of the same mass without planets (Figure 6). We also know, as shown in figure 7, that more massive stars have higher metallicity. If we take a star with planets that have high metallicity, we can find in figure 7 a star with similar metallicity but without planets. The star without planets will have higher mass then the star with the planets. We can conclude that the star with planets was a larger star in its past and it went through a significant mass loss. The only way a star can lose a significant part of its mass is by turning into a red giant. In the red giant state the star has a strong stellar wind that disperses the star material to the interstellar space. After millions of years in the red giant state the star return to the main sequence with smaller mass but it keeps the high metallicity from the time before it turned into a red giant (Figure 8). So, stars with planets that show high metallicity were red giants in their past and returned to the main sequence with smaller mass. Some of the material ejected by the star stellar wind when it was a red giant, condensed and created comets that formed the planets. This way, the link between the high metallicity of the star and the formation of its planets stem from the temporary transition of the star to a red giant.

This discussion of star metallicity unveils the formation of the solar system, stellar systems, planets and exoplanets. The formation of planets in the solar system and in many other stellar systems occurs when the star turn into red giant. The sun metallicity is 20% higher then stars of the same size and it has a large and complex planetary system. This leads to the conclusion that the sun was a red giant in the past. Stars can turn into red giant many times during their life. The star accumulates mass in the main sequence and then discards this mass in the red giant state. The intricate structure of the solar system is an outcome of not one but many transitions of the sun to a red giant state along tens of billions of years. The meteorites and chondrules in the solar system have the age of 4.6 billion years because the last sun red giant transition was at that time.


M68 - [Fe/H]=-2.0

M5 - [Fe/H]=-1.1

Figure 5 - Comparing M68 and M5 show evidence that old stars are more massive, more metal rich and more luminous then young stars. The stars of M68 are young and many of them are red dwarfs that show at the bottom of the main sequence. The stars of M5 are older so all the red dwarfs evolved into higher mass stars. Low mass stars like red dwarfs cannot turn into red giants so M68 show few red giants while the higher mass stars of M5 show higher fraction of red giants. The comparison between M68 and M5 also indicate that the metallicity of stars depends on their mass. Low mass stars like red dwarfs cannot synthesis heavy nucleus. Massive stars have high temperature and high pressure at their core to synthesis metals. Therefore, the metallicity of M5 (-1.1) is higher then the metallicity of M68 (-2).

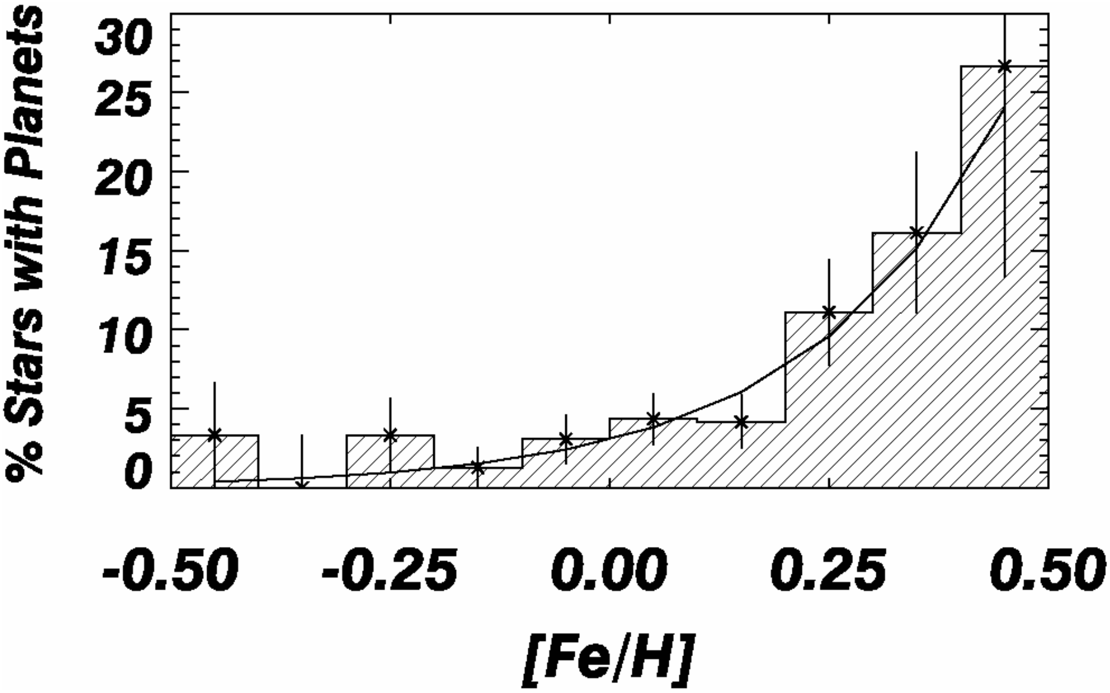


Figure 6 - Stars with higher metallicity are more likely to have planets. Planets are formed when the star is turned into a red giant and its strong stellar wind supply material that is used as the building blocks of its planets. Star that was a red giant lost some of its mass, so before it was a red giant it was bigger and more massive. Stars with higher mass develop higher metallicity by the high pressure and temperatures in their cores. Therefore, after the star was a red giant it will keep its past high metallicity but will have a smaller mass and likely to be with planets. (From Fischer & Valenti 2005)

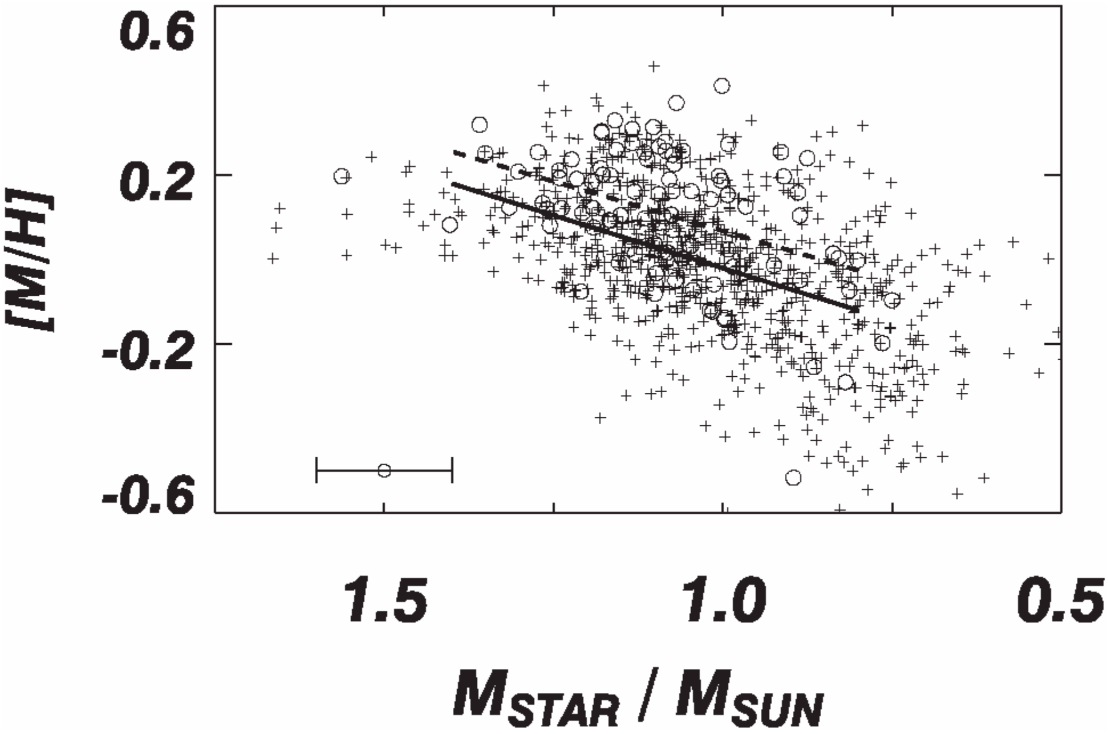


Figure 7 – There is a correlation between the mass of the stars and their metallicity. Stars with higher mass have higher metallicity. This correlation stem from the fact that stars with higher mass have higher pressures and higher temperatures at their cores. This increases the fusion rate of the metals in the core and raises the overall metallicity of the star. The metallicity of stars with planets shown by the dashed line is higher then the metallicity of stars without planets. Stars with planets like the Sun show higher metallicity because they were once bigger stars with higher mass. Those stars lost some of their mass but kept the high metallicity that was built under higher mass. The stars lost part of their mass when they turned into a red giant. Red giants have strong stellar winds that cause mass loss to the star and supply material to build planets. The higher metallicity of stars with planets indicates that they were once red giants. The sun was a red giant 4.6 billion years ago and the meteorite and chondrules condensed at that time. (From Fischer & Valenti 2005)

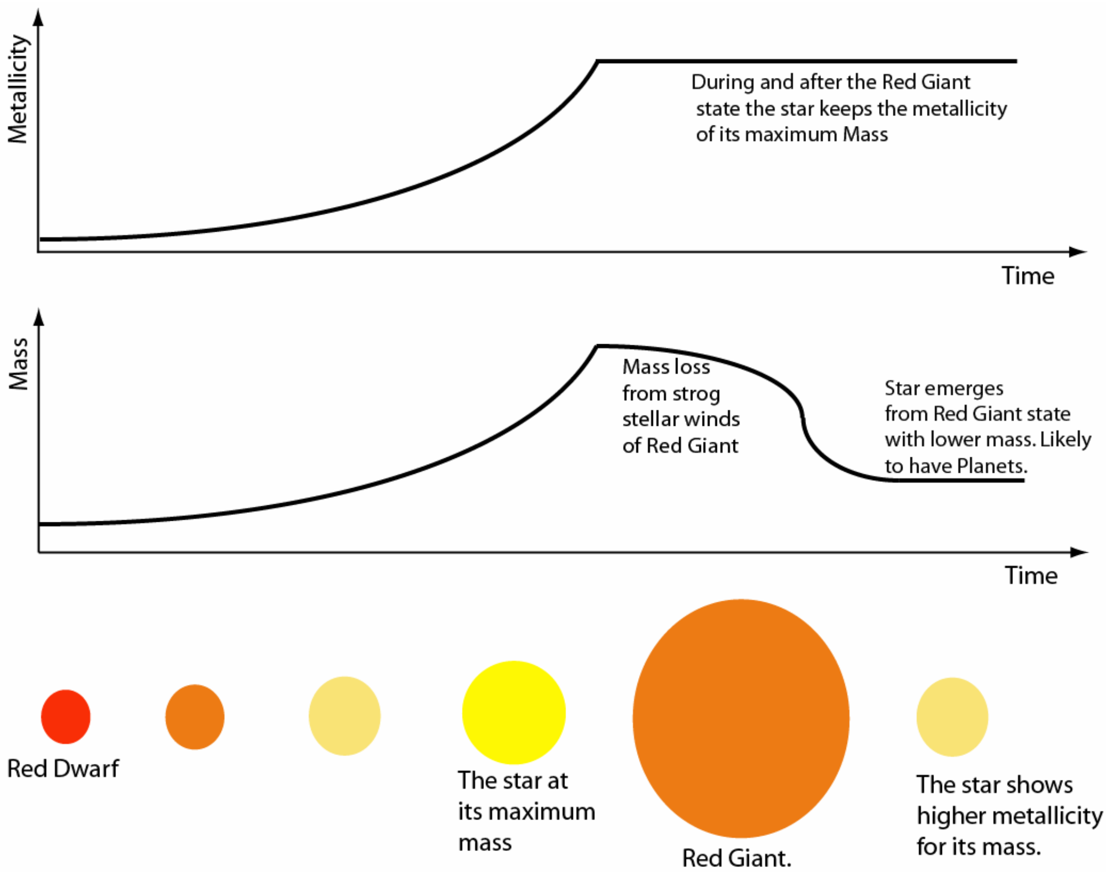


Figure 8 – This figure shows schematically the growth of the star mass and metallicity as it turns into a red giant and back to a main sequence star. The star grows from converting the energy of its stellar cycle magnetic fields to mass, so both the mass and the metallicity of the star increase. The metallicity of the star depends on its mass as is shown in figure 7. Stars with higher metallicity have higher pressures and higher temperatures in their cores, so as the star mass increase its metallicity also increase. At some point the star turn into a red giant. In this state the star have strong stellar winds that inflict mass loss. The mass of the star decrease, but its metallicity is not changed and the star keeps the same metallicity from the time it was with its maximum mass. When the star returns to the main sequence it has smaller mass and high metallicity for its mass. The star is also likely to have planets from the condensed stellar wind of the red giant. Some of the mass lost during the red giant state is the source of the planets mass.

The star before a red giant transition have more mass than after the red giant transition. The mass loss can be caused by more than one red giant transition. In this case of a series or sequence of red giant transitions it is likely that the mass lose will be greater than mass lose from a single red giant transition. This mass lose affect the metallicity of the star; higher mass lose will give higher metallicity compared to stars of similar mass. With higher mass lose the star is more likely to have planets since there is more material available to form planets. This is evident from the correlation of star metallicity and planet formation shown in figure 6. Similarly, higher mass loss will provide more material to form larger planets as is evident from figure 9. Higher mass lose will also reduce the angular speed of the star as its angular momentum is lost to the red giant stellar wind.

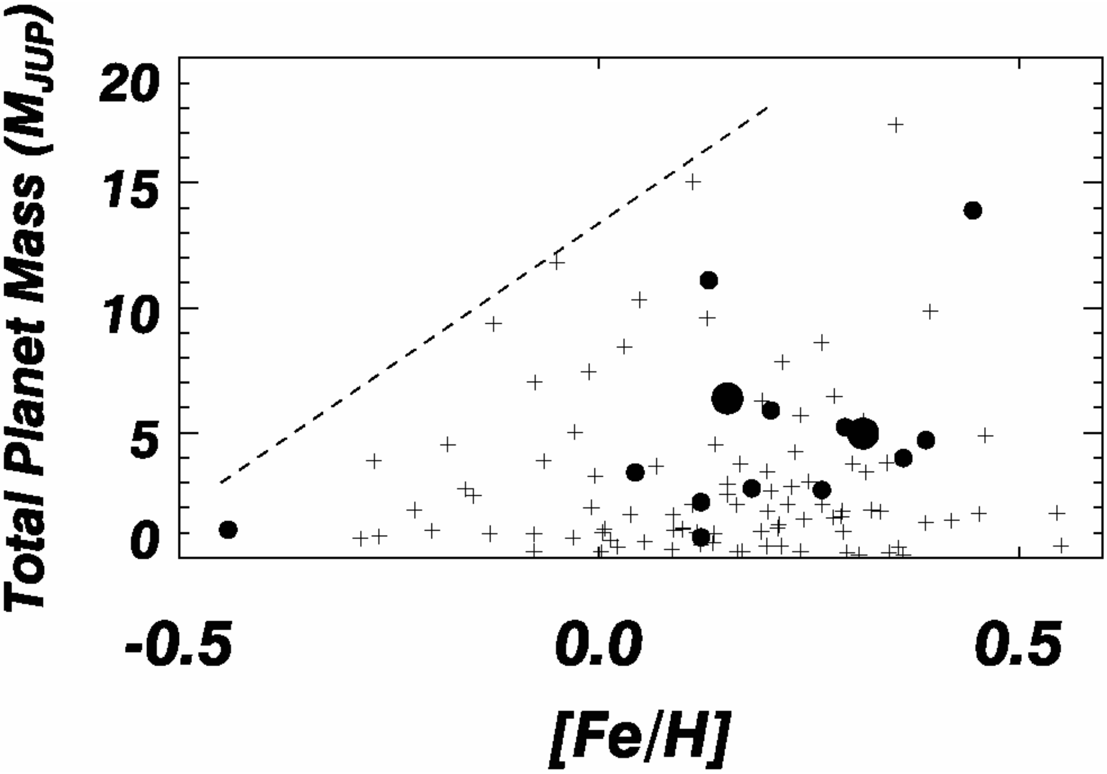


Figure 9 – The mass of the exoplanets is related to the metallicity of the centeral star. The plus sign indicates a system with single planet, while a circle represent a multiple planet system. The dashed overplotted line shows that stars with higher metallicy have more massive planets. The planets are created from the material ejected from the central star when it was a red giant, so the higher the mass ejected by the red giant star the higher is the planet mass. A mass loss from a red giant will decrease the star mass, but the matallicity of the star will stay high, similar to what it was when the star was more massive, before the red giant transition. Therefore, a higher red giant mass loss will supply more mass to create larger planets and will also increase the star metallicity. (From Fischer & Valenti 2005)

The sun was a red giant

According to the standard solar model the stars evolve into red giant when the hydrogen fuel in their core is depleted and they start burning helium at higher temperatures. However, the stars are not getting their energy from hydrogen but from changing magnetic fields. So, the idea that a star turn into a red giant when its hydrogen fuel is depleted, is not valid. The question of why and how a star turn into a red giant when its energy come from magnetic fields, will be examined. This question of what process transforms a star into a red giant, must be answered, as red giant are a considerable part of the star population. The answer that follows leads to a new explanation to the formation of the solar system.

In reference 1 it was suggested that a star turn into a red giant because its composition change and it accumulate helium and metals. This cause helium poisoning that changes the properties of the star and prevents it from getting heated by the magnetic fields. However, this explanation is incorrect. Giant stars of spectral type O and B are starting from a small size of brown dwarf and grow by converting energy to mass. This conversion takes a lot of time and the O and B are the oldest stars. Still, their helium and hydrogen abundance is similar to smaller size stars and they show no sign of helium poisoning. The sun has abundance that is similar to that of nearby red giants. For instance, the sun has similar abundance to Aldebaran. If red giants are created by helium poisoning then the sun would not show similar abundance to nearby red giants and the signs of poisoning would be evident in the spectra of the red giants (Reference 17).

According to the standard solar model the stars will evolve into a red giant when the Hydrogen in their core is depleted and the star loses its energy source. Since stars are heated by magnetic field, any interruption in the magnetic fields will cause the star to lose temporarily its energy source and turn into a red giant. The sun solar cycle is irregular; there are interruptions and variation in the amplitude of the solar cycle and periods of very weak solar cycles. Between 1645 and 1715 the sun had very few sunspots that caused a low temperature and cold winters around the world called the little ice age. This period of low number of sunspot was named the Maunder Minimum in honor of the English solar astronomer Edward W. Maunder who dedicated much of his research to the study of sunspots. The solar cycle and its associated magnetic fields is not created internally by the sun, but is applied to the sun from the outside by the galactic disk. This is evident by the fact that the magnetic fields of the solar cycle are open and extend far into the galactic disk. The sunspots are created by the solar cycle magnetic fields as was shown in reference 3. If there is interruption in the sunspots, there are interruption in the magnetic fields of the solar cycle and the solar cycle stop supplying energy to the sun. The Maunder Minimum took about 60 years. If it was extending much longer to a period of tens of million of years the sun would not have an energy source and it will cool down. The solar cycle cannot stop completely for a period of tens of million of years. Instead, frequent short period of Maunder minimum and low amplitude of the solar cycle, will cause the same effect of reducing the energy supply to the sun and cooling the sun. Cooling the sun will turn it into a red giant.

The electric force is know to be much stronger than the gravitational force. When a star temperature is high there are many free ions inside the star. Those ions work to hold and pull the star together like a molecule is held together in an ionic bond. When the star is colder there are less ions and the star is not held together by the electric force. In reference 3 it was shown that the sun is circled by charged plasma belts. Those plasma belts are influenced by the pinch effect and acquire electric charge. There are possibly large number of much smaller plasma belts and streams that their charge works to pull and hold stars together. When the star is colder there are less such streams and ions that hold the star together and the star start to swell. It is getting bigger and its stellar wind is much stronger. When the star expands its surface area increases and the lower density of the star outer layers enable photons to escape, so the radiation or luminosity of the star also increases. The outer layers are pushed by radiation pressure to increase the mass lose by the stellar wind.

After a decrease in the strength of the magnetic fields, the energy supplied to the star is lower and the star will get colder. The star core will also get colder and the core gas pressure will not be able to hold against the pull of gravity. The star core will collapse and form a large degenerate core by taking material from higher layers of the star. When a large degenerate core is created the gravity felt by the star outer layers is lower. This lower gravity releases the outer layers to expand and to eject the massive stellar wind. After the elongated Maunder minimum is finished the star will get hotter by the magnetic fields. The core will get hotter and some of the degenerate matter will return to be a regular matter in higher layers of the star. This will increase the gravity on the outer layers of the star and will cause them to contract to the original size. Stars with higher metallicity will form more easily degenerate core and are more likely to turn into white dwarfs.

When there is interruption in the stellar cycle and the magnetic fields the star turn into a red giant, however, this is not permanent or final; the star can turn back to the main sequence if the magnetic fields supply enough energy to the star. In that case, the star will shrink back and will have weaker luminosity and higher temperature. When a star is turned to a red giant and then return back to the main sequence it loses small portion of its mass depending on how long and how deep the red giant state continued. The stellar wind of a red giant is much stronger then that of a main sequence star and the star lose some of its mass to the interstellar medium. In the red giant state the star has no surplus of energy and it is not converting energy to mass, so its mass does not increase.

In figure 2 it is shown that the star is turning to a red giant at a certain point in the main sequence and return to the main sequence to a lower mass. There are shown two transitions to red giant where one is longer and reach deeper into the red giant branch. The red giant transition that go deeper, also inflict larger mass lose to the star and cause it to return to the main sequence with lower mass. In extreme cases of very long Maunder minimum the red giant will have an extensive mass loss that will develop to a circumstellar envelop. Further extension of the Maunder minimum will cause the star to die and to turn into a white dwarf with planetary nebula. However, star death is very rare, it is more likely that the star will survive the red giant transition and return back to the main sequence.

Spiral galaxies have galactic arms that rotate faster than the galaxy. We know that the galactic arms rotate faster than the galactic disk because the swirling of the galactic arms is limited. The center of the galactic disk have higher angular speed then the edge of the galactic disk, so if the galactic arms were stationary relative to the galactic disk they would keep on swirling and look thinner and longer then they actually do. The galactic arms rotate faster than the galactic disk especially near the edge of the galactic disk. The stars in the galactic arms look brighter than the stars outside the galactic arms. They are hotter with more luminosity and shorter wavelength and also have higher mass compared to stars outside the galactic disk. The galactic arms are not sweeping the stars with them since the galactic disk angular speed is lower then the galactic arms angular speed. The stars get in and out of the galactic arms. When the stars get in the galactic arms they are affected by them. The Galactic arms are regions with strong magnetic fields. When a star is in the galactic arms it get strong magnetic fields that supply more energy to it and make it hotter. The stars outside the galactic arms are redder then star inside the galactic arms. This indicates that some of the stars leave the main sequence and enter the red giant branch. There are more red giants outside the galactic arms then red giants inside the galactic arms. As the galactic arms sweep through the galaxy they heat the stars inside them and change some of the stars from red giants back to a main sequence stars. When the galactic arms enter a region of the galactic disk it changes the stars to main sequence stars and when the galactic arms leave this region some of the stars will turn into a red giant stars. The time the stars reside in the galactic arms can be calculated based on the rotation curve of the galaxy. This enable to find how much time it takes for the star to change from a main sequence to a red giant and back to a main sequence. The galactic arms are like power lines that carry electric energy from the supermassive black hole at the center of the galaxy to the outer regions of the galactic disk.

The stars in the galactic arms show how the region of the star influence the star. In a region with strong magnetic fields the stars are more massive and luminous. Stars grow from planets, first by accretion and then by conversion of energy to mass. Both the star growth rate and its final mass are determined by the region and strength of the magnetic fields (Figure 12). In the Milky Way bulge the stars are more massive and luminous than the stars in the galactic disk. The changing magnetic fields are stronger in the Milky Way bulge, so the final size of the stars in this area will be larger than stars in the galactic disk where the changing magnetic fields are weaker. Stars in specific regions of the galaxy have a mass limit that depends on the strength of the magnetic fields in that region. If the mass of the star crosses this mass limit the changing magnetic fields will not be able to support its luminosity and energy consumption. The star will suffer from an extended Maunder minimum that will cool the star and convert it to a red giant. In the red giant state the star will have a strong stellar wind that will decrease the star mass. In this way, the red giant state of the star keeps its mass according to the mass limit allowed by the changing magnetic fields. After the star is losing considerable part of its mass to the stellar wind, its mass will return to be below the mass limit. The energy consumption of the star will be lower and it will return to the main sequence since the changing magnetic fields will be able to supply this energy consumption. In the Milky Way bulge and disk there is diffusion and stars change their position and region, so the mass limit is changing, and not obvious. However, in globular cluster the turn off point indicate this mass limit. Each Globular Cluster has changing magnetic fields of specific strength that enable the stars to grow to a specific size. This size is the turn off point. If the stars in the globular cluster grow beyond the mass limit of the turn off point, the changing magnetic fields cannot support their energy consumption and they turn into red giants. As stars change their position in the galactic disk or bulge their mass is fitted to the mass limit of the region. If a star of spectral Class A will drift into a region that can support spectral class G it will get into a red giant state for a long time and lose most of its mass in a circumstellar envelop until it will have a mass typical of Spectral class G. The separation of the stars to population I and population II also depends on the strength of the magnetic fields. Population I stars are found on the galactic disk and absorb strong magnetic fields so the stars grow larger and have more luminosity and higher metallicity. Population II are found on the galactic halo where the changing magnetic fields are weaker so the stars are smaller and many of them are red dwarfs.

Red giants can also be understood in the context of the galaxy energy production. The energy of the galaxy is supplied by a supermassive black hole at the center of the galaxy. Matter is continually falling to the supermassive black hole. This matter is produced by stars in the galaxy and much of it originated from stellar wind of red giants. The transition of stars to red giant is essential to maintain the energy production in the galaxy. The matter falling to the supermassive black hole create eddies of magnetic fields by the dynamo effect. The eddies of the magnetic fields disperse in the galaxy and heat the stars. If the amount of material that fall to the supermassive black hole decreases, the energy available to the stars in the galaxy also decreases; the galaxy will have weaker changing magnetic fields and many of the stars will turn into red giants. The red giants will eject large amount of matter by their stellar wind. After billion of years this matter will reach the supermassive black hole and increase the energy supplied to the galaxy. By this feedback mechanism between the matter ejected by the red giants and the matter falling to the supermassive black hole the galaxy maintain its energy balance.

When a star is in the state of a red giant for a long time the material ejected from its stellar wind will accumulate and form a circumstellar envelope. Circumstellar envelops are found using infrared radiation. The infrared radiation from circumstellar envelope is intense and show that the source is much bigger than an ordinary star. The red giant is found inside the circumstellar envelop but it is covered with dust and gas, so the star itself is invisible at optical wavelength and only the gas and dust infrared radiation is observed. The dust and gas infrared radiation indicate a low temperature of a few hundreds Kelvin of the circumstellar enevelop. Many of the circumstellar envelops were detected and observed by Infrared telescopes like the Infrared Astronomy Satellite (IRAS), the ISO satellite, the Spitzer space telescope and Herschel Space Observatory. IRAS detected about 100000 circumstellar envelops to show that this is common phenomena in the galaxy.

Circumstellar envelop indicate a significant mass loss of the star but it is not always signify the death of the star. The circumstellar envelop could disperse and leave a main sequence star of smaller size and lower luminosity. The dust and gas of the circumstellar enevelop have the potential to form planets around the star after the star return to the main sequence. The large number of circumstellar envelops found by IRAS indicate that they are a main source for the creation of planets in the galaxy. Circumstellar envelops contain large number of different molecules that many of them are also found in the solar system (references 13 and 14). There are circumstellar envelop molecules and atoms that are found both in the outer planets and in the terrestrial planets. Molecules like iron and silicone are very abundant and iron is the second most abundant metal in circumstellar envelops. The iron and silicon are the main constituents of the terrestrial planets. Circumstellar envelops contain molecules like water, table salt NaCl, and organic molecules like methane that is found in the outer planets. There is also formation of dust in the circumstellar envelops as the stellar winds move far from the star it cools and some of the material condenses to form dust grains reminiscent of chondrules in the solar system meteorites.

The Helix Nebula shows the formation of comets or knots (Figure 13). Those knots were formed when the gas and dust from the progenitor red giant star condensed and formed large bodies. Those knots are attracted by gravity to the planetary nebula nucleus at the center of the planetary nebula. The radiation from the planetary nebula nucleus puffs the knots so they have tail and enormous size of several AU. Those comets like objects, are also formed in other circumstellar envelops, but the opaque gas and dust hide them. The formation of comets and larger comet like objects in circumstellar envelops is parallel to the formation of objects in the Kuiper belt, so objects like Pluto and Eris were formed in a similar process. The formation of those objects is a major step in the development of the plants. The red giant stellar wind is first condensed into dust, then it clump into comets and larger comet like objects, and those create planet cores or fall to planets. The resemblance in the composition of the planets and material in red giants circumstellar envelops suggest that star with planets like the Sun were once red giants and that the ejected material from the stellar wind condensed and clumped to form the planets.

The star CW Leonis IRC +10216 is a red giant star 650 light years from earth having mass between 1.5 – 4 times the Sun mass. The star was observed with NASA's submilimitter wave astronomy satellite (SWAS) which is a radio telescope in low orbit around earth. SWAS was built to study the chemical composition of interstellar clouds and to find emission from water, molecular oxygen, carbon and isotopic carbon monoxide using radio waves. At CW Leonis SWAS found large amount of water, concentrated on icy bodies and comets in the envelop around the star. Those comets are similar to the comets in the Kuiper belt in the solar system. The water and comets in CW Leonis were created from condensation of the stellar wind similar to what is observed in the Helix Nebula but on a smaller scale. CW Leonis is not necessarily a dying star. As its stellar cycle will supply more energy to the star, the star can return to the main sequence, and its comets condensed from the stellar wind could form planets that will orbit CW Leonis. The fact that the solar system contains large number of comets, indicate that the sun was a red giant. When the sun was a red giant the massive stellar wind condensed and formed the comets. Some of those comets are still orbiting the sun in the Kuiper belt and Oort cloud but large number of them fell to the outer planets and increased their mass.

In 1991 Dale Frail and Alex Wolszczan found a pulsar that is a neutron star, which has planets orbiting him. The pulsar PSR1257+12 have 3 planets in orbit around it. The planets orbits reside on the same plane similar to the ecliptic plane in the solar system. If the pulsar planets were captured it is unlikely that they all have orbits on the same plane. Those planets were created from the material ejected by the progenitor star when it exploded in a supernova. This shows that planets are created from the material ejected by their central star. The solar system planets were also created from material ejected by the sun and the only way this could happen is when the sun turned into a red giant.

The Spitzer Space Telescope found, using its infrared detector, asteroids and silicate minerals around eight white dwarfs. Those asteroids are a remnant from the time the white dwarfs were red giants. The precursor red giants had strong stellar wind that contained silicate gas. This silicate gas condensed and form dust and larger bodies like asteroids. The asteroids of the solar system created similarly when the sun was a red giant, and silicate gas in the solar wind condensed to form chondrules, comets and asteroids.

The Sun has similar abundance to adjacent red giant stars. This similar abundance indicates that red giants and main sequence stars are actually the same star in different states. The Sun was a red giant 4.6 billions years ago and had at that time a similar abundance to what is found today. When the sun returned to the main sequence its abundance did not change. The similarity of the abundance of the Sun to red giants could be found, for instance, when comparing the sun abundance to that of Aldebaran (Reference 17).

The Sun metallicity is higher than similar stars of the same mass and spectral class by about 20%. The metallicity of stars depends mostly on their mass. Massive stars cores have high pressure and temperature that enables the fusion of metal nuclei. In massive star the fusion rate is higher and the star will generally show higher metallicity than a lower mass star. If a massive star is turned into a red giant it will lose some of its mass to the stellar wind. When it return to the main sequence it will have lower mass but will keep the high metallicity that it had before the red giant transition (Figure 8). Therefore, if a star has a higher metallicity than stars of similar mass, its means the star was once larger and went through a red giant transition that caused a mass loss. This situation is clear from the sun metallicity; since its metallicity is high, it means that the sun had higher mass long time ago that produced its high metallicity. Some of this mass was lost in a red giant transition. Most of the mass the Sun lost dispersed to the interstellar space but some of it supplied the building blocks to create the planets.

Meteorites are everywhere in the solar system, they constantly fall to earth and their composition can tell us about the origin of the solar system. The age of meteorite can be determined by radioactive dating, for instance the Uranium Lead dating. It is found that the meteorites were formed around 4.6 billion years ago. This date must be linked to a major event in the history of the solar system. At this event not only the meteorite were formed, but also material was added to increase the mass of the planets. The Sun existed 4.6 billion years ago and had existed for hundreds of billion of years before that time (Reference 4). The Sun was created first, hundreds of billion of years ago and the planets were created later, so the solar system has a dualistic origin. The event that created the meteorite 4.6 billion years ago was a transition of the Sun to a red giant. At 4.6 billion years ago the magnetic fields associated with the solar cycle weakened and the Sun cooled from lack of energy. This turned the sun into a red giant. When the Sun was a red giant it ejected massive solar wind that condensed far from the Sun and formed chondrules, meteorites and comets. Some of the comets and meteorites fell to the planets and increased their mass. The planets also existed 4.6 billions years ago and are much older than the last sun red giant transition 4.6 billion years ago. If the sun is 550 billion years old, (reference 4) the planets could be easily tens of billions years old. The fall of comet Shoemaker-Levy 9 to Jupiter in 1989 demonstrates the mass increase of a planet from falling comets.

The short lived isotopes or nuclides were created by the red giant sun and their trace is found in meteorites and chondrules. The short lived isotopes reveal how long the red giant state of the sun continued 4.6 billion years ago. The short lived isotopes show that the chondrules were formed in a period of 1.4 Million years and the meteorites were created in about 20 million years. The creation of the chondrules was probably an event at the peak of the red giant state of the Sun. The solar wind strength and the sun mass loss rate were at maximum at that time. However, before and after the creation of the chondrules there was a moderate period of the red giant Sun. Therefore, the period of the red giant sun continued more then 1.4 million years but lasted less then 20 million years. The meteorite formed well after the red giant peak and even after the end of the red giant state.

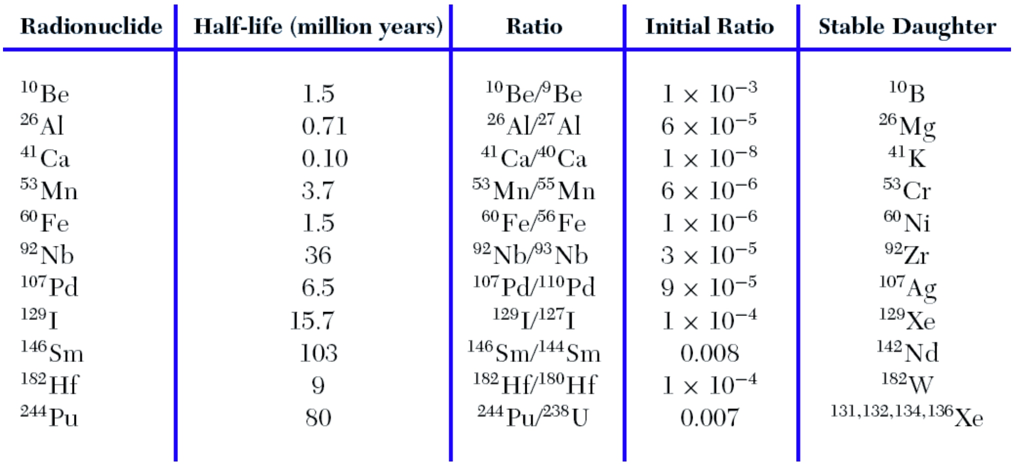
Table 1 shows a list of short lived isotopes found in the solar system. The half life range from 0.1 million years for Calcium 41, to 103 million years for Samariun 146. The short lived isotopes were ejected by the solar wind of the red giant sun. Far from the sun the gases in the solar wind condensed and incorporated the short lived isotopes. The short distance between the red giant sun and the meteorites explain how the short live isotopes managed to appear in meteorite so quickly before they decayed.

The half life of 0.1 million years for Calcium 41 is challenging to the solar nebula hypothesis. It requires the isotope to arrive to the solar nebula very fast and that the nebula will collapse and form the solar system in only about 1 million years. According to the solar nebula hypothesis the source of the Short lived isotope is either a supernova or a nearby red giant. The idea that a supernova triggered the creation of the solar system and at the same time supplied the short lived isotopes is prevalent. However, there are evidences against this idea. In 1979 NASA lunched the High Energy Astronomy Observatory 3 (HEAO 3). Its gamma ray spectroscopy experiment found a peak in the gamma ray spectrum for Magnesium. The Magnesium decayed from Aluminum 26. It was concluded that Aluminum 26 is spread around the galaxy in large quantities (Reference 5). Large quantities of Aluminum 26 where also found in the composition of the Allende meteorite and other meteorites. Since supernovas are rare events, it cannot be that those large quantities of Aluminum 26 are form supernovas. There are observations of red giants that show a high abundance of Aluminum 26. The nearby red giant IRC+10216 show very high abundance of Aluminum 26 (Reference 6). This confirms that the Aluminum 26 found in the solar system came from the red giant sun and not from a nearby supernova.

A further problem of the supernova as the origin of the short lived isotopes in the solar system is that some of the elements expected to be synthesized in a supernova explosion are missing. Tin(Sn) 126 with half life of 0.3 million years and Curium 247 with half life of 16 million years should have been present in the nebula and early solar system but their traces are not found. Those elements are r-process elements that should be created by a supernova in large amounts. The fact that they are missing indicates that the source of the short lived elements is a red giant and not a supernova (Reference 7).

Supernovas are very energetic and could easily destroy the solar system. The supernova must be far enough so that the shock wave will not be too powerful. However, the present of Calcium 41 with its short half life limit the distance of the supernova from the nebula. If the supernova was too distant the calcium 41 would have been decayed before being incorporated in the solar nebula. Those conditions put further constraints that discredit the supernova as a possible source of the short lived isotopes (Reference 7).

The initial ratios of the isotopes of the early solar system are presented in Table 1. Those ratios are similar to the ratio of those isotopes found in red giant stars. This shows that a red giant star is the origin of the short lived isotopes in the solar system (Reference 7).



Radionuclide	**Half-life (million years)**	**Ratio**	**Initial Ratio**	**Stable Daughter**
^{10}Be	1.5	$^{10}\text{Be}/^{9}\text{Be}$	1×10^{-3}	^{10}B
^{26}Al	0.71	$^{26}\text{Al}/^{27}\text{Al}$	6×10^{-5}	^{26}Mg
^{41}Ca	0.10	$^{41}\text{Ca}/^{40}\text{Ca}$	1×10^{-8}	^{41}K
^{53}Mn	3.7	$^{53}\text{Mn}/^{55}\text{Mn}$	6×10^{-6}	^{53}Cr
^{60}Fe	1.5	$^{60}\text{Fe}/^{56}\text{Fe}$	1×10^{-6}	^{60}Ni
^{92}Nb	36	$^{92}\text{Nb}/^{93}\text{Nb}$	3×10^{-5}	^{92}Zr
^{107}Pd	6.5	$^{107}\text{Pd}/^{110}\text{Pd}$	9×10^{-5}	^{107}Ag
^{129}I	15.7	$^{129}\text{I}/^{127}\text{I}$	1×10^{-4}	^{129}Xe
^{146}Sm	103	$^{146}\text{Sm}/^{144}\text{Sm}$	0.008	^{142}Nd
^{182}Hf	9	$^{182}\text{Hf}/^{180}\text{Hf}$	1×10^{-4}	^{182}W
^{244}Pu	80	$^{244}\text{Pu}/^{238}\text{U}$	0.007	$^{131,132,134,136}\text{Xe}$

Table 1 – The Short Lived Isotopes found in the solar system. A red giant sun 4.6 billion years ago is the only explanation for the source of those short lived isotopes. Other ideas like an external supernova or an external red giant are unlikely and have many flaws and contradicting evidences.

If the planets were born from the stellar wind of a red giant, then why it must be the sun and not an external red giant? The planets of the solar system are arranged in a complex structure. Most of them orbit the sun, and spin in the same direction. All the orbits around the sun have low eccentricity. The planets were not created from a single dust cloud all at the same time, instead the planet were created gradually in a long period where a new planet was added if the inner planets were in a stable, coplanar and circular orbits. If the solar planets were created by an external red giant then one travel near the red giant will not suffice. The sun has to travel near different red giants several times. To absorb material form a nearby red giant the solar system needs to be around 0.1 light years from the red giant. If the solar system is half built with for instance 6 planets a transit near a red giant 0.1 light years away will surely destabilize the planets orbits and destroy the solar system. Therefore, it is not possible for the planets to be formed by an external red giant.

Many of the meteorites show signs of differentiation. The meteorite were part of large bodies that melted, and heavy elements like iron were deposited at the center of the body, while lighter elements like silicone deposited at the outer layers of the body. To melt large bodies like asteroids require a considerable amount of heat. This heat came from short lived isotopes like Aluminium-26 that was supplied by the red giant sun. This also invalidates an external red giant source. It is unlikely that the an external red giant will supply the large amount of short lived isotopes, and that the sun will pass near this external red giant at the right time to pick the short lived isotopes before they decay.

Further evidence in support of the red giant sun is the strong similarity between the abundance of the sun, planets, meteorites and chondrules. This similarity indicates that the material for those objects came from a single common source. If the planets were created from an external red giant, the sun and planets would show dissimilar abundance.

Chondrules are small spheres found in chondrite meteorites with an average size between 0.2 to 1.5 millimeter and made of silicate material like olivine and pyroxene (Figure 10). Chondrite meteorites are the most common meteorite and about 80% of all meteorites found on earth are chondrite. Chondrules are a major constituent of chondrite meteorites and more than 50% of the mass of the chondrite meteorite is chondrules. This make the chondrules a widely spread ingredient of the solar system and only a process on a massive scale was able to produce them. Condensations from the solar wind of the red giant sun can certainly produce chondrules at such an extensive scale. The composition of chondrules is very similar to the composition or abundance of the sun. The chondrules are therefore condensation of the sun gas (Reference 11). The chondrules are striking evidence that the sun was a red giant, as they formed when silicate vapor from the red giant sun cooled and condensed. It is very hard to explain the creation of chondrules with the solar nebula hypothesis and extreme conditions are used like shock waves in the nebula or lightning. The chondrules carry a mix of materials like olivine Mg_2SiO_4 that when melted is broken to 2MgO or magnesium oxide and SiO_4 or silicon dioxide also called silica. If the chondrules were cooling slowly, as would be expected by the solar nebula hypothesis, those minerals will find their most stable state and will be equilibrated. However, what is found in the chondrules are minerals in unequilibarated form, an evidence that the chondrules cooled very quickly in an hour or few hours. As the silicate vapor was carried by the fast solar wind of the red giant sun, it cooled very fast. The temperature of the vapor decreased as the distance from the hot sun increased and the volume of the gas increased. The chondrules condensed at temperatures between 1200 to 2000 K. Those temperatures are comparable to the temperature observed in the photosphere of red giant stars. Therefore, the red giant sun could supply the right environment and conditions for the condensation of the chondrules.

Chondrules show evidence of reheating and then cooling again. The reheating could be the result of turbulence in the red giant solar wind or fluctuation in the solar wind strength.

The present of volatile material in the chondrules reflect the high concentration of volatile material in the solar wind of the red giant sun.

Observation of circumstellar envelops also support the idea that chondrules condensed form the solar wind of the red giant sun. There are observations that indicate the formation of dust grains in circumstellar envelops around red giants (Reference 13). Some circumstellar envelops also contains olivine and pyroxene that are the building blocks of chondrules.

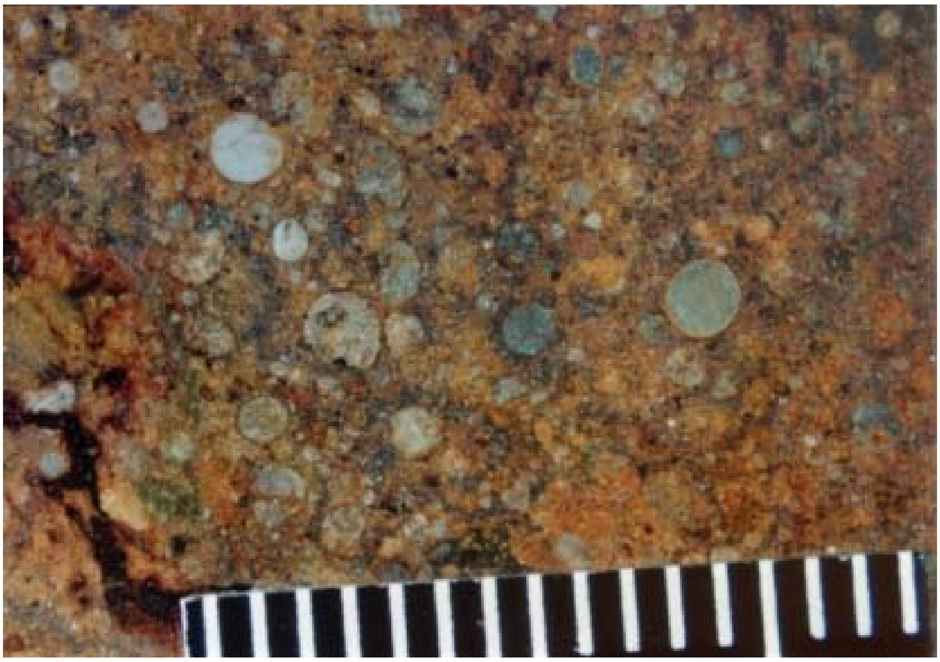


Figure 10 - Chondrules are small spherules 0.2 to 1.5 millimeter in size found in chondrite meteorites. Chondrules have abundance similar to that of the sun. The chondrules are condensation from the solar wind when the sun was a red giant 4.6 billion years ago. The chondrules show evidence that they cooled very fast as the high speed solar wind carried the silicate gas quickly to the outer and cooler region of the solar system.

Analysis of dust from comet Wild 2, collected by NASA's Stardust mission, revealed dust grain with features of high temperature similar to chondrules. The oxygen isotopes ratio found on these grains was similar to what is found on both asteroids and the sun. The origin of Wild 2 comet is from the outer reaches of the solar system or the Kuiper belt. Those chondrule like dust grain, to reach the Kuiper belt, needed to travel all the way from the inner parts of the solar system to the Kuiper belt. This migration can easily be understood if those grains were condensed in the red giant solar wind and then drifted by the dense solar wind to the Kuiper belt. According to the solar nebula hypothesis the dust grains that show feature of high temperature were created near the sun. It is hard to imagine how they got so far from the sun to be found on comet Wild 2.

When the sun was a red giant, 4.6 billion years ago, its radius was about 4 times its present radius. The sun did not swell to a size that reach planet Mercury. The terrestrial planets existed before the sun red giant transition 4.6 billion years ago and they emerged from the sun red giant transition unharmed. The spin or rotation of Mercury and Venus is unusual. The solar day of Mercury is 176 earth days and Venus have a retrograde spin, so it spins in opposite direction to the spin of the other planets. The origin of this unusual spin could be linked to swelling of the sun 4.6 billion years ago. The tidal forces from the red giant sun acted to impede the spin of Mercury and reverse the spin of Venus (Reference 3).

Spectroscopy of the sun reveals that the elements Lithium, Beryllium and Boron are scarce in the sun. The high temperature of the sun destroys those elements. On earth those elements can be found in large quantities. If the planets were created from condensation of gas from the sun, those elements should not be present on earth. However, the planets were formed from condensation of the sun gas from the time it was a red giant. In the red giant state the sun was cooler then it is today. There are observations of red giant stars with high abundance of lithium (Reference 16).The light element are replenished inside the cooler red giant sun and released with the strong solar wind of the red giant sun. Therefore, the present of those light elements on earth support the formation of the planets from the solar wind of the red giant sun.

The exoplanet search programs found many red giants with planets (Figure 11). This indicates that planets can survive the transition of the central star to a red giant. So, a planetary stellar systems like the solar system can grow gradually by many red giant transitions and at each transition material and mass is added to the planets. In figure 11 the stars with planets are concentrated near the turn off point of the Hertzsprung Russell diagram. This confirms that planets are created by fluctuation of the star between a red giant and a main sequence star. At the turn off point the stars are most likely to fluctuate between a red giant and a main sequence star.

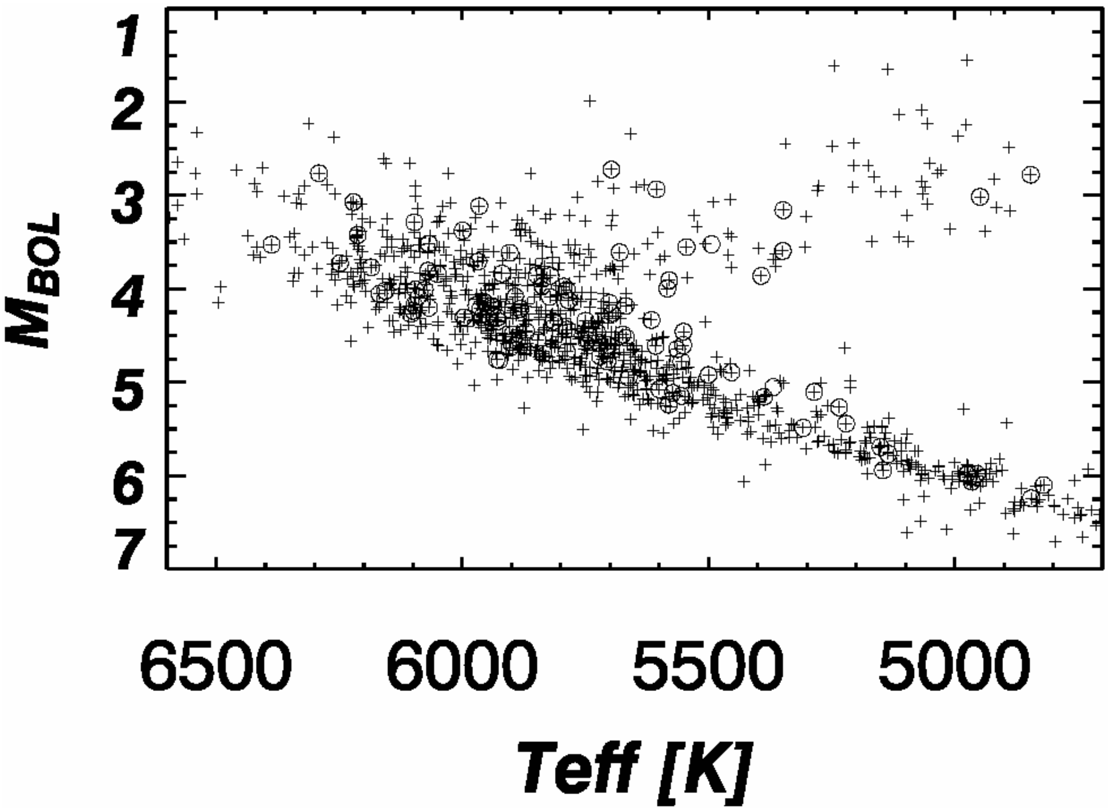


Figure 11 – This Hertzsprung Russell diagram shows the luminosity and temperature of the stars in the exoplanet search programs. The stars that have planets are shown with circles. The diagram shows many observations of red giants with planets. This indicates that red giants and their planets can coexist and that the planets can grow from the strong stellar winds of the red giant. The planets can withstand the transition of the star to a red giant state without being destroyed. Therefore, the planets survive and collect mass from repeating red giant transitions. The planets are created gradually not by one but by many transitions of the star to a red giant. Form this

diagram it is also clear that the majority of the stars with planets are concentrated near the turnoff point of the H-R diagram or where the red giant branch is diverging from the main sequence. Stars at the turnoff point are most likely to fluctuate from main sequence to red giant. Stars at the turnoff point are close both to the main sequence branch and to the red giant branch. This shows the link between red giant stars and the formation of planets. (From Fischer & Valenti 2005)

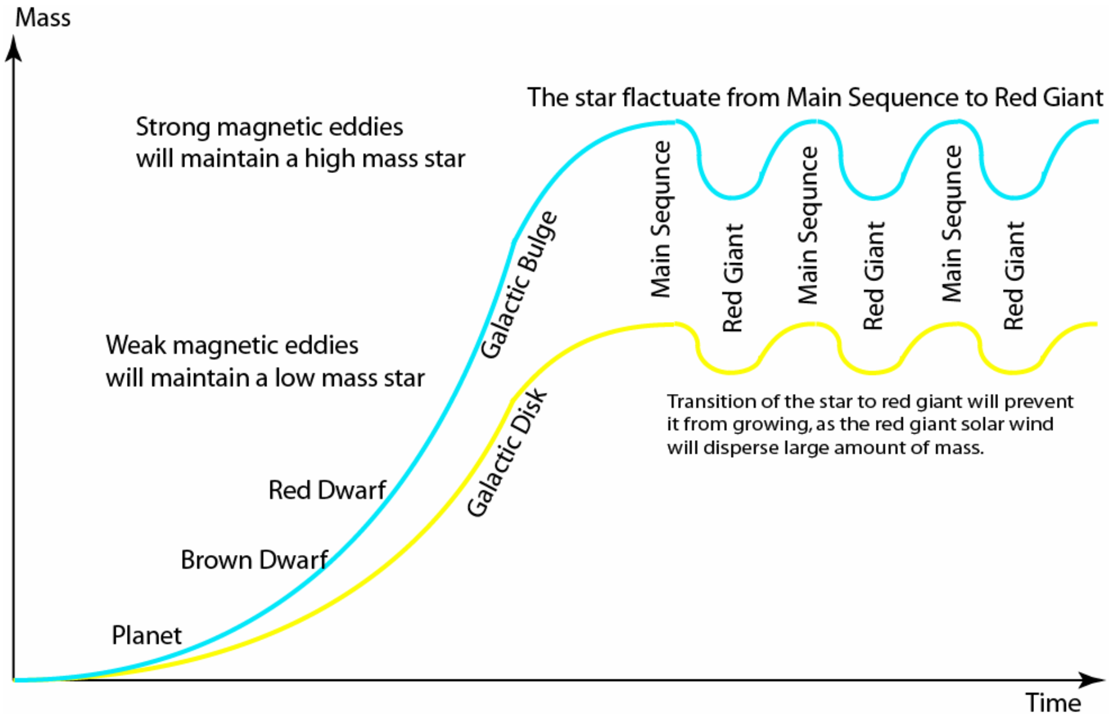


Figure 12 – The stars starts their life as planets. They first grow from accretion and then from conversion of energy to mass. The final size of a star is determined by the strength of the magnetic fields in its region. In the Milky Way bulge the stars will absorb strong magnetic fields so they can grow faster and get to larger size than stars in the Milky Way disk. Each region in the galaxy can support stars of certain size; if the star is crossing this size limit, the magnetic fields will not be able to support its energy consumption. The star will get into an extended Maunder minimum that will turn it into a red giant. In the red giant state the star will lose some of its mass to strong stellar wind. The star will get smaller until it will return to the size limit supported by the specific region in the galaxy. The stars can gain mass and also can lose mass so in the long run their mass is determined by the strength of the magnetic fields. This is clear in the globular clusters where the turnoff point is determined by the strength of the magnetic fields.

The planets were born from the solar wind of the red giant Sun

Stars have very long lives. In reference 3 it was shown that the sun could be several hundred billion years old. In such a long time, it could be argued that planets could accumulate their mass from interstellar material. One source of the planets mass could be interstellar material that enters the solar system and a second source could be from condensation of the solar wind of the main sequence sun. The planets could accumulate their mass from slow accretion and there is no need for the sun to turn into a red giant in order to explain the mass of the planets. However, such slow accretion scenario cannot explain the fact that the meteorite and chondrules are 4.6 billion years old. Slow accretion scenario also cannot explain the source of the short lived isotopes. The fact that meteorite are 4.6 billion years old and have the same composition of the sun and distributed all over the solar system, indicate that large quantities of material was ejected from the sun 4.6 billion years ago. If the meteorites were from a planetary collision 4.6 billion years ago, than the meteorites would not have the exact composition of the sun and their distribution in the solar system would be more localized.

The sun was a red giant and as a red giant it dispersed large amount of mass and matter by its solar wind. To get to the planets the solar wind went trough a long and complex process until it was accreted and captured by the planets. To reveal this process we can use observation of the solar system like its comets and the Kuiper belt, observation of nearby red giants stars , circumstellar envelops and planetary nebulas, and we can use some of the ideas of the solar nebula hypothesis especially those that describe the formation of large object from gas and dust.

Stars that turn into a red giant eject large amount of matter. A red giant typically have a mass lose of 10^-7 solar masses per year. After a long time in the red giant state this matter will accumulate and form large gas and dust shell around the star called Circumstellar Enevelop. Circumstellar envelops hide the red giant star at their center and can be observed in Infrared. There are observations of tens of thousands of circumstellar envelops in the Milky Way. The composition of the Circumstellar enevelops reveals diverse materials like silicates, iron, water, and organic compounds. Those materials are also found in the solar system.

Circumstellar envelops can turn into Planetary Nebula in which most of the material of the star is dispersed to form large gas and dust nebula. An example of a Planetary Nebula is the Helix nebula (Figure 13). In this image it is shown that the gas and dust cloud is clumped into knots or comet like objects. Those comets like objects reveal how the gas and cloud ejected by the star is turned into large bodies. Those knots and comets are the building blocks of planets and are a developmental stage that link between the gas and dust of the stellar wind and the formation of planets. In circumstellar envelops and red giants there is similar growth of comet like objects, but on a smaller scale, since the mass of the gas and dust of a circumstellar enevelop is smaller then the mass of the planetary nebula.

The comets of the solar system were created by the red giant sun 4.6 billion years ago as is evident from radioactive dating of meteorites. Meteorites and asteroids are actually comets that their ices were evaporated. Comets are icy object found in the outer regions of the solar system. When comets get near the sun the ices are evaporated and the comets appear with long tail of gas and dust. The comets form two tails one is of dust and gas that follow the comets orbit and one is made of ions that is always pointed directly away from the sun and is induced by the solar wind of the sun. There are comets with short period like Halley's Comet that are originated from the Kuiper belt and there are comets with long period like comet Hale Bopp that are originated from the Oort cloud. The comets contain ices like water ice, carbon monoxide, carbon dioxide, methane and ammonia. The nucleus of comets is rocky and has composition similar to asteroids. The materials found in comets are also found in circumstellar enevelops. The comets are therefore condensation of the solar wind 4.6 billion years ago when the sun was a red giant. The red giant sun had massive solar wind; this solar wind condensed at the outer regions of the solar system and formed the Kuiper belt and the Oort cloud (Figure 15). The comets that formed at the Kuiper belt grew from impact, collisions and cementation of dust aggregates. As the comets collided, the energy form the collision melted some of the ices and when the ices froze again the colliding bodied where connected. Those impacts created large comets of tens of kilometers in radius. Those large comets later aggregated by gravity to form very large objects like Pluto and Eris. Those objects were pulled by the sun gravity, by gravitational pulls of other large comets or existing planets and drifted to the inner parts of the solar system. Those objects as they approached the sun were captured by the sun to from cores or nucleuses of new planets. After the new planet orbited the sun it accreted comets and asteroids and its mass increased. Subsequent transitions of the sun to a red giant supplied additional material that formed new comets, and again, some of them were captured by the new planets to increase the planets mass. This way, in a gradual process over many transitions of the sun to a red giant, new planets were added to the solar system and the mass of existing planets increased (Figure 17).

The orbits of some comets are at high angle to the ecliptic plane of the solar system. For instance, comet Hale Bopp have almost perpendicular angle to the ecliptic. This support the idea, that the comets are originated from the solar wind of the red giant sun. The solar wind spread material in all directions and some of it will reach to regions that reside at high angles to the ecliptic plane. Therefore, some comets will be formed at high angle to the ecliptic plane. However, most of the comets will have orbits with small angle to the ecliptic plane.

The Kuiper belt is found beyond the orbit of Neptune between 30 to 55 AU. The Kuiper belt contains tens of thousands of objects larger then 100 kilometer. Spectroscopy of Pluto and other large Kuiper belt objects shows that they contain water ice and methane, this confirms the idea that the large Kuiper belt objects grew by accreting comets. The Kuiper belt, right after the time of the last red giant transition, was much denser and contained many more objects. Some of those objects shifted their orbits by the gravitational pull of the outer planets of the solar system or other large comets and fell to the inner parts of the solar system. Some of those objects were accreted by the planets and increased their mass. The depletion of the Kuiper belt continues until this day as is evident by observations of comets that are falling to planets. Jupiter is the most massive planet in the solar system and by its large gravity it captures many of the comets and Kuiper belt objects. A striking example of this is the comet Shoemaker-Levy 9 that fell to Jupiter in 1994. As it fell to Jupiter it broke apart and showed that is was an aggregate of smaller object that were clumped together. This demonstrates how the planets grew from falling comets.

Those days the fall of comets to the planets is rare, but short after the red giant transition 4.6 billion years ago this happened frequently and large comets fell daily to the planets.

While comet Shoemaker-Levy 9 demonstrate how the mass of the planets grew from accreting Kuiper belt objects, Neptune moon Triton demonstrate the formation of new planets and moons from large Kuiper belt objects. Neptune moon Triton has a highly inclined and retrograde orbit around Neptune, indicating that it was captured. It is also from the Kuiper belt, since its composition is the same as the Kuiper belt objects. Triton resembles Pluto in its composition and brightness and this suggest that they form at the same region. Triton is an example of a new moon but in different circumstances when the outer planets were missing it could easily get into orbit around the sun and form the nucleus or core of a new planet. The solar system grew gradually and at earlier times there were fewer planets in the solar system (Figure 17). At those earlier times large Kuiper belt objects like Pluto were released from the Kuiper belt by gravitational pull of planets, nearby star or other Kuiper belt object and fell to the inner parts of the solar system to form new planets. Not all Kuiper belt objects that fell in this way created new planets, most of them fell to the sun or collided with existing planets. The Kuiper belt objects could form both the outer gas giant planets and the terrestrial rocky planets. Pluto has a rock to ice ratio of 70/30 so even if its ices evaporate by the sun heat, still much material will be left to form the nucleus of a new terrestrial planet.

Figure 13 shows how the solar wind of a red giant forms comets. This figure shows many knots and comets that formed by the dust cloud of the Helix planetary nebula. Those knots are similar to the Kuiper belt objects and indicated that the Kuiper belt objects formed from the solar wind of the red giant sun. In circumstellar envelops around red giants there is a similar process of clumping comets from the dust and gas clouds. Those comets are the building blocks of the solar planets. Many of the exoplanets were also formed by this process from comets created by a red giant stellar wind. The high metallicity of stars with planets confirms that the star went through a mass loss when it was a red giant. The process by which the dust and gas cloud is clumped to from larger and larger comet like objects can be understood from studies of the solar nebula hypothesis that describe the formation of large bodies or planetesimals. The dust and gas ejected by the red giant sun is not very different from the dust and gas cloud described by the solar nebula hypothesis.

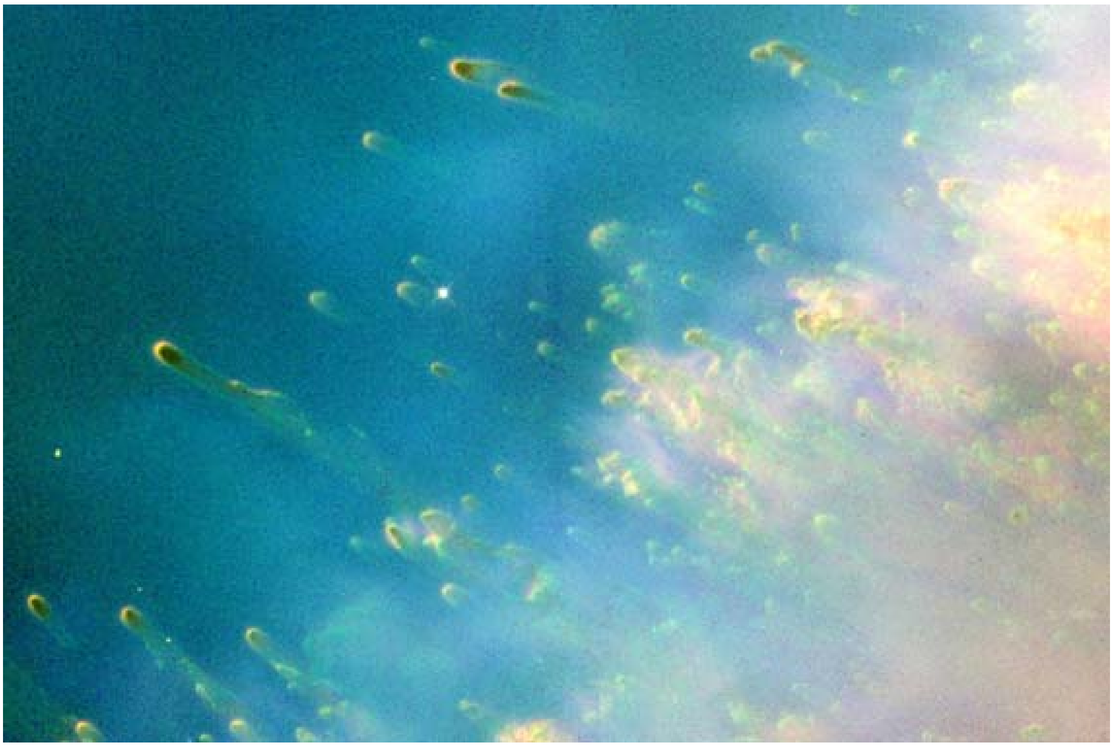


Figure 13 – This is a photo of the Helix planetary nebula. Planetary nebulae are developed after a star turn into a red giant and eject strong stellar wind for a long time. Most of the star mass is ejected outward and form a gas and dust cloud around the star. This figure shows the formation of knots or comet like objects that are reminiscent of Kuiper Belt objects in the solar system. It demonstrates the formation of comets and larger objects that are the building blocks of planets. In a similar process the stellar wind of a red giant form a circumstellar enevelops that condense to form comets. Those comets are then falling toward the star under its gravitational pull and form new planets or are been accreted by existing planets. The comparison to the solar system comets is limited since the large Helix nebula Knots have the size of several AU.

At the lowest level, the dust particles, condensed from the solar wind, are colliding together. The collisions chemically bond the particle and friction between the dust particles electrically charge the particles, so they stick together by electrostatic forces. A NASA Space Shuttle experiment called Cosmic Dust Aggregation Experiment - CODAG - showed how dust particles stick together in microgravity conditions and grow rapidly to fractal dust aggregates (Reference 18). The electrostatic forces create small fluffy objects; those fluffy objects are colliding with each other and can grow to size of one meter. When the fluffy objects collide, their kinetic energy compact the objects and absorb the energy of the impact. This way the objects do not bounce from each other but stick together. The bodies will also condense gas to form layers of frost and ices around the bodies. Those ices will melt upon impact and stick the objects together when frozen again. Additional process that forms small objects is surface tension that creates the chondrules to have sizes of few millimeters. Aggregates of dust can also be combined by cementation in the presence of water or ice.

The growth by impacts dominates the growth of larger bodies. Collisions of larger bodies can fragment and scatter the objects. So, to avoid fragmentation the growth continues by collisions between large objects and small objects. When the small objects are hitting the larger object the larger body will not fragment and it will absorb the smaller body. When the objects reach sizes of several kilometers they attract other objects by gravity. Large objects sweep all the smaller objects in their vicinity. The larger the object, the larger its gravitational pull on nearby objects and the faster it grows. This growth by gravity creates objects the size of Pluto and Eris. Those objects can be captured by the sun or planets to form the nucleus or core of a new planet or moon. The large objects, of few kilometers in diameter or larger, affect other bodies in their vicinity by their gravity. The gravity disrupts the orbits of nearby objects and enables some of them to leave the Kuiper belt and enter to the solar system. When those comets enter the solar system they are captured by planets and increase their mass. Extremely massive bodies like Pluto can create the nucleus or core of new planet or moon.

The Kuiper belt objects are concentrated near the ecliptic plane. Their distribution reminds more a donut shape than a disk shape. The solar wind is spreading in all direction, so many comets and the Kuiper belt objects should be found at high angle to the ecliptic. The fact that the Kuiper belt is concentrated near the ecliptic suggests that there is a process that drifts the dust from the solar wind toward the ecliptic. The solar wind is pushed outward form the sun but it also rotates with the sun. The solar wind drifts the dust in the solar system with it. The dust is hit by particles in the solar wind and it also affected by the magnetic fields of the solar wind that by the Lorenz force carry the dust particles. So, the dust rotates with the solar wind around the sun. This rotation applies a centrifugal force on the dust particles that tend to pull them away from the sun (Figure 14). The gravitational force that the sun exerts on the dust particles has a horizontal component and a vertical component. The centrifugal force is in opposite direction to the horizontal component of the sun gravitational force. This decreases or cancels the horizontal component of the gravitational force. The vertical component is not affected and pulls the dust particle toward the ecliptic plane. This drift toward the ecliptic plane is evident from the distribution of the Kuiper belt objects and also by the zodiacal light. The zodiacal light can be seen in dark nights and far from the city and its light pollution. It is a reflection of sunlight by interplanetary dust that resides near the ecliptic plane. The zodiacal light and the interplanetary dust form a lens shape near the ecliptic plane centered around the sun. The zodiacal light shows that the dust in the solar system is pulled to the ecliptic plane. The dust was also pulled to the ecliptic plane when the sun was a red giant and the material ejected from the red giant sun accumulated near the ecliptic plane. The dust particles had a curved trajectory similar to what is seen in figure 15. The dust particles will be pushed outward by the solar wind and at the same time move toward the ecliptic plane. At the outer regions of the solar system and near the ecliptic plane the gas and dust will condense to form comets. After a red giant transition many large comets develop and circle the sun. The dense distribution of the comets will induce collisions and gravitational pulls that will cause them to fall toward the sun and the inner planets. As seen in figure 15 the material that was ejected by the sun follows a cycle denoted by 1, 2, and 3. At 1 material is ejected by the solar wind, at 2 the gas and dust condense to from comets near the ecliptic plane and far from the sun near the Kuiper belt, at 3 the comets fall to the planets on the ecliptic plane. The fact that the comets fall to the planets near the ecliptic plane causes the outermost planets to grow faster as they collect most of the comets (Figure 17). Only few comets reach the inner planets so their growth is slower then that of the outer planets.

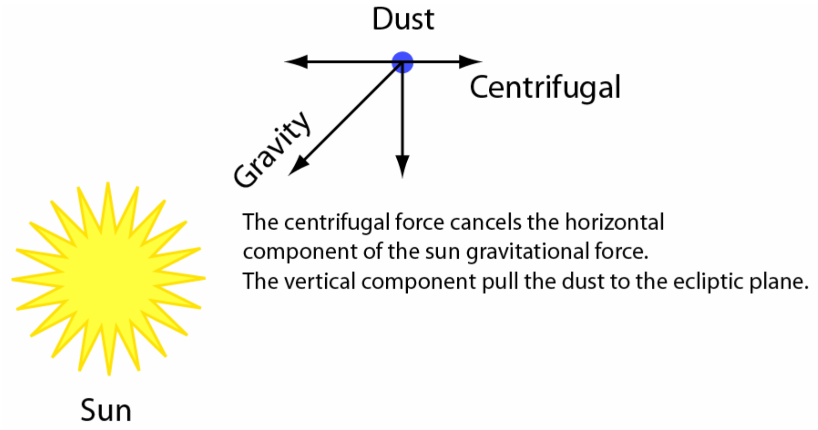


Figure 14 – The solar wind from the red giant sun formed the comets in the Kuiper belt. The solar wind is spreading in all directions but the Kuiper belt objects are concentrated near the ecliptic plane. So, there is a flattening process that pulled the dust to the ecliptic plane. The dust is drifted to the ecliptic plane by the vertical component of the sun gravitational force. The solar wind blows outward and it also rotates with the sun. Dust particles will rotate with the solar wind and will be pushed outward by the centrifugal force. The centrifugal force is perpendicular to the sun rotation axis and parallel to the ecliptic plane. The centrifugal force will cancel the horizontal component of the sun gravitational force. The sun vertical component of the gravitational force is unaffected and will exert force that will pull the dust to the ecliptic plane. The drift of dust to the ecliptic plane is evident from the zodiacal light that is created by interplanetary dust.

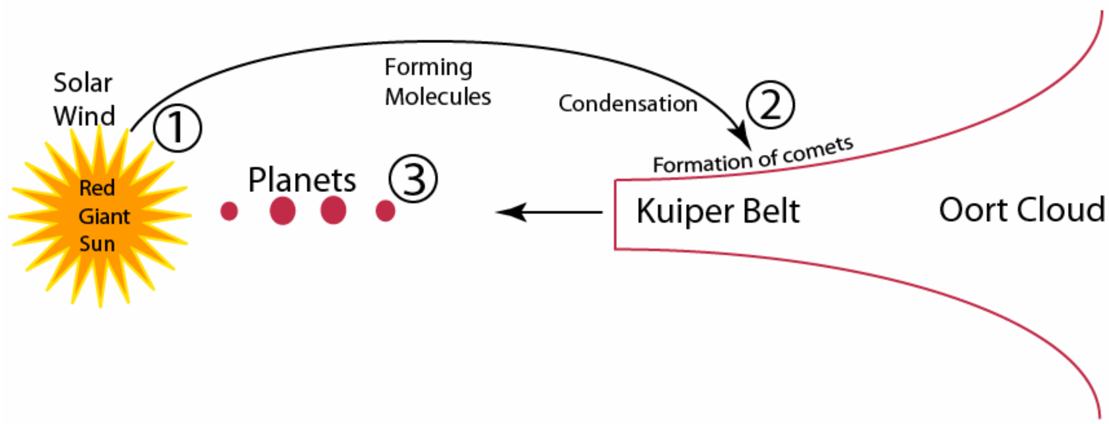


Figure 15 – The transfer of mass from the red giant sun to the planets was indirect, despite the fact that the solar wind was blowing close to the planets. The solar wind was in a hot plasma state near the planets and it could not sink to the planets. The solar wind blew to the outer regions of the solar system where the temperatures are colder. The plasma of the solar wind first recombined to form atoms, then the atoms formed molecules and those molecules condensed to form dust. The dust clumped by electrostatic attraction and by impacts and formed comets and larger objects around the ecliptic plane and near the Kuiper belt. The comets under the gravitational pull of the sun, planets and other comets fell from the outer regions of the solar system to its inner parts and then captured by the planets. The track of mass from the sun to the planets is denoted by the numbers 1, 2, and 3.

The material that builds the planets is entering the solar system from the outside and from the ecliptic plane. The injection of material in this form gives the solar planetary system its disc like shape. If one takes a bucket of sand and slowly pour it to the floor the sand will form a small pile with a peak directed toward the bucket from where the sand was poured. Similarly, the flow of material from the Kuiper belt to the ecliptic plane formed the planets on the ecliptic plane with a layered structure that grow outward and got closer and closer to the Kuiper belt from where the material arrived (Figure 17).

The solar wind of the red giant sun rotated with the sun, so the comets condensed from the solar wind also rotate in the same direction as the sun and the solar wind. Those comets when they create the nucleus or cores of new planets or increase the mass of existing planets will give the planets orbits that are in the same direction as the sun rotation. Therefore, the orbits of the solar system planets are in the same direction and correspond to the sun rotation.

The flattening process of the dust in the solar system created the comets and the Kuiper belt on the ecliptic plane. As the Kuiper belt supplied the mass for the planets and this mass arrived on the ecliptic plane, the comets created a coplanar planets on the ecliptic plane. Therefore, all the planets orbits reside approximately on the same ecliptic plane.

As comets from the Kuiper belt are falling to the planets they hit the planets on their outer hemisphere facing toward the Kuiper belt, but not on the hemisphere facing the sun. The speed of the comets is also higher then the speed of the planets since the comets gain speed by falling to the solar system. Therefore, when the comets hit the planets they exert a torque on the planets that spin them in the same direction of the sun rotation. Therefore, most of planets spin in the same direction and this direction correspond to the sun rotation. Another factor in the planets spin is that dust and micrometeorites fall to the planets on their outer hemisphere facing the Kuiper belt. The dust and micrometeorite are carried by the solar wind and have greater speed then the planets. Therefore, when hitting the planets they apply torque that spins the planets in the same direction as the sun rotation.

The solar wind as it rotates with the sun prevents the formation of planets with retrograde orbits. Large Kuiper belt object or planet nucleus that is capture by the sun with retrograde orbit will travel against the solar wind. This will form drag that will slow the planet and decrease its speed. The planet will spiral slowly toward the sun and then will hit the sun and vanish. Large Kuiper belt object or planet nucleus that are captured by the sun to have an orbit in the same direction as the sun rotation will not be slowed by the solar wind and will keep orbiting the sun.

The sun slow rotation can be explained from the fact that it was a red giant in the past. The sun was a red giant and it ejected strong solar wind. When the outer layers of the sun expanded, the combined moments of inertia of the sun and the outer layers increased. To conserve the angular momentum the angular speed of the sun had to decrease. This is similar to an ice skater that spread his arms during rotation. While his angular momentum is conserved, his rotation speed decrease. Most of the solar wind of the red giant sun was lost to the interstellar space and some of the angular momentum of the sun lost with it. However, some of the solar wind condensed to from comets that formed the planet. This way some of the sun angular momentum, that was lost to the solar wind, transferred to the planets. In reference 3 it was shown that stellar rotation is driven by the changing magnetic fields of the stellar cycle. According to the standard solar model the magnetic fields of the stellar cycle are created by the rotation of the star. However, in reference 3 it was shown that the opposite is correct, the magnetic fields of the stellar cycle drive the stellar rotation. In summary, during the main sequence the rotation speed of the star increase, while in the red giant state the rotation speed of the star decrease.

The changing magnetic fields not only determine the rotation speed of the star but also the direction of the rotation axis. The star will try to align itself to the changing magnetic fields so that the energy it collects is maximized. If there is a small angle between the changing magnetic fields and the star rotation, the plasma belts that circle the star will not be perfectly perpendicular to the rotation axis, but will be at some angle (Reference 3). The star rotation axis will try to conform to be perpendicular to the plasma belt and by that will change slightly. This change of the rotation axis explains the 7 degrees angle between the sun equator and the ecliptic plane.

The solar planetary system is too complex to be created by one red giant transition of the sun. If there was only one red giant transition that extended over long period, the solar system would have one or two planets. The rest of the mass from one red giant transition that was condensed to form comets, would be lost by chaotic collision between the comets and larger bodies. The comets would fell to the sun or flung outward from the solar system. The concentric orbits of the planets are like the layers or strata in old rocks where the different layers created in different events or epochs. The solar system was built gradually by many red giant transitions. Each red giant transition added material to the planets. The amount of material that each red giant transition supplied was small enough that it did not shatter the delicate structure of the solar planetary system.

It is hard to estimate the number of red giants transitions the sun went trough to create the planets. We can use a simple calculation to roughly estimate this number. We can set the mass loss of the red giant sun to be 10^-9 solar mass per year. We also know that the total mass of the planets is 2.7*10^27 kg. The chondrite meteorites were created in a period of about 20 million years so 4.6 billion years ago the sun was a red giant for the same period of 20 million years. The total mass ejected by the red giant sun during this period is the multiplication of the length of time and the mass loss rate.

$$20 \cdot 10^{6} \cdot 10^{-9} \cdot 1.98 \cdot 10^{30} = 3.96 \cdot 10^{28} \text{ kg}$$

We know that most of this mass loss is lost into the interstellar space or falling back to the sun after condensation, so we can assume that only 0.5% of this mass loss is captured by the planets. In figure 17 it is shown that at earlier times the planets configuration was different and only the inner planets were present. At those earlier times when, for instance, just mercury, venus and earth were present, the planets captured much smaller part of the condensed solar wind. At the present time the massive Jupiter and outer planets attract the comets and asteroids so larger portion of the condensed solar wind can be captured. The earlier configuration of low mass inner planets indicates that only small fraction of the red giant mass loss is captured by the planets. If we divide the mass of the planets by the captured mass loss of the last red giant transition we can get an estimate of the overall number of red giant transitions that formed the solar planets:

$$\frac{2.7\cdot 10^{27}}{3.96\cdot 10^{28}\cdot 0.005} = 13.6$$

So the sun went through about 13 times a red giant transition.
In reference 4 it was shown that the sun is roughly 550 billion years old, so it is possible that the sun was a red giant many times more then what is suggested by this calculation. It is also possible that the solar planetary system we find today is not the first planetary system of the sun. The sun could have one or more earlier planetary system, and after it was destroyed by collisions between planets or gravitational tides from nearby stars, a new planetary system was started from scratch.

Figure 16 shows the history of the sun. In the beginning the sun was a planet and it grew by converting energy to mass. Along its history the sun went through many red giant transitions; in each red giant transition the sun lost some of its mass by strong solar winds. Some of this mass arrived to the planets so at each red giant transition the total mass of the planets increased slightly. The sun is very old and in reference 4 it was suggested that the sun is about 550 billion years old. It is only possible to speculate on how many red giant transitions the sun went through in such a long time. The last red giant transition was 4.6 billion years ago as is evident from radioactive dating of meteorites. The process that turns the sun to a red giant is chaotic in nature, so the period of 4.6 billion years does not indicate the average time interval between successive red giant transitions. The high metallicity of the sun indicate that it went through a considerable mass loss in the past so it can be speculated that before 4.6 billion years ago the time gap between successive red giant transition was shorter then 4.6 billion years.

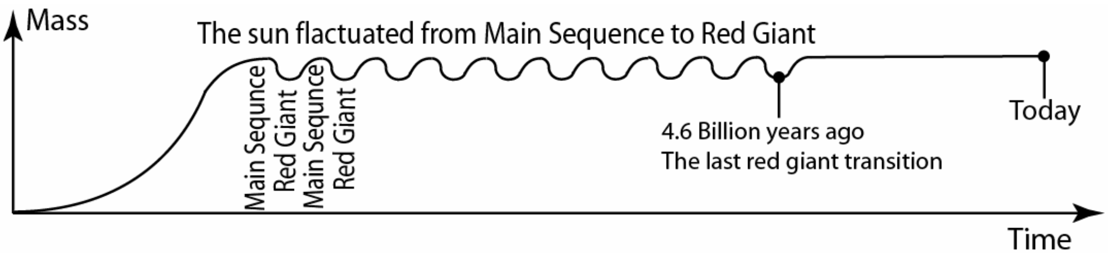


Figure 16 – In its past the sun was a planet and grew to its current size by conversion of energy from its solar cycle to mass. The sun transformed many times in its past to a red giant. In the red giant state, the sun ejected large amount of mass that formed the planets. The elaborate structure of the solar system is due to gradual growth from many red giant transitions. Each transition contributed a small a mount of mass that made exiting planets grow and formed new planets. The last Sun red giant transition was 4.6 billion years ago. The mass ejected at that time formed the meteorites and chondrules so their radioactive dating gives their age to be 4.6 billion years.

The growth of the solar system was gradual. The planets did not form all at the same time. First, the innermost planets Mercury and Venus formed. Then, gradually, more planets joined the solar system. Mercury and Venus are the oldest planets of the solar system while Uranus and Neptune are the youngest. The age of earth could be few tens of billion of years as it is one of oldest planet of the solar system. Uranus high axial tilt of 98 degrees can be linked to the fact that it is a young planet. The time interval between the formation of the innermost planets and the outermost planets could be few tens of billion of years. During this period the sun went through many red giant transitions that each contributed mass to the planets growth. During a red giant transition the sun ejects material that accumulates at the outer regions of the solar system near or beyond the position of the Kuiper belt. This material was condensed and clumped together to form comets of various sizes. The comets were concentrated near the ecliptic plane. There are collisions and gravitational pulls between comets. Those collisions and pulls between comets can reduce their speed below the orbital velocity. For instance, there could be a gravitational attraction between two large comets. One comet will speed up and will climb into higher orbit while the second will slow down to a speed below the orbital velocity. At a speed below the orbital velocity, the comet will not be able to hold its orbit and it will fall inward toward the sun and planets. There is a considerable time between the red giant transition and the time comets start to shower toward the sun and planets. The formation of large comets can take millions of years, so there could be a delay of millions of years between the peak of the red giant transition and the peak in the fall rate of the comets to the solar system. The planets were created one at a time and long time separated the formation of each planet. First a large comet fell toward the sun and was captured at the orbit of Mercury. This created the nucleus or core of the new planet. This nucleus grew from attracting other falling comets by gravitation or by collisions. After Mercury reached a considerable size, it dominated its region so new comets that fell into nearby orbit were swept up by Mercury gravitation. Therefore, new planets could not form very near the orbit of Mercury but only farther out from Mercury. This way, the orbit of Venus could only be formed far enough from Mercury. Again it was created by a new large comet that arrived from the outer regions of the solar system. The new comet formed a new nucleus of the planet that attracted other smaller comets. This way, all the planets grew one by one from the inner planets to the outer planets (Figure 17). The comets are formed near the ecliptic plane, so matter fall to the planets through the ecliptic plane from the outside. Therefore, the outer planets grew faster since they collect the matter that is falling to the ecliptic plane from the outside. The outer planets have slower orbital velocity and this also increases their growth rate. The inner planets are not collecting much mass since most of the comets are collected by the outer planets and comets are unable to cross the orbits of the outer planets. The higher mass of the outer planets will cause higher portion of the comets to be captured by the outer planets. This situation where the outer planets are capturing most of the comets, while the inner planets rarely do, is observed at the present time in the solar system. Jupiter is collecting much of the comets and asteroids that enter the solar system, while the earth and inner planets are not. Tens of billions of years ago when Jupiter was smaller or nonexistent the earth was capturing much of the comets that entered the solar system.

In order for a comet to form a planet nucleus, it must obey several conditions. It must have the correct speed that will fit the Orbital velocity of the new orbit. It must enter an orbit near the ecliptic plane. It must have low eccentricity. The orbit must be in the same direction as the sun rotation. A retrograde orbit will not form a new planet; the solar wind will slow it until it will fall to the sun or collide with a planet. It must be heavy enough so that it can grow by sweeping nearby smaller objects and comets. It also needs to find an orbit that is far enough from existing planets. If those conditions are met, the comet will hold its orbit around the sun for a long time and will be able to grow during this time to a planet by capturing other comets and asteroids.

The sun turned into a red giant many times to create the solar system. After each red giant transition, a shower of comets fell to the planets and increased their mass. The time intervals between successive red giant transitions are also an essential factor in the formation of the solar system. Between the red giant transitions the orbits of the newly formed planets lost their eccentricity and got circular. Their orbits also flattened out to have a smaller inclination relative to the ecliptic plane of the solar system. The orbits of the planets got circular by tidal interaction with the sun. In an eccentric orbit the planet is approaching and receding from the sun continually. Each time it approach and recede from the sun it lose some energy of its eccentric orbit until its orbit turn circular. Gravitational interaction with other planets will also decrease the eccentricity and will pull the orbit to the ecliptic. This way between the red giant transitions the solar system is organized and stabilized. When the next red giant transition come, the solar system is stable and can withstand gravitational pulls by large comets and it is steady enough to capture and form a new planet.

The outer planets grow faster by accreting most of the comets, however, the inner planet are almost not growing at all. The mass accreted to each planet is limited by planets that are found farther in outer orbits. The larger the mass and number of those outer planets, the smaller the accretion rate. This can be described with the following relation:

$$\frac{dM}{dt} \propto \frac{M}{\sum_{r}^{n} r \cdot M_r} \qquad (2)$$

M - is the planet mass.
r, n - is the range of planets in outer orbits. For instance, for Jupiter the outer planets will be Saturn, Uranus and Neptune so r will be 1 and n will be 3.
Mr - is the mass of the outer planets.

For Jupiter the accretion rate will look like this:

$$\frac{dM_{Jupiter}}{dt} \propto \frac{M_{Jupiter}}{1 \cdot M_{Saturn} + 2 \cdot M_{Uranus} + 3 \cdot M_{Neptune}} \qquad (3)$$

The accretion rate of the planet will increase if the planet is more massive and will decrease if there are many massive planets in outer orbits. This relation demonstrates that the growth of inner planet is almost nonexistent, but the growth of the outer planets is rapid since they capture most of the comets that arrive through the ecliptic plane.

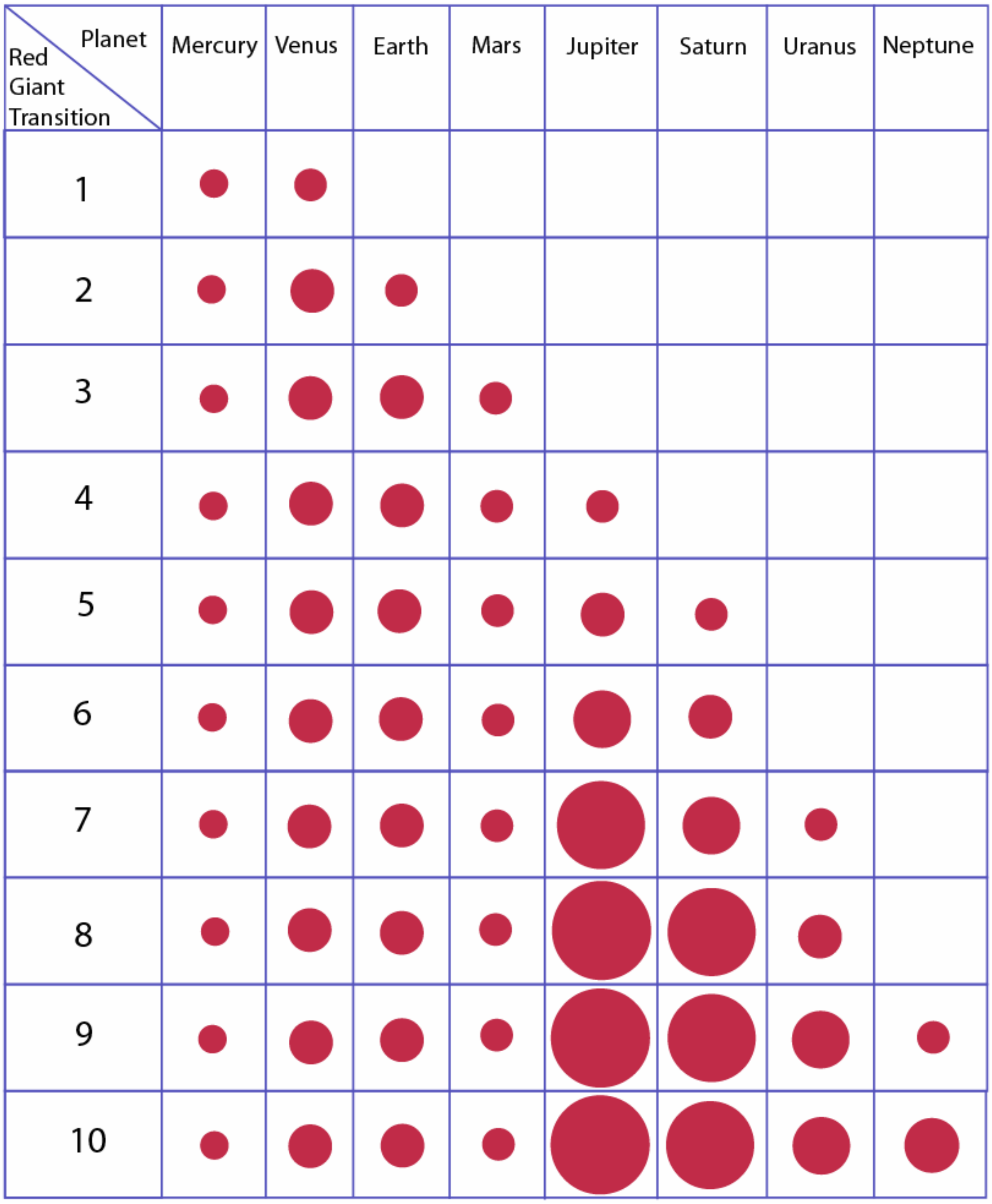


Figure 17 – The gradual formation of the solar planetary system from many red giant transitions of the sun. Each red giant transition added material to the planets. This material was captured mainly by the outermost planets, or formed a new planet beyond the outermost planet. The last sun red giant transition (denoted 10 in the figure) happened 4.6 billion years as is evident by meteorite age. The figure shows the gradual formation of the planet by 10 red giant transitions. This number is speculated and in reality the number of red giant transition could be higher or smaller then 10. The time between each red giant transition is random and could be anything between 200 million years and 10 billion years.

There are few red giants in the Orion nebula. The changing magnetic fields in the Orion nebula are very strong, so they can support the high luminosity and strong stellar wind of the many O and B type stars of the Orion Nebula. Since red giants stars are created by drop in the strength of the changing magnetic fields, they are rare in the Orion Nebula. Betelgeuse a massive red giant found in the Orion nebula is an exception. The strong changing magnetic fields in the Orion nebula supply a lot of energy to the stars. This enables the stars to grow rapidly by conversion of energy to mass. There are evidences of free floating planets in the Orion Nebula that indicate that planets are created there but there are no red giants that can produce planets. So in stellar nurseries like the Orion nebula there must be a different process by which planets form. In the Orion Nebula the stars are massive and produce strong stellar wind. Planets cannot be created near an O or B type stars because the stellar wind is too strong and will abrade any object near the star. Therefore, the stellar wind of the O and B star will condense around smaller stars that are found in the region of the O and B stars. The presence of the O and B star create favorable conditions for the formation of stars as was mentioned earlier in the chapter Stars Originate from Planets. Planets in the Orion nebula can also form in the many bow shocks observed in the nebula. There are collisions between the stellar winds of nearby stars that create bow shocks. If there is such a stellar wind collision of a giant star and a smaller star, gas and dust will condense near the smaller star and will create comet like object that can build planets around the smaller star. The stellar systems created in stellar nurseries like the Orion nebula will have typically one gaseous planet that will grow rapidly and will be released from its star when it reaches the size of a brown dwarf. In summary, there are two processes that form planets; one is from the stellar wind of a red giant where the planets form around the red giant itself. The second is from the stellar wind of blue giants, where their stellar winds condense and form planets on nearby smaller stars.

Conclusions

The planets are born and grow by accreting material like comets and asteroids. When the planets mass is close to the mass of a brown dwarf they are released from the central star by gravitational pull of a nearby star. When the planet reaches the mass of a brown dwarf, it absorbs energy from its stellar cycle magnetic fields. The star grows gradually by converting energy from the stellar cycle magnetic fields to mass. As the star grows it climbs along the main sequence, its luminosity increases and its spectral class evolves to that of more massive stars of shorter wavelength.

The matallicity of stars depend on their mass. Stars with higher mass have higher matallicity. The high metallicity of stars with planets suggest that they had higher mass in the past. Stars with planets that show high metallicity went through a significant mass loss. Those stars lost part of their mass when they turned into a red giant and ejected massive stellar wind to the interstellar space. This decreased the mass of the stars but did not change the matallicity of the star. The sun has high metallicity compared to similar stars of the same size. This suggests that the sun was a red giant and went through a significant mass loss. There are many evidences that the sun was a red giant, especially the present of short lived radioactive isotopes and the condensation of chondrules in meteorites.

The solar system planets formed by the stellar wind of the red giant sun. The strong stellar wind condensed and formed comets in the Kuiper belt. Those comets fell back to the inner solar system and formed new planets or increased the mass of existing planets. The sun went through many transitions to a red giant. Each transition added more matter to the planets and gradually increased the number and the mass of the planets.

The idea that the sun was a red giant can only be derived from the hypothesis that the sun energy is from the solar cycle magnetic fields. There is hard evidence found in support of the red giant sun, especially the short lived radioactive isotopes located in meteorites. The fact that there is hard evidence in support of the red giant sun disprove the standard solar model and the solar nebula hypothesis and verify that the sun energy is from magnetic fields.

Carl Sagan once said "We are made of star stuff". Now we can be more specific and say that this stuff or dust came from the sun. We are made of sun stuff - the atoms in our body were synthesized in the sun core. The energy to create this stuff in the sun core came from much farther from the supermassive black hole at the center of the Milky Way Galaxy.

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