Chemistry of interstellar medium& nebulae and their relationship to elements formation

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Abstract: How magnificent is the universe! Lots of materials had been observed through modern telescopes, lots of reactions had been estimated ;but not yet cosmologists had found the true mechanism of the universe formation ,not even the galaxies or stars…The chemistry of heliosphere and cosmic rays affect our Earth directly as well as the life of our Sun. Knowing the chemistry and components of nebulae and interstellar medium may help us found new ways to make nucleosynthesis and new atoms; this may help to save Earth and Sun some day. The chemical process in the interstellar medium may appear to be like those on Earth but the existence of neutrinos and active nuclei in the centre of galaxies make things going different. Studying the stars and galaxies from formation to death may open our minds on the system the universe follow. Some theories goes to the fusion of atoms together as a reversible nuclear reaction ,may be focusing on the nuclear reaction mechanism and following its steps in deep universe allows us some day to start a new century of chemistry studies, when we don't only make molecules but we make atoms as well.

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Introduction to cosmology:

Haven't we ask ourselves how that fabulous universe came from, how stars die and how it is reborn again, lots of theories has been established, Most cosmologists believe that the whole universe came from one explosion science 13.7 million years, this explosion was very hot and turned its energy into electrons then protons and neutrons appeared, after that they combined together to form the first elements "He, Be &Li" that was within only 100 seconds, after 380000 years it was able to form other known elements.

Cosmology is the discipline that deals with the origin, structure, and space-time relationships of the universe or a theory of describing the natural order of the universe. Cosmologists study the universe as a whole: its birth, growth, shape, size and eventual fate…

But astronomy studies individual celestial objects such as stars, planets, and galaxies.

Cosmology focuses on the big picture: How the Universe works, how it came into being, and how it might end. It studies the structure of galaxies.

Cosmology differs from Astronomy, astronomy seems to concentrate on the naming of stars and the description of Earth's solar system; Cosmology concentrates more on the physiology of the Universe as it were.

Chemistry of heliosphere:

The heliosphere is often described as a kind of bubble that contains our solar system, it mostly consists of interstellar gas of "H, He, N, O, Ne, C+". This magnetic sphere, which extends beyond Pluto, is caused by the Sun's solar winds. These winds spread out from the Sun at around 400 km/s until they hit what is known as interstellar space, which is also called local interstellar medium (LISM) or interstellar gas. Interstellar space is the space in galaxies that is unoccupied by either stars or planets.

When the solar winds hit local interstellar medium, a kind of bubble forms and that prevents certain material from getting in. Thus, the heliosphere acts as a kind of shield that protects our solar system from cosmic rays, which are dangerous interstellar particles. The interaction between interstellar gas and solar winds depends on the pressure of the solar winds and properties of interstellar space, such as pressure, density, and qualities of the magnetic field. Astronomers believe that other solar systems have their own heliospheres caused by different stars.

Although electrically neutral atoms from interstellar volume can penetrate this bubble, virtually all of the material in the heliosphere emanates from the Sun itself.

For the first ten billion kilometers of its radius, the solar wind travels at over a million km per hour. As it begins to drop out with the interstellar medium, it slows down before finally ceasing altogether. The point where the solar wind slows down is the termination shock; then there is the heliosheath area; then the point where the interstellar medium and solar wind pressures balance is called the heliopause; the point where the interstellar medium, traveling in the opposite direction, slows down as it collides with the heliosphere is the bow shock.

Solar wind is the wind consists of particles (ionized atoms from the solar corona) and fields (in particular, magnetic fields). As the Sun rotates once in approximately 27 days, the magnetic field transported by the solar wind gets wrapped into a spiral. Variations in the Sun's magnetic field are carried outward by the solar wind and can produce magnetic storms in the Earth's own magnetosphere. The heliosphere's outer structure is determined by the interactions between the solar wind and the winds of interstellar space…

Chemistry of cosmic ray:

Cosmic rays are energetic charged subatomic particles, originating from outer space. They may produce secondary particles that penetrate the Earth's atmosphere and surface…

About 89% of cosmic rays are simple protons or hydrogen nuclei, 10% are helium nuclei or alpha particles, and 1% is the nuclei of heavier elements. These nuclei constitute 99% of the cosmic rays. Solitary electrons (much likes beta particles, although their source is unknown) constitute much of the remaining 1%.

Cosmic rays have a primary role in the formation of the lithium, beryllium, and boron in the universe, through the process of "cosmic ray nucleosynthesis". They also produce some so-called cosmogenic stable isotopes and radioisotopes on Earth, such as carbon-14. In the history of particle physics, cosmic rays were the source of the discovery of the positron.

Cosmic rays may broadly be divided into two categories, primary and secondary:

Primary cosmic rays:

These primary cosmic rays can interact with interstellar matter to create secondary cosmic rays.

Secondary cosmic rays:

The Sun also emits low energy cosmic rays associated with solar flares. The exact composition of primary cosmic rays, outside the Earth's atmosphere, is dependent on which part of the energy spectrum is observed. However, in general, almost 90% of all the incoming cosmic rays are protons, about 9% are helium nuclei (alpha particles) and nearly 1% is electrons. The ratio of hydrogen to helium nuclei (28% helium by mass) is about the same as the primordial elemental abundance ratio of these elements (24% by mass He) in the universe.

Secondary cosmic rays consist of the other nuclei which are not abundant nuclear synthesis end products, or products of the Big Bang, primarily lithium, beryllium, and boron. These light nuclei appear in cosmic rays in much greater abundance (about 1:100 particles) than in solar atmospheres, where their abundance is about 10^{-7} that of helium.

This abundance difference is a result of the way secondary cosmic rays are formed. When the heavy nuclei components of cosmic rays, namely the carbon and oxygen nuclei, colloid with interstellar matter, they break up into lighter nuclei (in a process termed cosmic ray spallation) – lithium, beryllium and boron. It is found that the energy spectra of lithium, beryllium and boron fall off somewhat more steeply than those of carbon or oxygen, indicating that less cosmic ray spallation occurs for the higher energy nuclei presumably due to their escape from the galactic magnetic field. Spallation is also responsible for the abundances of scandium, titanium, vanadium, and manganese ions in cosmic rays, which are produced by collisions of iron and nickel nuclei with interstellar matter.

Detection:

Cosmic rays can also be detected directly when they pass through particle detectors flown aboard satellites or in high altitude balloons.

Sheets of clear plastic such as 1/4 mil Lexan polycarbonate can be stacked together and exposed directly to cosmic rays in space or high altitude. When returned to the laboratory, the plastic sheets are "etched" [literally, slowly dissolved] in warm caustic sodium hydroxide solution, which removes the surface material at a slow, known rate. Wherever a bare cosmic ray nucleus passes through the detector, the nuclear charge causes chemical bond breaking in the plastic. The slower the particle, the more extensive is the bond-breaking along the path; and the higher the charge (the higher the Z), the more extensive is the bond-breaking along the path. The caustic sodium hydroxide dissolves at a faster rate along the path of the damage. The net result is a conical shaped pit in the plastic; typically with two pits per sheet (one originating from each side of the plastic). The etch pits can be measured under a high power microscope, and the etch rate plotted as a function of the depth in the stack of plastic. At the top of the stack, the ionization damage is less due to the higher speed. As the speed decreases due to deceleration in the stack, the ionization damage increases along the path. This generates a unique curve for each atomic nucleus of Z from 1 to 92, allowing identification of both the charge and energy (speed) of the particle that traverses the stack. This technique has been used with great success for detecting not only cosmic rays, but fission product nuclei for neutron detectors.

Interaction with the Earth's atmosphere:

When cosmic ray particles enter the Earth's atmosphere they collide with molecules, mainly oxygen and nitrogen, to produce a cascade of lighter particles, a so-called air shower.

In reality, the number of particles created in an air shower event can reach in the billions, depending on the energy and chemical environment (i.e. atmospheric) of the primary particle. All of the produced particles stay within about one degree of the primary particle's path. Typical particles produced in such collisions are charged mesons (e.g. positive and negative pions and kaons). Cosmic rays are also responsible for the continuous production of a number of unstable isotopes in the Earth's atmosphere, such as carbon-14, via the reaction:

$$n + \mathrm{N}^{14} \rightarrow p + \mathrm{C}^{14}$$

Cosmic rays kept the level of carbon-14 in the atmosphere roughly constant (70 tons) for at least the past 100,000 years, until the beginning of above-ground nuclear weapons testing in the early 1950s. This is an important fact used in radiocarbon dating which is used in archaeology.

Effects:

Changes in atmospheric chemistry:

Cosmic rays ionize the nitrogen and oxygen molecules in the atmosphere, which leads to a number of chemical reactions. One of the reactions results in ozone depletion.

Role in ambient radiation:

Cosmic rays constitute a fraction of the annual radiation exposure of human beings on the Earth. For example, the average annual radiation exposure in Australia is 0.3 mSv due to cosmic rays, out of a total of 2.3 mSv.

Hint: The sievert (symbol: Sv) is the International Unit for the equivalent absorption of radiation by the body "the harmful dose"; it is the gray "the dose in Jules by one kilogram of body" divided by quality factor "the maximum harmful dose"

$1 \text{ Gy}/Q = 1 \text{ Sv} = 1 \text{ J} / \text{kg}Q$

Effect on electronics:

Cosmic rays have sufficient energy to alter the states of elements in electronic integrated circuits, causing transient errors to occur, such as corrupted data in electronic memory devices, or incorrect performance of CPUs, often referred to as "soft errors" (not to be confused with software errors caused by programming mistakes/bugs). This has been a problem in extremely high-altitude electronics, such as in satellites, but with transistors becoming smaller and smaller, this is becoming an increasing concern in ground-level electronics as well. Studies by IBM in the 1990s suggest that computers typically experience about one cosmic-ray-induced error per 256 megabytes of RAM per month. To alleviate this problem, the Intel Corporation has proposed a cosmic ray detector that could be integrated into future high-density microprocessors, allowing the processor to repeat the last command following a cosmic-ray event…

Chemistry of interstellar medium:

Simply, the interstellar medium is the material which fills the space between the stars. Many people imagine outer space to be a complete vacuum, devoid of any material. Although the interstellar regions are more devoid of matter than any vacuum artificially created on Earth, there is matter in space…

Interstellar Gas:

Approximately 99% of the interstellar medium is composed of interstellar gas "neutral atomic gas, ionized gas, molecular gas, coronal gas,", and of its mass, about 75% is in the form of hydrogen (either molecular or atomic), with the remaining 25% as helium. The interstellar gas consists partly of neutral atoms and molecules, as well as charged particles, such as ions and electrons. This gas is extremely dilute, with an average density of about 1 atom per cubic centimeter.

Even though the interstellar gas is very dilute, the amount of matter adds up over the vast distances between the stars.

The interstellar gas is typically found in two forms:

1. Cold clouds of neutral atomic or molecular hydrogen.
2. Hot ionized hydrogen near hot young stars.

The cold clouds of neutral or molecular hydrogen are the birthplace of new stars if they become gravitationally unstable and collapse. The neutral and molecular forms emit radiation in the radio band of the electromagnetic spectrum. In dense interstellar clouds, a large number of molecular species have been identified in the gas phase via high resolution spectral techniques, chiefly rotational spectroscopy in the millimeter wave region of the electromagnetic spectrum. These molecules range in complexity from H_2 to a 13-atom linear nitrile, HC_{11} N.

But the ionized hydrogen is produced when large amounts of ultraviolet radiation are released by hot newly-formed stars. This radiation ionizes the surrounding clouds of gas. Visible light is emitted when electrons recombine with the ionized hydrogen, which is seen as beautiful red colors of emission nebulae. Examples of emission nebulae are the Trifid Nebula or the Orion Nebula.

Interstellar Dust:

Interstellar dust is not like the dust that you might find under your bed; it is made of very different substances. These dust particles are extremely small, just a fraction of a micron across, which happens to be approximately the wavelength of blue light waves. The particles are irregularly shaped, and are composed of silicates, carbon, ice, and/or iron compounds.

When light from other stars passes through the dust, a few things can happen. If the dust is thick enough, the light will be completely blocked, leading to dark areas. These dark clouds are known as dark nebulae.

Abundance studies in the ISM show that many of the refractory elements "C, Si, Mg, Fe, Al, Ti, Ca" are locked up in dust.

The nature of interstellar dust:

1. Ranges in size from about 1 nm to 10 µm, with many more small grains than large.
2. The larger grains are likely to be non-spherical, and perhaps porous, fluffy, and even fractal.
3. Composition is likely to contain cores of metallic silicates, carbonaceous material, and GEMS "like jewelry", probably in different populations rather than mixed in individual grains.
4. Mantles of ices (H_2O, CO, CO_2, CH_3, and OH) are found in cold dense regions.

Towards the end of stars lives, some stars develop rather extended atmospheres that may be cool and dense enough for solid nuclei to form. Then any atoms and molecules that are supersaturated will be rapidly deposited on these nuclei, forming solid particles. Radiation pressure from the central star is then capable of accelerating the dust and establishing an outflow in the entire dusty envelope, which travels out from the star until it mixes with the interstellar gas.

About half the dust grains in the interstellar medium are derived from red giant AGB "asymptotic giant branch" carbon stars at a rate up to 10^{-4} solar masses per year and about half from type II supernovae. As turbulence develops in the nebula, clumps of grains are likely to form by sticking together in low velocity collisions .Growing to centimeter size in the outer nebula. What struck the grains together? Clumps of silicate dust must have been in existence before chondrule formation "round grains found in chondrites which is a kind of meteorites" and must have already been separated from metal and sulfide phases. There is a great variety of components in the interstellar dust. The inorganic components (carbon and silicates) of the dust are formed in stars in the later outflow stages of stellar evolution, when major outflow occur, particularly during the red giant and subsequent stages. The organic and icy components, on the other hand, seem to be formed in the lower temperature environments of the interstellar medium by accretion and reactions induced by ultraviolet radiation. An important question for the evolution of the material in the solar system turns on whether the dust that eventually accretes to the nebula is amorphous or crystalline. This bears on problems as diverse as the temperature of the nebula, the depletion of volatile elements in the inner nebula, the formation of chondrules and much else. Some silicate dust in the interstellar medium appears to amorphous, but crystalline dust is observed in comet and in disks around young stars. Presumably analogs for the solar nebula, as well as in cool disks around red giants. As the temperatures in these disks are too low for annealing, crystallization must occur at low temperature.

Data from the Infra Red space Observatory (ISO) from dust around both young and evolved stars provide much evidence for the presence of crystalline olivines "magnesium iron silicate with the formula $(Mg,Fe)_2SiO_4$" and pyroxenes "$XY(Si,Al)_2O_6$ (where X represents calcium, sodium, iron^{+2} and magnesium and more rarely zinc, manganese and lithium and Y represents ions of smaller size, such as chromium, aluminum, iron^{+3}, magnesium, manganese, scandium, titanium, vanadium and even iron^{+2})". Important from our point of views is that these crystalline silicate are Mg-rich, containing low concentrations of Fe and Ca, an observation that bears on the production of chondrules that are depleted in Fe. Mg-rich crystalline olivine and pyroxene occur in several locations in disk systems and in out flows from late AGB stars, that contribute much of the dust to the interstellar medium .Crystalline silicate spectra have also been observed in diffuse regions around the Trifid nebula and in other star forming regions.

Thus the case for the presence of crystalline Mg-rich olivines and pyroxenes (Mg/Fe> 0.9) appears reasonably well established. This has important implications for nebular temperature and history. If silicate dust arrives in crystalline form as olivines and pyroxenes with the minor components present in as yet undetected phases, then evaporation of this dust in a cool nebula, rather than condensation in a hot nebula, becomes the dominant process responsible for element fractionation in the inner portion of the primordial solar nebula.

It is commonly supposed that carbon in the interstellar medium is present as graphite. This is based on the identification of an absorption line at 2175 Å as due to graphite. Graphite is however, probably not a very important component of the interstellar dust although some secondary graphite particles, about one micrometer in diameter, may be present. Based on the mineralogy of primitive meteorites and interplanetary dust particles, the main forms of carbonaceous material that accreted to the solar nebula were hydrocarbons or poorly crystallized and amorphous carbon rather than graphite.

Large interstellar molecules:

Beside dust grains, the interstellar medium also contains a population of large molecules. These molecules are partially visible at mid IR wavelengths.

These IR emission features are characteristics for polycyclic aromatic hydrocarbons materials.

Stars of all masses in various stages of their lives pollute environment with gas, dust, and metals. The dust budget has been split out into two separate columns according to whether the stellar source contains carbon rich zone (C/O >1), which lead to carbonaceous dust formation; or oxygen rich zones, which lead to the formation of oxides (silicates) or metals. Thus, while 20 years ago high mass stars were thought to be mainly responsible for the carbon in the interstellar medium, in more recent studies carbon rich red giants dominate. These injection rates also vary across the galaxy, because of the general increase in metallicity towards the inner galaxy. The ratio of the O-rich to C-rich giants increases towards the galactic centre .However; massive stars are more efficient in producing and injecting heavy elements, such as O and Si. The origin and evolution of galaxies are closely tied to the cyclic process in which stars eject gas and dust into the ISM, while at the same time gas and dust clouds in the ISM collapse gravitationally to form stars.

Interstellar ices:

Stars and star-forming regions often emit enough infrared radiation to act as spectroscopic light sources. Their emission can be partially absorbed by cold material in dense clouds between them and us. More commonly, infrared absorption spectra arise from cool gas and dust in front of IR emitting young stellar objects ‘‘protostars’’ within dense interstellar clouds. These protostars tend to warm up the area around them so that the physical conditions in the foreground absorbing regions are neither as well characterized nor as homogeneous as when the source of the infrared radiation is a background field star. Still, the existence of ices in these regions implies that temperatures are quite low (-100 K). In addition to the H_2O, CO, and CO_2 seen towards Elias 16 “a star”, significant abundances of methanol, methane, formaldehyde, OCS, and formic acid are present in grain mantles.

Presolar material:

Interstellar material is identified by the present of isotopic anomalies that are bizarre by the standards of the solar system and that don’t appear to result from solar nebula or solar system process as we understand them. By this means notably SiC and Diamond, as well, as graphite, corundum and silicon nitride (Si_3N_4) have been identified in meteorites. These grains of true stellar origin are usually about one micrometer in diameter but occasionally are as large as 20 micrometers.

Diamond:

Diamond is the most abundant presolar material recognized in meteorites .The diamonds are tiny, typically containing only about 25 atoms or so. One possibility is that the diamonds formed in high velocity grain-grain collision in supernova shock waves, where pressure and temperatures are high enough to convert graphite into polycrystalline diamond. Evidence for this is the similarity between meteoritic diamond and samples produced in detonation soot by high explosive detonated in argon-filled chambers. The size, shape, and degree of crystallinity of the diamond clumps produced are almost identical to the meteoritic diamond, consistent with the production of the latter by shock synthesis. Another possible site for the production of diamonds appears to be in the atmosphere of late type carbon-rich stars. However, it is also possible to form diamond films from reactions in the gas phases under low pressures so that there may have been ample opportunity, even within the solar nebula, for diamond films to have been formed by the reactions with CH_4.Thus it is equally likely that the diamonds formed in a way similar to chemical vapor deposition, without involving shock.

Silicon carbide:

Several varieties, ranging in size from 0.3 to 20 micrometers, occur in association with the diamonds, amorphous carbon occurs along with the diamond and SiC. Their identification as interstellar is particularly clear and rests upon the presence of isotopically anomalous C, N, Si, and noble gases.

Carbon, silicon, and nitrogen isotope data on individual grains show wide differences, apparently indicating separate sources. Silicon carbide may form in the atmospheres of C-rich stars; diamond most likely formed in the supernova shock waves. The isotopic anomalies in diamond and SiC are typically orders of magnitude greater than those observed in oxides.

SiC is rare in meteorites, SiC constituting only 4 ppm of the total carbon content. This is surprising, since SiC is thought to be relatively common in the interstellar medium .These examples of interstellar material are very risestant, surviving both natural and laboratory processing .Possibly they don’t represent an average sample of interstellar dust and the solar nebula didn’t receive much material derived from carbon stars.

Chemical processes:

Astrochemistry describes a cosmic dance of the elements in which atoms are constantly reshuffled from one species to another .this molecular rearrangement may be effected by gas phase binary collisions where atoms change partner or through recombination on grain surface .This “dance” is driven by the action of various energy sources, including photons and cosmic rays, in order to appreciate astrochemistry property. There is a variety of processes that can lead to the formation of molecules in the interstellar medium, but these can be separated into two broad classes "reactions that occur in the gas phase and reactions that occur on surface of small grains prevalent throughout the interstellar medium".

Gas phase chemical reaction:

Gas phase reactions can be divided into different categories depending on their general effects. There are the bond formation processes including irradiative association, which link atoms into simple or more complex species. Reactions such as photo dissociation, dissociative recombination, and collisional dissociation are bond destruction processes, which fragment species into smaller species. Finally, there are the bond rearrangement reaction, ion molecule exchange reactions, charge transfer reaction, and neutral –neutral reaction, which transfer parts of one coreactant to another one.

	reaction	rate
photo dissociation	$AB + h\nu \rightarrow A+B$	$10^{-9} s^{-1}$
Neutral-neutral	$A+B \rightarrow C+D$	$4\times10^{-11} M^3 s^{-1}$
Ion molecule	$A^+ + B \rightarrow C^+ + D$	$2\times10^{-9} M^3 s^{-1}$
Charge transfer	$A^+ + B \rightarrow A + B^+$	$10^{-9} M^3 s^{-1}$
Rediative association	$A+B \rightarrow AB + h\nu$	
Dissociative recombination	$A^+ + e \rightarrow C+D$	$10^{-7} M^3 s^{-1}$
Collisional association	$A+B+M \rightarrow AB+M$	$10^{-32} M^6 s^{-1}$
Associative detachment	$A^- + B \rightarrow AB + e$	$10^{-9} M^3 s^{-1}$

General gas phase reactions and their rates

Molecular stability:

All the universe is made from a few simple particles of normal matter "the protons, neutrons, and electrons that compose atoms". Arranged in different ways, they produce the chemical elements.

Molecules cannot exist at high temperatures. In the solar atmosphere, for example, only molecules that like CH are tied tightly enough to withstand the constant collisions of a 6000K gas can survive .At 9000 K, the surface temperature of the bright star Vega "the brightest star in the constellation Lyra and the fifth brightest star in night sky" , no molecules are left at all. As the lower stellar temperature reaches ,however ;molecular astronomy becomes quite important ,cool stellar spectra are dominated by fragile titanium oxide (TiO).Carbon stars "those that for evolutionary reasons, have more carbon than oxygen ,the reverse of normal situation" are loaded with C_2,CN ,and many other compounds .On the coolest stars we also see oxides of other metals and even water vapor.

In spite of the early observation of CH and CN, no one thought space chemistry would be very significant. The low densities and temperatures of the interstellar medium were expected to inhibit molecule formation, and high energy photons from hot stars should quickly destroy those that could be created. Now, however; consider the interstellar refrigerator, dusty clouds block high energy stellar radiation, and, without an external source, they cold. Furthermore, with no high energy photons to disrupt the molecules directly, molecules once made can survive in abundance.

Molecular clouds:

Interstellar space is filled with ultraviolet photons from hot stars, as is obvious from the existence of the low density, warm ionized medium and the faint background of H α –emitting gas seen all over the galaxy. Such high energy radiation is death to molecules because it easily split the fragile bonds between atoms. We therefore find no molecules within the warm ionized medium, nor even within the warm neutral medium.

The globules, which are rich in molecules like CO, claim the right to be called molecular clouds, albeit small ones. Larger ones, "giant molecular clouds" or "GMCs", are everywhere, but not always as obvious.

Chemistry of nebula:

A basic starting point for looking at the chemical evolution of the nebula is to look at what chemical species are thermodynamically stable under those temperatures, pressures, and elemental abundances that are expected in the nebula, as is done in condensation calculations.

Meteorites:

Imagine a parcel of solar composition gas at a pressure of 10^{-4} bar, and a temperature high enough such that the only species present are in the gaseous state (while the molecular composition of the gas will change during the following discussion, we focus on the solids that form as they are more relevant to the formation of meteorites). This initial condition may have been appropriate for the inner solar nebula, as it has been speculated that material "out at least to where the current asteroid belt is located", was initially in the vapor phase during the earliest stages of nebular evolution. Such a state may be needed to explain the moderately volatile element depletions described below.

As the gas cools (maintaining the constant pressure), the first solids to form are Ca, Al, and Ti-oxides such as corundum, hibonite, grossite, gehlenite, perovskite, and titanates. These refractory minerals begin to form at temperatures near 1700 K, with some not appearing until temperatures reach 1500 K. These minerals are commonly found in primitive meteorites as CAIs "Calcium-aluminum-rich inclusions", and thus support the conclusion that these inclusions are composed of the first condensates in the solar nebula.

As the gas continues to cool, Mg-bearing silicates begin to condense, with the most abundant being forsterite and enstatite. These minerals form over a small temperature range, between 1310 and 1360 K, with metallic Fe appearing at the same time. Mg, Si, and Fe are the most abundant rock-forming elements, and make up the bulk of the material found within primitive meteorites, including both chondrules and the surrounding matrix. After the major rock-forming elements condense at a temperature of ~1300 K, less-abundant elements will continue to be incorporated into solids, adding little to the bulk mass of condensed species. Those elements that condense between this temperature and the condensation temperature of sulfur (~650 K) are called "moderately" volatile elements. As the system cools below the sulfur condensation temperature, leftover Fe is predicted to react with O in gaseous water molecules to form iron oxides, such as magnetite. Significant mass is not added to the solid component until temperatures are low enough for water ice to condense at a temperature of ~160 K. It should be pointed out that the condensation processes may differ from element to element. In the case of Fe, a Fe atom in the gas may condense to become part of a Fe grain

Fe (gas) → Fe (solid)

However, under canonical conditions, S condenses when hydrogen sulfide gas reacts with existing Fe grains to form troilite (FeS)

Fe (solid) + H_2S (gas) → FeS (solid) + H_2 (gas)

This reaction could only take place if there was solid Fe available to react with the nebular gas. The solar nebula was in place around the Sun for a finite time (10^6-10^7 yr). In chemical reactions, the formation of a product takes an amount of time dependent on the concentration of the reactants as well as their temperature or mobility — it is not instantaneous. If the amount of time needed for a given reaction to take place was long compared to the lifetime of the solar nebula, then, despite being thermodynamically stable, that reaction product would not form in the nebula. Kinetic inhibition explains why some equilibrium products are not observed in meteorites. In addition, it also demonstrates that there are other considerations that must be made when looking at the chemical evolution of the solar nebula. For example, all the Fe in some carbonaceous chondrites (CM, CI) is locked up as FeO. As described, as silicates condense, they are expected to be Mg-rich with Fe condensing to form metallic grains. At lower temperatures(<550 K), Fe is predicted to react with water in the gas to form FeO, which will then diffuse into the existing forsterite grains, replacing MgO, to form the observed mineralogy.

However, as summarized by *Ebel and Grossman* (2000), this requires equilibrium to be achieved, which is unlikely at these low temperatures due to the slow diffusion rate through olivine. Despite the expected kinetic inhibition of these species, they are still observed in carbonaceous chondrites. As discussed below, if the products of a reaction thought to be kinetically inhibited are observed in meteorites or protoplanetary disks, they likely are due to parent body processes or formation in non-canonical nebular conditions.

Environment:

While the various processes described above operated in the solar nebula, various chemical environments would have formed defined by their pressures, temperatures, and elemental abundances. In this section, we describe what kinds of chemical environments may have been created by the different modes of protoplanetary disk evolution and discuss how the meteoritic and astronomical records preserve signatures of these environments. Calculating the survivability of various materials, based on vaporization temperatures, in model nebulae, they found that, generally, the most refractory compounds could survive entry into the nebula up to almost within 1 AU" (astronomical units) is a measure of distance based on the average distance from the Sun which the Earth orbits. It is set at 149597870691m ± 30 meters (About 93 million miles)." However, they found that subsequent survival depended upon the disk accretion rate and optical depth. For low disk accretion rates, and consequent lower disk luminosities, silicates and refractory organic material could survive up to within the terrestrial planet region but water ices would be vaporized within about 5 AU. At higher disk accretion rates, silicates could be destroyed out to a few AU, whereas more volatile organics (such as methanol and formaldehyde) and water ices could only survive outward of 20 AU and 30 AU, respectively. At the high number densities ($>10^{12}$ cm^{-3}) and temperatures of the accretion shock (~2000–4000 K), collisional dissociation of H_2 can occur and the key parameter for the chemistry is the H/H_2 ratio in the postshock gas. This can increase by many orders of magnitude from its value in quiescent dense gas and the resulting population of highly reactive hydrogen atoms acts to destroy many other molecules For a given mass accretion rate, the highest shock speeds occur closer to the protosun "The condensation of material that lay at the center of the solar nebula and accreted material from it to form the Sun" and here the accretion shock can be fully dissociative, i.e., molecules are atomized. The slow (non- dissociative) shock speeds and low preshock densities in the outer nebula would favor the survival of interstellar molecules. For example: estimated that at 100 AU interstellar material would be accreted in pristine form with its D/H ratios intact. At intermediate disk radii, the shock is only partially-dissociative and the chemistry is sensitive to the actual H/H_2 ratio in the postshock gas. Under these conditions, CO and H_2O can survive the accretion shock and in fact increase from their preshock abundances; chemical erosion of H_2O to OH and O by H atom abstraction reactions is overwhelmed by hydrogenation reactions with H_2. The abundances of some mantle molecules, like CH_4 and CO_2 are partially reduced. However, other molecules, such as CH_3OH, OCS, and H_2CO, are completely destroyed since they do not have formation pathways with H_2 in the hot gas Thus, once the disk was formed, an interstellar chemical signature could have been retained over much of the protosolar disk, apart from within about 1 AU. Subsequent processing of this material was then responsible for spatial and temporal chemical alteration of it throughout the nebula. Once the disk has formed, chemical reactions will proceed within it, altering the solids that survived the in-fall from the molecular cloud and creating new ones out of the vapor of those that were destroyed. Not only will the chemical reactions that take place in the disk depend on the chemical environment that is present at a given location in the disk, but the modes of the chemical reactions will as well. This forces us to develop different models for determining what chemistry will take place under the variety of environments that will exist.

To have an overall picture of nebulae contents look at pictures in atlas:

Red shows emission from sulfur atoms, green comes from hydrogen, and blue from oxygen. The exquisite image reveals magnificent structures of cosmic dust and gaseous filaments, glowing under intense ultraviolet radiation. The region is on the edge of a "stellar nursery", a dark molecular cloud containing the raw material for star formation Clusters of hot young stars already born within NGC 2074 emit fierce ultraviolet radiation, gradually eroding the nebula. A young cluster may lie beyond a circle of brilliant gas at center.

Protoplanetary nebula:

Can also be called preplanetary nebula (PPN) ,it is an astronomical object which is at the short-lived episode during a star's rapid stellar evolution between the Late Asymptotic Giant Branch (LAGB) phase and the subsequent Planetary Nebula (PN) phase. A PPN emits strongly in infrared radiation, and is a kind of reflection nebula. It is the penultimate high-luminosity evolution phase in the life cycle of intermediate-mass stars.

Molecule-rich PPN has been well studied by the Infrared Space Observatory (ISO) and a number of complex organic molecules, including the only detection of benzene (C_6H_6) in an object outside the Solar System have been observed. Some 20 molecules have been detected which, surprisingly, given the presence of molecules such as C_2H_2, C_4H_2, CH_3CCH and CH_2C_4H, the oxygen-bearing molecules OH, H_2O and H_2CO have also been detected. It has been proposed that these latter molecules are formed from O atoms released either from the photo-dissociation or the shock-driven destruction of CO. In general terms the molecular composition of PPN is less complex than that of C-rich AGB stars but more than that of PN.

Westbrook Nebula (CRL 618) is an aspherical protoplanetary nebula…

The ISO observations of CRL 618 made by Cernicharo and collaborators have driven a couple of major investigations of the chemistry which must produce OH and water at the same time as having large abundances of carbon-bearing chain molecules.

This nebula is divided into 3 zones, Zone I being the region in which H_2 can be photo-dissociated; in Zone II H_2, but not CO self-shields; and in Zone III, both H_2 and CO are shielded.

In common with the calculations by Cernicharo (2004), the results show that photo-dissociation of parent molecules drives a very fast and extensive chemistry which effectively builds large hydrocarbon molecules, including benzene. It should be noted here that the Cernicharo (2004) model does not attempt to reproduce the observed abundance of benzene, and that the models of "Woods Etal, (2002, 2003)" do not attempt to reproduce the observed abundances of OH, H_2O and H_2CO. Chemistry is fast because the collision time at high density is about 1 s. At this point the grains can no longer protect the molecules and they are destroyed rapidly.

If the velocity is larger than 5km/s, then geometric dilution drives down the extinction so quickly that parent molecules and daughter products are destroyed before they can synthesis larger species. In this sense, the presence of a long-lived, high density torus seems to be essential for the production of abundant complex organic molecules.

Although many species are in reasonable agreement with observations, including benzene, there are some severe discrepancies, including ethane, which reflects the difficulty in hydrogenating carbon-bearing molecules, and HCO+ - despite adopting a cosmic ray ionization flux enhanced by a factor of 500 over the standard interstellar value.

This failure to reproduce the HCO+ abundance is also a feature of chemical models of planetary nebulae.

Oxygen isotopes:

Oxygen is a dominant element in the inner solar nebula, according for about one third of the condensed matter. It is therefore of much interest that the ratios of the three oxygen isotopes display wide variations among the Earth, mars and meteorites.

Two explanations are current. The first; envisage the existence of distinct pure ^{16}O reservoirs that are mixed in to produce a non-mass dependent isotopic effect. The source of the ^{16}O reservoirs is attributed to addition to the nebula of material formed by nucleosynthesis. The oxygen isotopic anomaly is so large that similar effects should be expected in elements such as Si or Mg but these are not observed.

The second explanation, based on the Thiemens model, proposes that non-mass dependent fractions may also be produced by chemical effects. The average of this model is that it requires only one reservoir for oxygen where as “nucleosynthetic model required several distinct oxygen isotopic reservoirs that do not correlate with anomalies in other elements”. The reason that oxygen is the element that displays such behavior is because “oxygen is the only element in the periodic chart that could produce a symmetry dependent isotopic fractionation, essentially all other elements are coordinated to oxygen and are thus incapable of producing a symmetry dependent isotopic fractionation”.

Experimental data support the notion that the variation in oxygen isotopes observed throughout the inner solar system are compatible with chemical processes in the solar nebula rather than being derived from a pure reservoir of ^{16}O.

In the nebular model, the inner nebula is depleted in water and other volatiles by very early intense solar activity. Water condenses as ice around 5 AU out from the Sun and the minerals forming closer to Sun are anhydrous in accordance with the evidence from meteorites .Water, as ice, subsequently drifts back into the inner nebula as suggested by Cyr and Coworkers. This supports the separate formation of minerals and ice in the inner nebula; otherwise reactions would have been produced uniform oxygen isotope signatures. On this interpretation, the water now in the Earth was not derived from hydrous phases in the accreting planetesimals, but from ice drifting inwards from around Jupiter.

Among other observations that may be made, it is clear that the present population of meteorites mostly do not have oxygen isotope signature similar to those of the terrestrial planets.

The carbonaceous CO, CM and CV groups “those are not compounds, they are types of meteorites” are clearly very distinct from the terrestrial value. This makes them an unlikely source for the popular late-accreting veneers used to account for everything from excess siderophiles “iron-loving” in the upper mantle to the presence of oceans; it has been suggested from the oxygen isotope data that the CO, CM, and CV groups of carbonaceous chondrites formed in the outer and inner regions makes this likely.

Chemical reactions in nebulae:

Chemical reactions within the nebula are driven by the thermal energy of the nebula; other possible sources “lighting ,shock waves, solar photons, heating from radioactive decay” are of secondary importance. The opacity of the nebula due to dust means that heating by intense solar ultraviolet photon fluxes will be restricted to the inner parts of the nebula, probably within 4 AU of the Sun. It is unlikely that such material processed in the inner nebula will diffuse outwards .A flux between 10^2 and 10^3 times the present flux would be needed before this process becomes important in nebular chemistry. This means that most chemical processing of nebular gases and grains will occur within the inner nebula or within planetary sub nebulae where temperatures and pressures may rise sufficiently to initiate reactions.

The state of carbon and nitrogen in the nebula is critical for models for the formation of the outer planets and their satellites. If the primitive nebula reflects its parental source in the giant molecular clouds, carbon is present mainly as CO, not as methane CH_4 ,with CH_4/CO ratio less than 10^{-2} ,and nitrogen is principally present as N_2 not as NH_3 .this assumes that no processing has occurred during nebular separation and collapse and this picture is probably overly simplistic .The presence of abundant CH_4 and NH_3 in the outer solar system satellites and giant planetary atmospheres points to extensive chemical processing in the planetary sub-nebulae .The existence of these compounds in Comet Halley also raises the some awkward questions. Only about 10% of carbon is present as a condensed phase .Studies of the composition of Pluto and Neptune suggested that carbon is not present as CO or CH_4 ices, nor in clathrate-hydrates, but principally resides in complex organic compounds.

Stars from formation to death:

Element	**Current Abundance (percent of atoms)**	**Constituents of Cool Primordial Nebula (percent by mass)**	
Hydrogen	92.1	**hydrogen**	74
Helium	7.8	**helium**	24
Oxygen	0.061	**Condensed Solids**	
Carbon	0.030	**Water**	.95
Nitrogen	.0084	**Methane**	.5
Neon	.0076	**Rock**	.5
Iron	.0037	**ammonia**	.05
Silicon	.0031		
Magnesium	.0024		
aluminum	.00026		
Sulfur	.0015		
Potassium	.000012		
calcium	.00019		
titanium	.0000074		
Chromium	.000042		
Manganese	.000029		
Nickel	.00015		

Current abundance of chemical elements observed in the Sun

The formation of stars from the interstellar medium and the return of matter from stars back into interstellar space is a partially closed cycle that opens up to produce a few unrecyclable objects.

During the 19th and the first half of the 20th century theories of solar system origin were advanced. Although they showed much diversity, they can be classified into three categories:

Tidal theories; in which the formation of the planets occurred from material extracted from the Sun or a passing star after these bodies had formed.

Accretion theories; in which material was captured by the Sun from interstellar space.

Nebular theories; in which the planets formed directly either concurrently or consecutively from the same nebula as the Sun.

Tidal theories:

They are now out of favor, although they were very popular in the past, the initial idea seems to be due Buffon who proposed that a cometary collision with the Sun ejected a disk of material. The mass of comets then unknown were thought to be about 0.1 solar masses. When the true masses of comets became established, the theory languished until the comet was replaced with a collision with a passing star. Other proposals involved a head-on collision or a collision between two nebulae, the true nature of nebulae as galaxies not being established at that time.

Two difficulties for tidal theory:

The first is that planetary compositions differ significantly from the present composition of the Sun. This is particularly marked for the abundances of deuterium and lithium. Both are highly depleted in the Sun due to thermonuclear reactions, but are present at about their cosmic abundance levels in the planets. Accordingly, the material now in the planet could not have not been resident in the Sun for any extended period. Thus, formation of the planets would have to occur by the process of tidal fission more or less immediately following the formation of the Sun. As the Sun and the planets indeed appear to have formed within 10^8 years of one another ,these tidal hypotheses demand that two unrelated processes, stellar formation and close approach of another star, occur very close in time.

The other problem was long recognized; the present distribution of stars makes such an event unlikely. This criticism has become weaker since it has been realized that stars are likely to form in associations and so be much closer together at an early stage of stellar formation .Thus, some of these objections fall away, and the coincidence of solar and planetary formation might be explicable. The fatal problem with the tidal theories seems to be that the filament of material would be dispersed rather than condenses into planetesimals, let alone planets.

Another version of the tidal hypothesis suggests the event occurred during the formation of a stellar cluster. When the Sun and a protostar of low mass and luminosity interacted to produce a filament from which the planets condensed. This hypothesis goes some way to bridging the gap with more conventional theories. The events all occurred close to the formation time of the Sun, thus avoiding the geochemical problems with the high abundances of deuterium and lithium in the nebula relative to present depleted solar values. This model is essentially another version of the giant gaseous protoplanet hypothesis, and seeks to build the planets by fragmenting the nebula. It suffers from the same problems as that theory.

Solar accretion theories:

In accretion theories, the Sun captures material from interstellar space. There would thus be no necessary connection between solar and nebular compositions. Material so accreted to the nebula could contain primordial abundances of lithium, beryllium, and boron. In Schmidt’s theory, a companion star was present whose task was to distort the accreting material and provide it with angular momentum to account for the observed values. This represents yet another attempt to get around the angular momentum difficulty. A completely distinct hypothesis proposed that the material in the nebula was plasma so the accretion was dominated by ionization effects.

A principal and probably fatal objection to such models is that there is no significant correlation between elemental abundances and the ionization potentials of the elements, that should be expected on the basis of such a theory .Other workers proposed the accretion of a ring of material to the Sun during the final stages of solar formation, and were able to obtain satisfactory agreement for the mass of the individual planets.

The general advantage of such hypothesis is to avoid the light element abundance problem. The disadvantage is that the Sun and the nebula might have different compositions.

Nebular theories:

The critical feature of Laplace (1796) model for forming the Sun and the planets from the solar nebula was that as the cloud contracted, rings were successively ejected. A resent variation on this theme proposed that the gravitational constant, G, was decreasing with time. In this case, the Sun is rotating at the edge of instability. As G decrease, an additional ring will be thrown off. As G was proposed to decrease on timescale of 10^9 years, the theory should predict that the outer planets should be billions of years older than the inner planets. Evidence for that is not obvious.

One of the key features in the development of the modern understanding of the lives of stars –the oldest thing in the universe –is the feedback between theory and observations. In their computer simulation ‘usually called model’ astrophysicists are able to use the understanding of how nuclear reactions takes place that has been derived from particle accelerator experiments on Earth. With this calibration of their calculations, they can work out how rapidly a star like the Sun burns its fuel, and how long it will take for such star, starting out with an initial mixture of hydrogen and helium, with just a smattering of everything else, to reach a state in which it looks like the Sun does today. But we already know that the solar system is about 4.5 billion years old .so this is another constraint on the astrophysical models “they should tell us that the model version of the Sun has a computed age of 4.5 billion years when it looks the way the Sun does today” perhaps by adjusting the precise initial proportions of hydrogen and helium, or the initial combination of the traces of other elements present in the model. Once this is done, it means that the models can be run on further into the future ,to see what will happen to the Sun as it gets older still and they can be applied to stars with different masses.

I don’t have space here to go into the details of how astrophysicists unraveled the secrets of stellar evolution “even measuring the masses of stars other than the Sun is no easy task and involves painstaking measurements of the way in the binary systems orbit around one another”. But the story that had emerged by the end of the 1960s has one key feature which tells us, at once, that the Sun cannot be the oldest star in the universe. The solar system contains heavy elements which cannot possibly have been made in a star like the Sun, but must have been made in stars that were around before the Sun was born. The Sun and solar system were made out of the debris of at least one generation of preceding stars, which ran through their life cycle relatively quickly and exploded, scattering the raw materials from which we are made out into space.

It was those first stars that were made solely out of hydrogen and helium, which we now know, was produced out of pure energy in the Big Bang.

One of the key feedbacks from the theory of the Big Bang to astrophysics is the prediction, based on combination of model calculations and the understanding of particle and quantum developed in experiments here on Earth, that the mixture of atomic material that emerged from the Big Bang was 75 percent hydrogen and 25 percent helium. Sure enough, the oldest stars we can see do indeed have a mixture of that content in their atmosphere, as determined by spectroscopy. They presumably have relatively more helium in their cores, where hydrogen nuclei have been fusing to make helium for billions of years; but their atmospheres are thought to contain the primordial stuff of the universe. So we have a good idea what the first stars were made of. We also have a good idea how they made the heavy elements.

Leaving out the details, the story of the evolution of a star like the Sun can be told quite simpler. The bigger “more massive” a star is, the more quickly it has to burn its fuel, because it has to generate more pressure to hold itself up against its own weight. The Sun itself has enough hydrogen in its core to maintain itself in more or less its present state for a total of about ten billion years, so it is now roughly halfway through its lifetime in its present form .A less massive star will keep on steadily burning hydrogen for longer, even though it has less to start with, because it doesn’t need to burn so fiercely; a more massive star will have a shorter lifetime, even though it has more fuel to start with, because it has to burn its fuel more fiercely. As you would expect, this translates into the brightness of the star. More massive stars are brighter, and less massive stars are dimmer. The brightness of a star is also related to its color, all hydrogen burning stars lie along a single band in the diagram, a band which is called the “main sequence”, running roughly diagonally from top left to bottom right. The diagram itself is called the Hertzsprung-Russel, or H-R diagram. The position of a star on the main sequence depends on its mass, hot-big stars are in the top left of the diagram, and cool-small stars are in the bottom right.

All gases, including those of Earth's atmosphere, exert pressure, due to random collision of fast-moving atoms or molecules. In a star, temperatures are far higher than those within our atmosphere. Such great heat produces extremely rapid collision speeds, causing thermal pressures capable of withstanding even the crushing gravity of a massive star. Stellar life begins with the gravitational collapse of giant clouds rich in molecular hydrogen. Thousands of these clouds, which also contain dust and helium, are scattered through our galaxy. So vast are these clouds that their masses range from a hundred thousand to more than a million times that of our Sun. A typical diameter for these interstellar nurseries is about 100 light years. Such clouds are cold, dark, and unstable. At their low temperature, about 10 degrees above absolute zero, there is barely enough pressure to provide support against gravity. As clouds of gas and dust fall inward, they become protostars. When protostars form, their higher density attracts still more gas and dust. No one has observed the entire process of stellar birth, but computer models show that it can last from thousands to many millions of years, depending on the mass of gas involved. When temperature reaches several thousand degrees, a protostar begins to glow. Eventually temperatures soar into the millions of degrees, igniting thermonuclear reaction. A star is born.

A star may burn for billions of years .Astronomers observes numerous clusters of infant stars, still surrounded by vast hydrogen clouds. The more massive stars burn with greater brightness and higher surface temperature. Ultraviolet radiation emitted by these massive stars ionizes the surrounding hydrogen .forming a reddish nebula within a much larger, dark molecular cloud. Some of the most beautiful regions in the sky were formed this way, notably the glowing Orion, Eagle, Swan nebulae. Sooner or later, the supply of hydrogen in the star's core will be exhausted. Our Sun's life time will be in the range of 10 billion years , give or take a few billions, for some 5 million years , hydrogen burning has powered the Sun. But as the end nears, hydrogen in the Sun's core is depleted, ultimately making it more difficult for the stars' outer layers to be supported against the crush of gravity. As these layers squeeze the layers beneath them, compression and the energy from gravitational contraction will cause an increase in temperature. Hydrogen in a shell just outside the former core will heat to the point where it too will ignite in fusion reactions. This heat combined with that from the core contraction will heat the surrounding layers of gas, which will then expand enormously to form a red giant star. In the case of our Sun, its volume will increase to envelop at least the entire orbit of Venus, threatening any life that might then exist in the inner solar system. When a stellar core heats to 100 million degrees, helium burning begins, forming carbon nuclei. In the case of a relatively low- mass star like our Sun, helium burning will begin about a billion years into the red giant phase, but no supernova happens. Gradually, as its helium is used up, it will shrink to form a type of burnt-out star called white dwarf.

For larger stars, the story is far different. What follows is a typical scenario leading to supernova explosion. Contraction causes the ignition of yet another phase of burning, requiring ever higher temperatures to overcome the repulsion of heavier and more highly charged nuclei. Carbon burns to form neon, which itself burns to form oxygen. Carbon and oxygen can fuse to form silicon; oxygen can combine with more oxygen to form sulfur and so on, finally, in silicon burning, the ^{56}Fe nucleus of iron is formed. This nucleus is so strongly bound that any reaction with it absorbs energy rather than release it.

For a massive star, as iron formed in its core, the end is near. The doomed star's internal structure resembles an anion, with shells of sulfur and silicon surrounding the core, layers of oxygen, carbon, and helium outside, and an outermost shell of hydrogen. Amazingly, the final stage of silicon burning in a massive star, which has lived for many millions of years, takes but days. As iron is added the core, no further nuclear reactions take place there. During the collapse, virtually all the electrons disappear, combining with protons to form neutrons. The central part of the core may become a single gigantic nucleus, or neutron star, a few kilometers in radius with an incredible density of about 3×10^{14} grams per cubic centimeter.

While the star's mass falls into the core, in this case one possible thing can happen, the formation of a black hole. If the star's original mass is large enough, it is also conceivable that a black hole could be formed earlier, in the iron core collapse. As the shock wave penetrates the star's outer layers, heating triggers new nuclear reactions forming elements heavier than iron and creating radioactive decay products that prolong the explosion. When electrons in the iron core combine with protons, each such reaction liberates an energetic neutrino. When a star collapses, a storm of neutrinos flies outward through its layers at the speed of light.

Supernovae believed to form by collapse are known as type II ,science the parent stars have outer layers of un-burnt hydrogen, astronomers expect to see spectra lines for hydrogen when they look at type II supernovae. Astronomers usually see such supernovae in the arms of spiral galaxies, known to be rich in younger massive stars. But many supernovae show no hydrogen lines .Astronomers believe their parent stars are white dwarf.

White dwarf; are burnt-out remains of stars about the mass of our Sun, they lack hydrogen; it has all been consumed. Nuclear reactions no longer provide energy within them. White dwarf would cool over billions of years until it stopped glowing and its temperature approached absolute zero.

Mass falling onto a white dwarf creates the opportunity of new life for the star, but it also sets the stage for a possible violent death. Hydrogen or helium can form a surface layer in which thermonuclear reaction ignite. This burning can proceed explosively, leading to ejection of a shell of hydrogen; such is the cause of common nova formally confused with supernovae. Once a white dwarf picks up enough mass from its close binary companion to exceed the limit, it is doomed. Fusion reacting proceed rapidly through the silicon burning stage in a tremendous thermonuclear explosion, the result is type I supernova. Both types of supernovae, the type I that lake evidence of hydrogen and the type II that have it, cause spectacular flare ups in the sky that human have marveled at for thousands of years.

Supernovae are generally classified into two types:

Type I, which are due to the explosion of white dwarf stars, in which elements up to iron are synthesized; and type II supernovae, which are the result of the explosion of red giants and supergiants. The concept of synthesis of the heavy elements in stars has received striking proof with the observation of Ni, Co, Cl, and S products in the type II supernova 1987 located in the large magillanic cloud. Supernova 1987 was caused by the explosion of a comparatively small blue giant star that had a mass of about 20 solar masses. It was only about ten million years old and had apparently passed through a helium-burning red giant evolutionary stage during the last 10% of its rather brief life time span. When it's He was exhausted ,it shrank by a factor of 10 to a blue giant, commencing carbon burning and the rabid run down the explosion.

The light decay curve observed after the explosion matched the 77.1 day half life of ^{56}Co, initially, ^{56}Ni was formed. This decayed with a half life of 6.1 days to ^{56}Co, which then decayed with a half life of 77.1 days to stable ^{56}Fe.Supernova 1987 thus provided direct evidence of element synthesis in supernovae, the abundances of Co, Ni, S, and Cl currently observed being far in excess of normal stellar abundances (about 0.07 solar masses of ^{56}Ni were produced).The Fe, Ni and Cl abundance ratios are close to solar, although this may be a coincidence. Sulfur abundances are below solar levels.

A large dust cloud condensed about 600 days after the event, blocking out most of the light and effectively converted the optically bright object into a dusty infrared object. This is the only direct observation of the formation of dust in supernovae event. Type II supernovae are thought to produce about half of the dust in the interstellar medium, the other half coming from asymptotic giant branch "AGB" red giants.

This chemistry, as described by "*Nuth et al.* (2006)", proceeds at around 10 K and is comprised of a gaseous phase dominated by H_2 and CO with admixtures of other heavy molecules (e.g., HCN, NH_3, OH, HC_3N, SO, CS). Refractory silicate and carbonaceous dust grains are also present. These become layered with ice mantles predominately of water but also containing various polar and non-polar molecules (e.g., CO, CO_2, and CH_3OH). The initial chemical inventory available to the protosolar cloud is sensitive to the details of its dynamical evolution prior to the final collapse phase when the protosun and nebula formed. If magnetic fields dominated this evolution, then the final rapid gravitation collapse cannot occur until the sustaining magnetic support against gravity has been lost through ion-neutral drift. For typical molecular cloud ionization fractions ($\sim 10^{-8}$–10^{-7}) this ambipolar diffusion timescale is several million years. Chemically, this timescale is comparable to that needed for a cosmic-ray-driven chemistry to attain a steady state, but much longer than the timescale ($\sim 10^5$ yr) to freeze out atoms and molecules containing heavy elements through sticking collisions with cold dust grains (*Nuth et al.,* 2006).

Alternatively, molecular clouds may form collapse to form protostars, and dissipate on much shorter timescales, on the order of the gravitational free-fall time ($\sim 10^5$–10^6 yr). This scenario appears to be more in accord with the apparent chemical youth of molecular clouds, as well as with the estimated dynamical lifetimes of protostellar cores and molecular clouds. A third, intermediate possibility is that the dynamical evolution of the protosolar cloud was influenced by either the ejecta of a nearby supernova, or by the wind of a late-type AGB star. In either case the SN or AGB wind could initiate collapse of the natal protosolar core at some arbitrary point in its evolution, irrespective of the timescale on which its chemistry would otherwise evolve. This scenario also allows for the injection of fresh nucleosynthetic products into the protosolar nebula, an appealing aspect from the point of view of explaining the presence of live radionuclide in meteorites.

Black Hole:

A black hole is an extremely dense, small object whose gravity is so immensely powerful that even light cannot escape it. It is believed that a black hole is the endpoint of the evolution of a massive star, with a mass of at least 10-15 times the solar mass. It is theorized that when such a mighty star explodes, it may leave behind a black hole. The black hole is infinitesimally small in size, and has an infinite density. No black hole has ever been observed directly. Super massive black holes are believed to lurk within the cores of most galaxies, sometimes showing violent phenomena, such as the eruption of huge energetic jets of charges particles. This gallery presents Hubble Space Telescope images of peculiar galaxies, believed to possess black holes in their cores (nuclei).

As stars lived out their lives, their structures and properties changed as their nuclear fuels were depleted. When the stars' hydrogen and helium reserves were depleted, their cores began to contract rapidly, causing a dramatic increase in temperature. If the stars had sufficient mass, their core temperatures were high enough to trigger fusion cycles in which their helium atoms fused to make neon, manganese, oxygen, silicon, and sulfur.

As these stars became unstable, their lives ended as supernovae, at which time they either exploded violently, rapidly creating even heavier elements, and spewing much of their stellar material into space, or released the nuclear material from their interior zones to the surface where it was lost to space when the outer layers were blown off.

The birth of elements:

Formation of molecular hydrogen on surface of interstellar grains:

Although the low density ($n \approx 10^4$ cm^3), low temperature ($T \approx 10$ K) conditions in ‘‘dense’’ interstellar clouds do not appear to be favorable for chemistry, but reactions actually happens.

Hydrogen is the dominant element in the Universe; H_2 is the most abundant molecule by far, with CO in second place. For more than 30 years, chemists and astronomers have investigated gas-phase formation and destruction routes for most of the molecules detected in the gas phase. The major reactions are exothermic ion–molecule reactions, since these are rapid and are known to occur even at very low temperatures. Atomic and molecular ions are produced in dense interstellar clouds via collisions with cosmic rays.

The only feasible synthetic pathway involves the surfaces of interstellar dust particles. Consider a hydrogen atom striking a low temperature dust grain. The sticking probability is known to be high for a variety of surfaces representative of the interstellar medium. An atom of hydrogen can stick to a grain, if not to another hydrogen atom, because the grain is a thermodynamic entity and converts the energy of collision into a rise in temperature. The surface formation of H_2 can occur via two different routes. First, let us imagine a situation in which weak binding occurs between hydrogen atoms and the grain. An adsorbed H atom is then relatively free to diffuse over the grain either by tunneling from binding site to site or by thermally hopping over the barriers between such sites. The detailed nature of the diffusion has been investigated by many people, but appears to be very sensitive to the composition of the surface, including impurities. Since the binding is weak, re-evaporation (desorption) into the gas phase is also possible, even if the temperature is very low. The formation of molecular hydrogen occurs when two diffusing H atoms approach one another and transfer enough of the energy of molecular formation to the grain that the H_2 species is stabilized. The newly formed molecule can desorbs rapidly from the grain if some of the exothermicity of reaction can be channeled into translational motion perpendicular to the surface. Evaporation at a later time is also possible. The diffusive process is known as the Langmuir–Hinshelwood mechanism, and is probably the dominant interstellar process on surfaces such as silicates and amorphous ice. Following work of Salpeter and Co-workers, astronomers had long thought that H atoms landing on grains move rapidly over the entire grain by tunneling from site to site; such rapid motions ensure that there is a high efficiency of forming H_2 despite the possibility of evaporation.

Within the last several years, however, detailed experimental measurements on the diffusive formation of H_2 have been carried out at low relevant temperatures on olivine and amorphous carbon. It was found that diffusion of H atoms occur much more slowly than envisaged by astronomers and that it occurs mainly by thermal hopping rather than tunneling. It was also found that the newly formed H_2 is desorbed from the cold surface a significant percentage of the time. Taking into account the new laboratory results, it still appears that, under interstellar conditions, H_2 can be formed by a diffusive mechanism on a surface such as olivine, but the temperature range over which this can happen is much smaller than previously assumed. At lower temperatures, diffusion does not occur efficiently, while at higher temperatures, evaporation occurs before reaction.

An alternative possibility for surface H_2 formation occurs if the H atoms are bound sufficiently strongly to the surface that diffusion is not competitive. In this case, evaporation is also unlikely to be important, and interstellar grains will ‘‘rapidly’’ form monolayers of atomic hydrogen. The formation of molecular hydrogen can then occur via an Eley–Rideal mechanism, in which a gas-phase hydrogen atom lands atop a surface hydrogen atom, forming a molecule which leaves the grain surface. Although the exact mechanism of H_2 formation on grains is still uncertain, the total conversion of atomic to molecular hydrogen can occur on grain surfaces in a time of 10^5 years if it is assumed that nearly all H atoms that land on grains eventually form H_2. The time of 10^5 years is relatively short in an astronomical sense.

Formation of other species:

Molecular hydrogen is not the only species that can be formed at low temperatures on the surfaces of interstellar grains. If hydrogen atoms diffuse rapidly over a grain surface, they can interact not only with other hydrogen atoms, but with heavier species as well. Although more slowly moving than H atoms, heavier species can also react with one another. In a low temperature medium, the reactive species are likely to be limited in the main to atoms and radicals since they can react with zero or at most small activation energy. Positively charged species, which form in the interstellar gas are likely to be neutralized when they strike granular surfaces because the surfaces are thought to be negatively charged given the greater thermal velocity of electrons compared with positive atomic and molecular ions.

Helium formation inside the stars:

the problem was that although sticking four hydrogen nuclei (four protons) together to make one helium nucleus should indeed release energy, each proton carries a positive electric charge, and like charges rebel one another .If two protons approach one another, even head on, this electric repulsion will stop them from actually touching one another, unless they are moving very fast indeed. How fast they are moving depends on the temperature and at fifteen million degrees, they are not moving fast enough for a genuine collision to occur; allowing the nuclear processes that make nuclei fuse to do their work. Quantum physics was developed in the second half of the 1920s, on the subatomic scale entities like protons and electrons should not be thought of as point-like particles, the way they were thought of before about 1926, but as some combination of wave and particle, with a fuzzy, spread out nature. On this picture ,if a proton approaches another proton “ or a positively charged nucleus”, the edge of the wave of the first proton can overlap with the edge of the wave of the other proton “or nucleus” before the cores of the wave packets ,as they are called ,are on top of each other .The extent of this over lapping of the waves at the edges can be calculated very precisely using the law of quantum physics ,and under some circumstances is enough to allow the nuclear interactions which pull the two entities together and blend them into a single new nucleus to take place ,even at temperature like those inside the stars. This process is called the tunnel effect. The first steps were taken in 1929, by Robert Atkinson and Fritz Houtermans. They were still thinking in terms of adding protons to larger nuclei, not the simple fusion of hydrogen nuclei to make helium, because at that time astronomers still had not realized that the Sun is mostly made of hydrogen. But they showed that at the temperatures appropriate for the heart of the Sun enough protons would indeed be moving fast enough for the tunnel effect to work some of the time. In many collisions, the proton would be repelled by the positive charge of its “target”; but the fastest moving protons could penetrate the electric barrier, as if they had tunneled through it. It is called the proton – proton “or p-p” chain ,and it begins with a collision between two protons in which the tunnel effect allows them to fuse together to make a nucleus of deuterium “a deuteron”, which consists of a proton and a neutron bound together by nuclear forces. In the process, they spit out a positron “which is essentially a positively charged electron, and carries away the spare positive charge” and a particle called neutrino. another proton can then tunnel into the deuteron, producing a nucleus of helium-3 .Finally , when two nuclei of helium-3 interact ,they can form a stable nucleus of helium-4 “made up of two protons and two neutrons bound together”, spitting out two spare protons as they do so. The net effect is that four protons “four nuclei of hydrogen” have been converted into one helium nucleus.

For large number of particles at a certain temperature, it is possible to calculate quite accurately what percentage of the particles will be moving at any particular speed above or below the average. Even at a temperature of fifteen million K, under the conditions that exist at the heart of the Sun the tunnel effect only allows two protons to interact in the required way if one of them is travelling at least five times faster than the average speed .Even then, the collision has to be almost head on for the trick to work –even a fast moving proton will not stick to another proton if it only strikes it a glancing blow.

Inside the Sun, just one proton in every hundred million is traveling fast enough to do the trick. The quantum calculations show that on average it would take an individual proton fourteen billion years to find a partner able to join it in forming a deuteron through a head on collision. The Sun is only 4.5

billion years old, which is why most of its protons have yet to find partners in this way "in any case only protons in the core of the Sun have any hope of taking part in the p-p chain; in the cooler outer layers of the Sun, nuclear fusion cannot occur at all". Whenever a nucleus of helium -4 is formed, about 5 million tones of mass are converted into pure energy every second at the heart of the Sun, 600 million tones of hydrogen is converted into 595 million tones of helium every second in the heart of the Sun. And even at this rate, so far the Sun has processed only about 4 percent of its original stock of hydrogen into helium.

Some elements in space:

Deuterium:

Deuterium abundance in stars are difficult to determine ,since the nuclide is destroyed in stellar interiors at temperature above 6×10^5 K ,being converted to ^{3}He .Probably the element is consumed during the highly convective contraction stage in the early stages of stellar evolution as the star moves towards the main sequence. The estimate for the primordial D/H ratio is $(3.4\pm0.5)\times10^{-5}$.

Helium:

One of the successes of the Big Bang theory has been that it can account for the high abundance of ^{4}He in the universe but the precise values are very close to the lower limits predicted. Thus a low value for the mass fraction of 0.230±0.004 has been measured for a primitive star with 1/50 of the solar heavy element abundances .Olive gives a range for the primordial mass fraction from 0.221 to 0.236 that is barely consistent with the Big Bang predictions. Values for ^{3}He are difficult to estimate because it is both produced and consumed by stars.

Lithium, beryllium and boron:

There is still uncertainty about the amount of ^{7}Li produced in the Big Bang and some revision of the standard model may be required. The rather uniform distribution of Li over the galactic halo argues for synthesis of thesis of this isotope during the Big Bang .a fairly constant Li/H ratio of 1×10^{-10} is observed in old population stars and this has been interpreted as the primordial abundance .Lithium is readily consumed in stellar interiors at temperatures greater than 2×10^6 K, so that deep convection will deplete Li.

The formation of the light elements, lithium, beryllium and boron has continued to present a problem .These elements are not formed by the major nucleosyntheic processes. Apart from ^{7}Li formed in the Big Bang, the remainder, along with Be and B, is probably formed by low energy cosmic ray spallation of fast oxygen and carbon nuclei interacting with helium and hydrogen nuclei in the interstellar medium. Although older models produced cosmic rays by acceleration of particles in the interstellar medium, it has become clear that they are more likely produced by supernovae accelerating their own ejecta. These are enhanced in carbon and oxygen and it is the spallation of these nuclei that produces the Li, Be and B.

Heavy elements:

One of the most significant achievements of scientific inquiry in the 20th century was the explanation of the origin of the chemical elements, a discovery resulting from an integration of nuclear physics, astronomy, and astrophysics.

Big Bang:

In the standard Big Bang cosmology, non of elements except hydrogen existed at very beginning. They were all synthesized, during the primeval fireball or later, by processes that involved nuclear reactions.

By about 1 second into the Big Bang , the universe had expanded and cooled to the point where nuclear physics could truly begin .The individual protons and neutrons in the primordial soup started sticking together to make heavier , more complex nuclei. Before that moment it was just too hot, with a temperature that exceeded 10 billion degrees, a million times hotter than the surface of our Sun today. Such a high temperature corresponds to an average particle energy of 1 million electron volts. With such high energies, individual protons and neutrons had been speeding about far too violently to stick together long enough to form heavier nuclei. But in a short period called "era of nucleosynthesis" which began about 1 second after creation and ended about 100 seconds later, our universe became a tremendous thermonuclear reactor where nuclei of the lightest elements could and did form .It resembled an enormous hydrogen bomb. Almost all our present helium and deuterium, and some of the lithium, were created during that brief stretch of time. For every proton or neutron there were at least a billion photons dashing about and perhaps as many as 10 billion. When the temperature was above 10 billion degrees, which was the case before the universe was 1 second old; the numbers of neutrinos and protons were roughly equal, because these particles were easily converted into each other. A neutrino striking a neutron produced a proton plus an electron about as easily as the opposite reaction, an electron plus a proton making a neutron plus a neutrino. And an antineutrino "the anti particle of a neutrino" striking a proton gave back a neutron plus a positron about as often as the reverse reaction. As long as the early universe was hot enough so that neutron producing and proton producing reactions balanced, their numbers remained equal, or n/p=1.

This state of affairs lasted until the universe was about 1 second old. By that time the temperature had fallen to 10 billion degrees, and the reactions producing neutrons from protons were slowing down .the universe still remained in equilibrium, but the balance between the neutron-producing and proton-producing reactions was shifting. A neutron is a bit heavier than a proton, about a tenth of a percent “or 1.3 MeV in energy units” here we are using the equivalence of mass and energy implied by Einstein’s famous formula, “$E=mc^2$”.When an electron and proton colloid, therefore, they must supply the additional energy needed to make up this difference; otherwise a neutron cannot form. At about 1 second after creation, when the average particle energy was around 1MeV, the ratio n/p of neutrons to protons had fallen to 1/3.At about the same instant; the weak nuclear force driving all these reactions was losing its effectiveness. This force has an appreciable impact only when subatomic particles are very energetic and come close together.

Cosmologists say that neutrinos “froze out” at this moment. Because they can feel only the effects of the weak force and none other, neutrinos and antineutrinos could no longer initiate reactions as fast as electrons and positrons, which can interact through the much stronger electromagnetic force, neutrinos and antineutrinos, therefore started decoupling from the rest of matter. Still no complex nuclei could form yet at least not for long. Proton and neutron might stick together briefly to make a nucleus of heavy hydrogen called deuterium. But a deuterium nucleus is a very shaky marriage indeed, with a “binding energy” of only 2.2 MeV holding it together.

As the universe kept expanding and cooling, the ratio of neutrons to protons continued to drop. An individual neutron can disintegrate into a proton, an electron, and antineutrino, increasing the supply of protons and decreasing the number of neutrons left. Protons, however, don’t decay; as far as we know, they live forever. So after about 100 seconds, there was only one neutron left for every seven protons, or n/p=1/7.Meanwhile the temperature of this particle soup had cooled to about 1 billion degrees by that time, corresponding to average particle energy of 0.1 MeV. While the baryon “composite particle made up of three quarks ,while a quark is an elementary particle as a proton, composed of two up quarks and one down quark” population was busy converting from neutrons into protons, the population of positrons was dying off and the number of electrons was becoming comparable to that of protons. When an electron and a positron meet, they annihilate one another, leaving behind only pure energy in the form of photons. A photon can regenerate an electron-positron pair when it smashes into a baryon, thus replenishing the positron supply, but it must have energy of at least 1 MeV to do so.

Suddenly at an age of about 100 seconds, the temperature of the universe had dropped to the point where a proton and a neutron could stick together to form a deuterium nucleus and not be immediately torn asunder “cut to pieces”. More stable unions can be formed with three or four members, two neutrons plus a proton to make a nucleus of tritium, two protons plus a neutron to make helium-3 ,or two protons and two neutrons to make helium-4.So just as quickly as deuterium could form, it became absorbed into tritium and two forms of helium. The most stable unions of helium-4, or ^{4}He in physicists’ shorthand, nuclei with two protons and two neutrons apiece. With a binding energy of 28MeV.combination of five or eight members disintegrate immediately, making it virtually impossible to form more complex nuclei, so the fusion process stopped almost as abruptly as it had begun. As the era of nucleosynthesis ended, essentially all the baryons in the universe existed either freely as single proton or were trapped inside of helium-4 nuclei. Some tiny residues of deuterium ^{2}H, tritium ^{3}H and helium ^{3}He remained, along with a scant trace of lithium ^{7}Li ,which has three protons and four neutrons per nucleus. The fraction of helium-4 nuclei in the universe depends on the ratio n/p .If there was one neutron for every seven protons at this instant, then we expect that one quarter of these baryons were swept up into helium-4, because each neutron takes a proton with it into bondage, leaving the other six to roam about fancy free. Two out of every eight baryons in existence, that is, were locked up inside helium-4 nuclei. Because protons and neutrons have essentially the same mass “and are far heavier than electron”, about two –eighths of the normal matter in the universe ended up as helium. One hundred thousand years later, when things had cooled to the point where the remaining electrons could finally bind to these primordial nuclei and form atoms, the helium mass fraction didn’t change noticeably. Electrons have less than a thousandth the mass of baryons, so adding one or two of them made little difference.

Only the very lightest elements were produced during the Big Bang. All the heavier elements “carbon, nitrogen, and oxygen in our bodies and in the air we breathe, silicon, aluminum, copper, and iron in common appliances and automobiles” were forged afterwards by hot thermonuclear firs burning in stellar ovens. Ordinary stars like our Sun cook hydrogen to make helium, other, having exhausted their hydrogen, burn helium to make carbon, oxygen, and a host of heavier elements. Eventually these elements are spewed into space by giant stellar explosions “supernovae”.

The best way to examine hydrogen and helium is to study the visible and ultraviolet light emitted by stars in our own and in nearby galaxies. When atoms of a particular element are heated, they emit electromagnetic radiation at few specific wave-length, or colors, that are characteristic of those elements. Astronomers study this starlight with a spectroscope, which employs a prism to spread out a spectrum of colors contained in the light. By comparing the intensities of the helium lines with those of the hydrogen lines, one can establish the relative amounts of these two elements present in the star.

By the early 1960s such spectroscopic measurements were becoming increasingly consistent, revealing that about 25 percent of the visible matter in the universe was helium-4, and that almost all the remainder was hydrogen.

During the late 1940s George Gamow, Ralph Alpher, and Robert Herman had suggested that helium would have been produced in the Big Bang. But it was not until the mid 1960s that Fred Hoyle and Roger Taylor at Cambridge, and others were able to make accurate calculations of primordial nucleosynthesis .Their successful explanation of the helium abundance was a great triumph for Big Bang advocates. Along with Penzias and Wilson's 1964 observations, helped convince many scientists that the universe had emerged from a very hot, violent explosion. Indeed, Gamow and his two colleagues had used their own nucleosynthesis arguments to estimate that the present temperature of the universe should be a few degrees, years before Penzias and Wilson measured in 1964.

Astrophysicists did not stop with calculating the helium-4 abundance due to Big Bang nucleosynthesis, in the early 1970s; they also realized that leftover traces of primordial deuterium and helium-3 provided a sensitive means of determining the actual density of the universe during the era of the nucleosynthesis. By a simple extrapolation forward in time, assuming a uniform Hubble expansion, they could obtain the average density of matter in the universe today, and therefore predict whether it would continue to expand for ever or eventually collapse.

Fowler had previously shown how heavier elements were produced in stars, a fear for which he shared the 1983 Nobel Prize. At least initially, nobody questioned his scenario for making deuterium and lithium. Then in the early 1970s, a group of astrophysicists in Paris led by Hurbert Reeves proved that newborn stars do not have enough energy to produce the nuclei of these light elements. In the summer of 1970, Reeves teamed with Fowler and Hoyle to suggest a different source of the light nuclei: cosmic rays ,but while they could thereby explain some of the lithium plus some of other light nuclei like beryllium and boron, their proposal failed completely when it came to deuterium.

Whether or not the Big Bang was the only possible source was finally resolved a few years later when Schramm and his students showed that deuterium nuclei can only be destroyed in stars, not created. And the solar wind measurements of the deuterium abundance were confirmed in 1973 by the spectroscopic analysis of ultraviolet starlight using the Copernicus satellite. By contract with deuterium, nuclei of helium-3 are created in stars, not destroyed .Therefore; its present abundance in the interstellar medium "also around 20 ppm" represents at least the amount of primordial helium-3 that was created in the Big Bang.

Elementary-particle physicists of the late 1970s were beginning to propose a number of new possibilities. Neutrinos, for example, the light, neutral cousins of electrons and positrons, had been ignored because almost every one considered these motes to be absolutely mass less. But give them even a tiny mass, less than a ten-thousandth the mass of an electron, and these ghostly particles can easily dominate the total mass of the universe because there are so unbelievably many of them around .With thousands of permeating every cubic inch, or hundreds per cubic centimeter, they billions of times more plentiful than electrons, protons or neutrons.

Primordial black holes:

Which formed not from the collapse of a huge star but during the first second of the Big Bang, would not be subject to the limits imposed by these nucleosynthesis arguments. The baryonic matter trapped in such an object would have bypassed the deuterium and helium formation that occurred during the era of nucleosynthesis.

Many cosmologists have tried to find other loopholes in the Big Bang nucleosynthesis arguments that would permit a larger baryon density today. In the late 1980s, several scientists suggested that there could have been density fluctuations during the first second after creation, before the era of nucleosynthesis even begin. Preliminary calculations showed that the total baryon density might indeed be higher. But more detailed studies proved that the baryon density still had to be less than about 10 percent of the critical value in order to account for the observed abundances of light elements. These calculations showed once again how robust were the conclusions about Big Bang nucleosynthesis.

Neutrinos:

"Neutrinos , they are very small , they have no charge and have no mass and don't interact at all , the Earth is just a silly ball to them ,through which they simply pass like dust maids down a drafty hall", John Updike, 1960

When the quantum theory was first discovered early in the twentieth century, physicists knew only of neutrons, protons, and electrons. Then Wolfgang Pauli hypothesized in 1930 that an unknown particle must also be released by the reaction. A year later the Italian –American physicist Enrico Fermi named the projected particle a neutrino “little neutron”. The neutrino was believed to carry away from the radioactive decay exactly the missing amount of energy.

The neutrino was seen as a charge less particle, and until 1998, it was believed to have no mass. In 1956, Fred Reines and Clyde Cowan discovered neutrino being emitted in a nuclear reactor on the Savannah River. In 1995, after Cowan’s death, Reines was awarded the Nobel Prize for discovering the particle whose existence was predicted a quarter of a century earlier. thus a particle whose existence was “created “ by scientists in order to account for energy that was mysteriously missing from the end products of a nuclear reaction was actually found. At around that time, the emerging knowledge of the mechanism of nuclear fusion convinced scientists that this kind of nuclear reaction must fuel the stars. And if the fires inside a star are nuclear fusion, which releases tremendous amounts of energy, then neutrinos must be emitted by stars, including our Sun. In 1987, both giant neutrino detection projects found neutrinos that resulted from a supernova explosion in space, located in the large Magellanic cloud and observed from the Southern Hemisphere. The neutrinos had traveled through the Earth to reach both of these detection sites. These were the first neutrinos confirmed to have come from outside our solar system, and their detection heralded the beginning of neutrino astronomy. In 1998, the American –Japanese team of 120 physicists working at the Kamioka Neutrino Observatory were able to determine experimentally that the elusive neutrino has a mass. This discovery has far- reaching consequences, it can have an impact on our understanding of the nature of matter and creation of the universe.

When the neutrino mass was discovered, the finding raised hopes that the neutrino might hold the key to the missing mass. However, if neutrinos do have mass, and there are lots of them in the universe, the additional mass is believed to still fall far short of the missing component. Either there are other huge sources of mass hiding in the universe, or the mass density of the universe is too small. If it is smaller than the critical masses, the universe is predicted to expand forever. Only if the mass density is greater than the critical mass density may the universe collapse back on itself due to gravity and produce a big crunch, possibly leading to a new universe from another Big Bang to follow.

In every galaxy astrophysicists studies, there was far less mass attributable to visible matter “stars or gas and dust” than calculated. The conclusion scientists could not escape was that the galaxies were permeated with an additional mass, accounting for 90% of all the mass in a galaxy. This mysterious, invisible yet mass was called “dark matter” this matter must be of a form unknown to science. It is not atoms or subatomic particles, it is something never seen before .One of the bigger mysteries of astronomy is the nature of dark matter. Some cosmologists seek to find what they believe is the universe’s “missing matter” in addition to the dark matter which we can detect by its effect on galaxies “is matter that neither emits nor scatters light or other electromagnetic radiation, and so cannot be directly detected via optical or radio astronomy. Dark matter is believed to constitute 83% of the matter in the universe.”

Nuclear reaction:

Chemistry of making new atoms in space is a kind of nuclear reaction, and to make a good knowledge about the mechanism of how it works, we should know some terms of the known nuclear reaction…

Radioactivity:

Is the spontaneous disintegration of an unstable atomic nucleus and the subsequent emission of radiation. But what makes atoms radioactive to begin with, and what makes them undergo radioactive decay? It turns out that there is a stable ratio of protons to neutrons for each element; for the first 20 elements on the periodic table (hydrogen through calcium), this ratio is 1 proton to 1 neutron, for example. Protons and neutrons in excess of this stable number can be emitted radioactively.

Alpha decay:

Occurs when the nucleus emits an alpha particle. Alpha particles have a positive charge and are equivalent in size to a helium nucleus, and so they are symbolized as ${}^{4}_{2}\mathrm{He}$. Alpha particles are the largest radioactive particle emitted. This type of radioactivity results in a decrease in the atomic number by 2 and a decrease in the atomic mass by 4. The equation below shows uranium-234 undergoing alpha decay:

$${}^{234}_{92}\mathrm{U} \rightarrow {}^{4}_{2}\mathrm{He} + {}^{230}_{90}\mathrm{Th}$$

Beta decay:

Occurs when the nucleus emits a beta particle. Beta particles have a negative charge and are much smaller than alpha particles. They’re equivalent to high-speed electrons and are symbolized by ${}^{0}_{-1}\beta$ or ${}^{0}_{-1}e$. This type of radioactivity causes an increase in the atomic number by 1 but no change in mass number. The equation below represents uranium-233 undergoing beta decay.

$${}^{233}_{92}\mathrm{U} \rightarrow {}^{0}_{-1}\beta + {}^{233}_{93}\mathrm{Np}$$

A neutron is composed of a proton and an electron fused together. In beta emission, the electron is emitted from the nucleus, while the proton part remains behind, thus increasing the atomic number by 1.

Gamma decay:

Consists of the emission of pure electromagnetic energy; no particles are emitted during this process. After beta, positron, or alpha decay, the nucleus is left in a high-energy state, and at this point it will often emit gamma rays, which allows it to relax to its lower-energy ground state. Since gamma rays do not affect charge or mass, they are often not included in nuclear equations.

Positron emission:

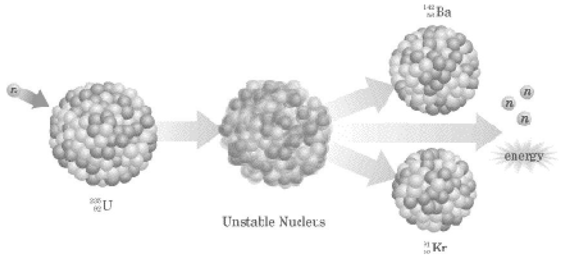
Occurs when an atom becomes more stable by emitting a positron ${}_{1}{}^{0}e$, which is the same size and mass as an electron but has a positive charge. This process converts a proton into a neutron; the positron is emitted and the neutron remains behind in the nucleus, decreasing the atomic number by 1.

$$p \rightarrow {}^{1}_{-0}n + {}^{0}_{1}e$$

Often the emission of an alpha or a beta particle creates another radioactive species, which undergoes further radiation or emission in a cascade called a radioactive series. Notice that in the course of all of these types of radioactive decay, neither protons nor neutrons are either created or destroyed.

There are two main types of nuclear reactions: fusion and fission. In fusion reactions, two light nuclei are combined to form a heavier, more stable nucleus. In fission reactions, a heavy nucleus is split into two nuclei with smaller mass numbers. Both processes involve the exchange of huge amounts of energy: about a million times more energy than that associated with ordinary chemical reactions. In either case, if the new particles contain more stable nuclei, vast quantities of energy are released.

Nuclear power plants rely on fission to create vast quantities of energy.



NASA Today:

First of NASA's four Great Observatories is The Hubble Space Telescope (HST), it is a space telescope that was carried into orbit by a Space Shuttle in 1990 and remains in operation. A 2.4 meter (7.9 ft) aperture telescope in low Earth orbit, Hubble's four main instruments observe in the near ultraviolet, visible, and near infrared. The telescope is named after the astronomer Edwin Hubble.

Second of NASA's four Great Observatories the Compton Gamma Ray Observatory, launched in 1991.

Chandra Observatory is the third of NASA's four Observatories. The Chandra X-ray Observatory is a satellite launched on STS-93 by NASA on July 23, 1999. It was named in honor of Indian-American physicist Subrahmanyan Chandrasekhar who is known for determining the maximum mass for white dwarfs. "Chandra" also means "moon" or "luminous" in Sanskrit .

the fourth and final of the NASA Great Observatories program is The Spitzer Space Telescope (SST), formerly the Space Infrared Telescope Facility (SIRTF) is an infrared space observatory launched in 2003.

Kepler is a NASA spacecraft equipped with a space observatory designed to discover Earth-like planets orbiting other stars. The spacecraft is named in honor of German astronomer Johannes Kepler. The spacecraft was launched on March 7, 2009, with a planned mission lifetime of at least 3.5 years.

James Webb Space Telescope; it will be the most scientifically powerful telescope NASA has ever built—100 times more powerful than the Hubble. It got a main mission to detect reactions happen in nebulae and knowing the origin of the universe ,it was supposed to launch at 2013 but postponed to 2015 then may be to 2018 ,however the whole cosmologists are waiting for the web telescope to prove or deny all what they ever known.

NASA is studying ways to make “Tracor Beams” a reality:

Tractor beams; the ability to trap and move objects using laser light , are the stuff of science fiction, but a team of NASA scientists has won funding to study the concept for remotely capturing planetary or atmospheric particles and delivering them to a robotic rover or orbiting spacecraft for analysis.

Ocean in space:

PASADENA, Calif., Using data from the Herschel Space Observatory, astronomers have detected for the first time cold water vapor enveloping a dusty disk around a young star. The findings suggest that this disk, which is poised to develop into a solar system, contains great quantities of water, suggesting that water-covered planets like Earth may be common in the universe. Herschel is a European Space Agency mission with important NASA contributions. The star with this waterlogged disk, called TW Hydrae, is 10 million years old and located about 175 light-years away from Earth. Ultraviolet light from the star causes some water molecules to break free of this ice, creating a thin layer of gas with a light signature detected by Herschel's Heterodyne Instrument for the Far-Infrared, or HIFI.

New oxygen molecules in space:

Herschel found oxygen molecules in a dense patch of gas and dust adjacent to star-forming regions in the Orion nebula.

Clues of creation of Earth’s oceans:

New measurements from the Herschel Space Observatory have discovered water with the same chemical signature as our oceans in a comet called Hartley 2 (5, 10, 2011), then scientists of NASA are using this information to detect an origin of oceans on our Earth.

Summary & Student overview:

Reactions in the far far away space is a mystery in our life ,when you get yourself out of the Earth then out of the galaxy then of the milky way then out of the near universe, you will find that we just like a little small grain of vaccine in that great universe.

The whole story of reactions in that far place is just like a story that begun centuries ago and till now we haven’t get the end yet ,the end that we will make by ourselves and some day students will just study it in schools like we do now with physics and chemistry and other branches of science.

I see the nebula as the uterus of the sky, it is the place where these fabulous stars and planets are born and so is our cosmology science, and then just like anything else they die and turn from dust to stars then to dust once more.

The past research has showed the composition of heliosphere which protects our solar system; as if any change happened in its composition it affects directly our solar life. Then we saw the composition and effect of cosmic rays on our Earth and other electronic devices, this cosmic ray not only penetrate Earth but also penetrate our own body so knowing its composition may help discovering solutions to many problems. Then we knew how that the interstellar medium isn’t just space but it got a large quantity of materials in the form of dust and gas not only that but also we found that there is ice over there, beside the presolar material like diamond and silicon carbide. When we look deeply in the nebula we could found the composition of meteorites and how planets and stars are born and what they left behind after death ,we also found out how the environment on various distances can affect the elements in the nebula ,then we saw how that there at nebula we can find oxygen isotopes. Then we discussed how scientists had made suggestions on how the stars are born and what they leave behind when they die whether a supernovae for large stars or white dwarfs for small ones, then we had a small look at black holes, and we found that till now this processes are not completely sure and still take lots of work for scientists to find how exactly stars are born and how they die.

We also mentioned some suggestions of the formation of elements such as helium out of hydrogen through the tunnel effect, then the formation of lithium, beryllium, boron and other heavier elements. Then we mentioned the Big Bang theory and how it suggested the beginning of the universe then the formation of elements, after that we had to talk about neutrino that small little thing that disturbed scientists for long and we had to tell about the dark matter that still a mystery after all. Then there was some nuclear terms that are so important for any cosmologist to know; such as radioactivity, “alpha, beta and gamma” decay and the positron emission.

Finally we talked about TODAY; NASA is taking the major place of research nowadays because it got the most powerful and high technique telescopes, scientists at NASA are working over the hour to know more about matter…

WHAT IF we really could found all about matter? The answer for that question is so easy, knowing the synthesis of such mechanism will just open the gate to a new century of chemistry, a world where you don’t just make molecules but you can also make atoms. Knowing this mechanism is just like the discovery of the DNA and genetic processes “it opened the gate to Cloning organisms and making new features for organisms”, the same for the atoms we can make cloning for atoms or making different properties for it …

This reaction also represents a kind of fusion of nuclei to form new atoms ,this is just the reversing process of nuclear reaction ,knowing the whole mechanism may allow us some day to reverse nuclear pump residues and make it safe after the pump explode.

if we really knew all about matter, we can make much more new atoms with new atomic numbers, we can turn atoms to another ones "turn something to another", we can play with matter, control it, we can make our own gas or petroleum products, we will be about to solve all the problems we got. But is that easy? Noooooooooooooo it is so hard, it needs money, efforts, knowledge, and cooperation of scientists in all field and still got much time to come to light.

Some months ago we just heard about that fast particle "neutrino" that was found travelling faster than light, that particle was just found in space and it denied the Einstein law $E=mc^2$ that says that '$c=3\times10^8$' which is the speed of light and what Einstein suggested the highest speed in the universe, this observation just deny all laws that use 'c' in it because 'c' is not the fastest thing in the universe, not after now. We are just waiting for third confirmatory experiment to cancel Einstein theory and may deny the theory of relativity.

Another thing that I see for myself is the black holes, we all know the law that says that "each action has a reaction that equals in amount and differ in direction", I just find that it doesn't match the law that says "energy can't be created or destroyed only turned from one form to another", if we said that energy is an action so it must have a reaction that equals in amount and differ in direction, what if that black holes doesn't have an energy but it have something else, something that equals energy and reverse it at the same time. That is why it comes out from explosions that usually emit large energy , that is may be the reason for its magnificent ability to absorb other matter as it lake energy so it attract it as a way of attraction between reversing charges or so. This means that the energy can be destroyed inside the black holes. Of course this is just a suggestion that someday will be proved whether it is wrong or right in both cases, the universe will keep being the most mysterious thing we ever known.

Another thing that was awarded the physics Nobel Prize this year "2011" was discovering that the universe is expanding denying the theory of shrinking that was believed before that and obeying the Holly Quran which says "with power did we construct the heaven ,verily we are able to extend the vastness of space therefore" "al Zaryat , 47".

Still all what we saw using those telescopes is just like seeing someone from far place and you can't recognize him for sure, so you must come closer to know him; and the more you come closer the more you become sure, so NASA is preparing to launch the Gems Web telescope it isn't known for sure when it will be launched but sure enough that all the world will wait for the results.

Finally the last thing NASA is working at, is the tracor beam that allows you to move particle using laser, just imagine yourself moving staff far from you, turning things to another, it's like a science fiction movie coming true.

Discovering the universe takes us deeply in the unknown, nobody really knows what is left behind; does cosmology really is taking us to delete all what we ever knew of physics and chemistry laws and theories. The only thing I really know is that we are too small and the universe is too large, we don't even know 1/billion of truth and don't think we will, we just must keep moving far in space trying to discover what is behind, the only thing that I am sure about is that god must have created that universe in purpose and he said in his Holly Quran "we will show them our signs in the universe and in their own selves until it becomes manifest to them that this "the Holly Quran" is the truth. It isn't sufficient in regard to your lord that he is a witness over all things?" "Foselat,53"

After all we find that studying the space isn't a worthless stuff, it is not just playing a game, but I can't deny that it got lots of fun. Discovering the space is passion derived work; our passion for knowledge is a main difference between us and animals, that passion leads us to explore and discover. That is what keeps us surviving till now. Exploring the universe opens gates on knowledge and while we keep searching we will find more to search for, that is why we are **HUMANS.**

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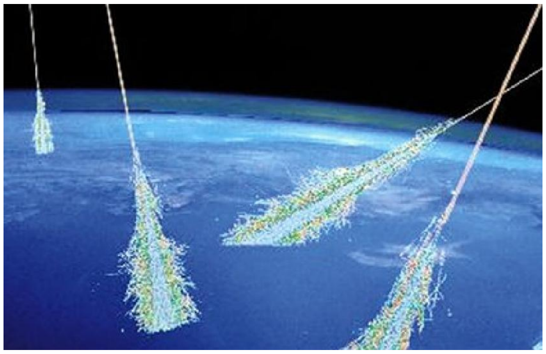
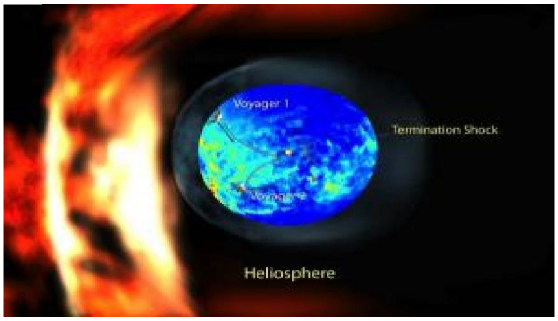
ATLAS



Cosmic ray animation

Cosmic ray animation

Heliosphere



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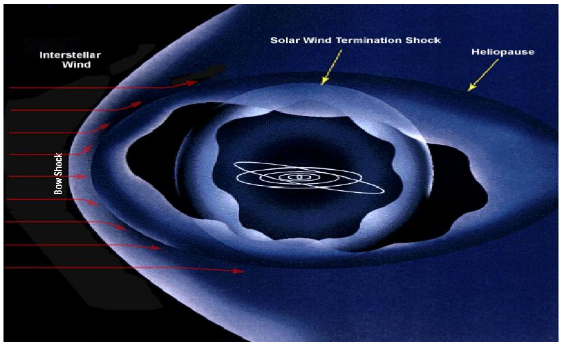

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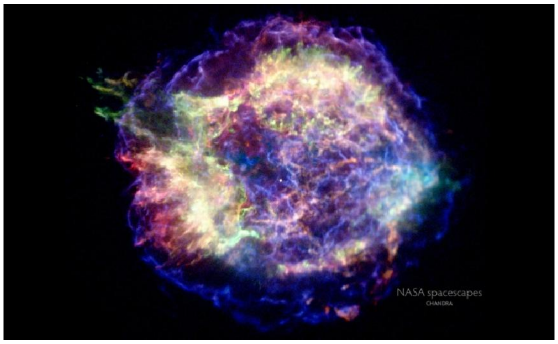


Image of the Cassiopeia A Supernova Remnant from NASA's Chandra X-ray Observatory

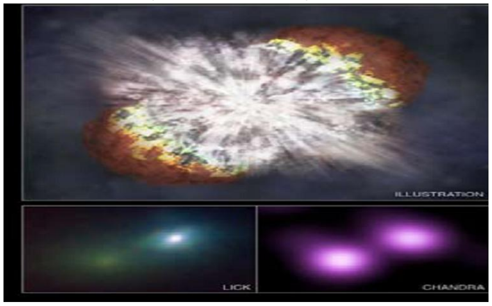
Image of the Milky way Galactic Center from NASA's Spitzer Space Telescope

Image of the Heart and Soul Nebula from NASA's Wide-field Infrared Survey Explorer (WISE)

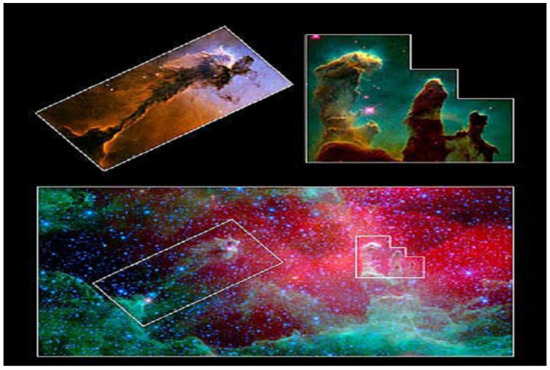
Image of the Orion Nebula by NASA's Spitzer and Hubble Space Telescopes

Image of the Cat's Eye Nebula from NASA's Chandra X-ray Observatory and Hubble Telescope

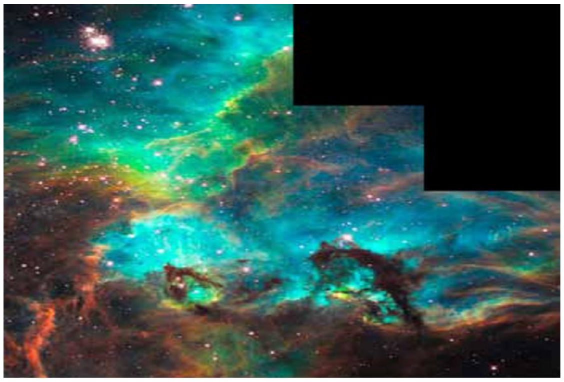
The Milky Way Galactic Center from Spitzer and Hubble Space Telescopes, and Chandra X-ray Observatory



Supernova, May 2007

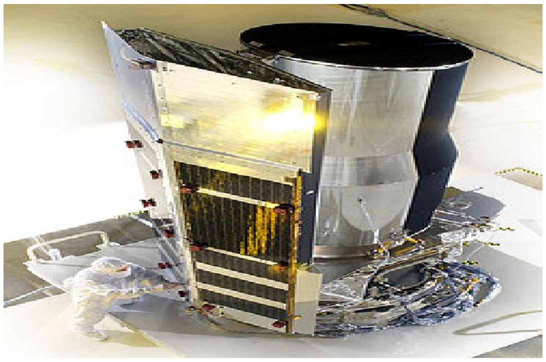


Eagle Nebula, as seen in infrared light by NASA's Spitzer Space Telescope



Energetic star formation process, perhaps stimulated by an explosion of a massive star (Supernova).nebula NGC 2074

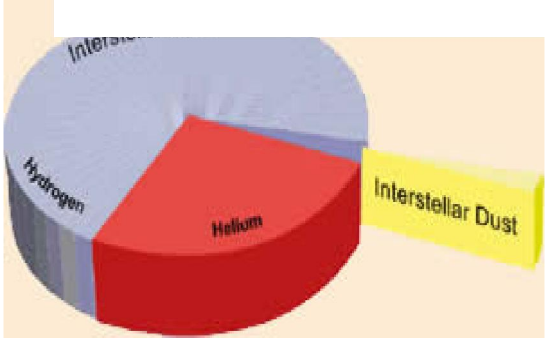
Westbrook Nebula

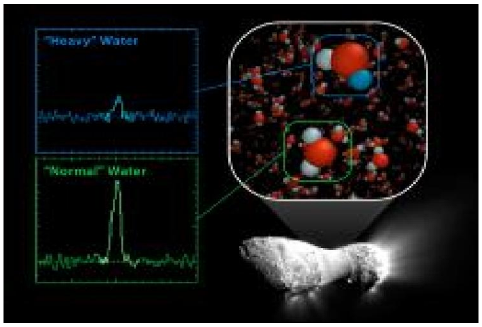


Spitzer Telescope

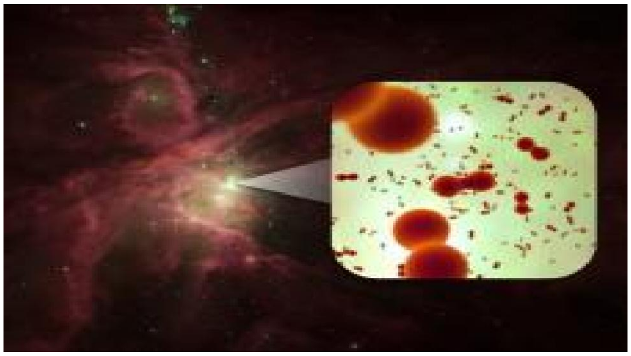
Chandra X-ray Observatory

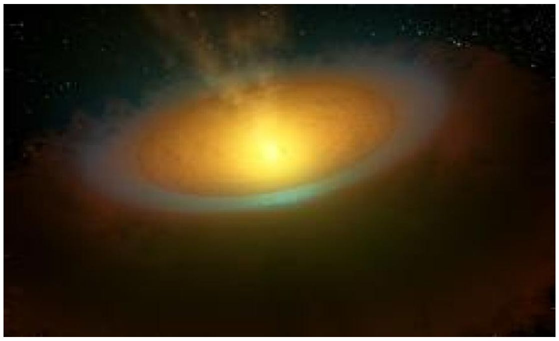
Hubble telescope





Water molecules seen by Kepler





Oxygen molecules in Orion nebula

This artist's concept illustrates

Received 2011 as a research for graduation

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