

REASONS TO BELIEVE – SEATTLE

"Science and CHRISTIANITY in Harmony"

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Life's Location and the Characteristics of Stars

by Pat Lewis

LIFE! Where is it found in the Universe? How did it come to be there, and what requirements had to be satisfied to make it possible? These are surely some of the most intriguing questions our minds can ask.

In an article describing up-to-the-minute research about our Sun, astronomer Guillermo Gonzalez explains a number of ways in which our star seems to have been designed to make life possible on Planet Earth. In several respects, the Sun is unlike the majority of stars; its uncommon **mass, stability, position** in the Galaxy, and especially its **chemical makeup**.*

Stars and planets form by condensation from huge clouds of gas and dust, but the first such clouds contain virtually no elements other than the two lightest gases, hydrogen and helium. These elements can only produce a star which initially is made up of those ingredients, and that type of star cannot provide a habitat suitable for living creatures. For that, *heavier elements* (both gas and dust) must first be available - but they are manufactured in the stars themselves. These heavier (life essential) constituents are called "***metals***" by astronomers. First generation stars must release those elements to enrich the interstellar clouds and condense to form a Protoplanetary Disk (see definition below). This is the predecessor of a later generation of star, and sometimes a new planetary system. However, just the existence of these elements is not enough. They must be in the proper amounts and ratios to allow a star like the Sun, and an Earth-like

planet with all of its life essential features to come into being.** In this excerpt from Dr. Gonzalez's article, he describes the very special "metallicity" (composition of) our Sun and its planetary system.

* How can we know what a star is made of? Astronomers analyze the star's light using spectrosopes to determine what elements are present in what amounts.

** Dr. Hugh Ross's book The Creator and the Cosmos, pages 188-199 discusses 128 variables that must be within narrow limits for advanced life to exist! It appears that in all these ways, the Cosmos has been fine-tuned for our existence!

Definitions:

- Metals: This definition is unique to Astronomy and refers to EVERY ELEMENT in the Periodic Table heavier than Helium including elements that would be termed non-metals or gases in other fields. Astronomers definition of this term is simply "shorthand" for them, since it is a natural distinction to make in Astronomical terms – in Stars, Gas Clouds, Nebulae, and Galaxies, etc.
- Non Metals: This term refers to Hydrogen and Helium ONLY in the Astronomer's nomenclature.
- Spectroscopy: The process of identifying matter by observing the spectrum of its light. When light is directed through a prism or narrow slit it is divided up into its constituent colors (including colors whose frequencies are too short or too long to be visible). This spectrum contains both continuum radiation (light that is not divided into lines) and light that is divided into individual lines. Spectral lines are characteristic of a particular energy transition that happens at a single frequency (when atoms jump from one energy state to another).
- Gas Giants: Planets which are typically many times larger than the Earth and have a large percentage of their mass made up by Gas, mostly Hydrogen and Helium. In the Solar System these are the outer planets, Jupiter, Saturn, Uranus and Neptune. This is in distinction to "Rocky" or "Terrestrial" Planets, such as the Earth (and Mercury, Venus, and Mars).
- Habitable Zones: Habitable zones are the very limited areas of the Universe in which life is possible. Locations which enable the long term existence of advanced life are very rare. These locales are sometimes called "Goldilocks zones", where everything is just right.
 - Circumstellar Habitable Zones (CHZs): The annular (donut shaped) region surrounding a star where liquid water can exist on the surface of a terrestrial planet. For the Earth it extends inward about 5% and outward about 20% from the Earth's position. Liquid water might also exist in different environments outside the CHZ, such as the interior of Europa, one of the moons of Jupiter However, it is unlikely that the full extent of the CHZ is adequate for complex life.
 - Galactic Habitable Zones (GHZs): The small circular or donut shaped region similar to the CHZs on a galactic scale. This small region can only exist in spiral galaxies, and the conditions that prevail outside this small zone make the existence of life unlikely.
- Protoplanetary disks: The disk which forms from the gravitational collapse of a large cloud of gas and dust, providing the material for a new planetary system including the central star (or sun). The further collapse of this disk then produces all the planets which make up the system.
- Gravitational Accretion: The process by which gas (or dust) is pulled by gravity into a disk surrounding a star or planet and then down to its surface.

The Uncommon Composition of the Sun

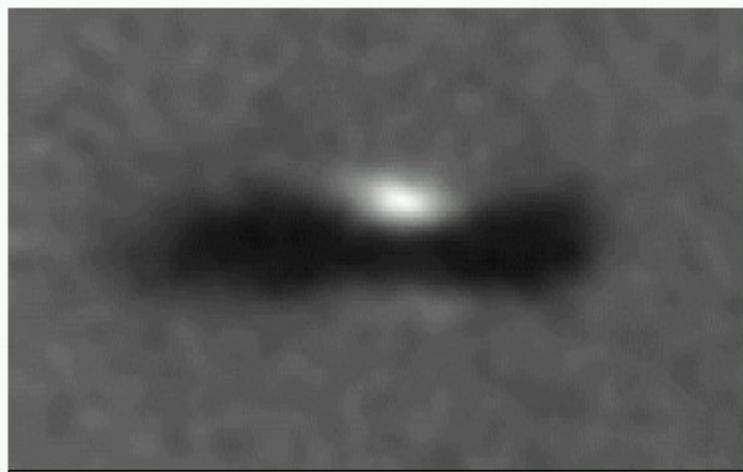
By Guillermo Gonzalez *

Using high-resolution spectroscopy, astronomers can determine the relative abundances of over 30 chemical elements in the atmosphere of a solar-type star. They've known since the middle of the twentieth century that the compositions of stars are not all the same. Older stars are more "metal-poor" (with less of the elements heavier than hydrogen and helium) than younger ones.

As detector technology and stellar atmosphere modeling software have improved, astronomers have been able to study more subtle stellar composition variations. Beginning about 10 years ago such data have shown the Sun's metallicity to be moderately above average when compared to nearby stars. But, again, there is more than one way to compare stellar metallicity. The nearby star sample contains a mix of stars born over the entire history of the Milky Way galaxy. Restricting the comparison to stars similar in age to the Sun (4 to 5 billion years) makes the Sun appear even more rare in metal richness. Only now are nearby stars forming with metallicity as high as the Sun's.

The Sun's metallicity can also be compared to nearby stars selected according to other criteria. For example, the Sun can be compared to other stars with giant planets. Doing so places the Sun on the metal-poor tail of the distribution (while most of the stars with giant planets are similar in age to the Sun, they are also more metal-rich on average). So, not only is the Sun's metallicity atypical compared to the general field population (most of which lack giant planets), but also atypical compared to nearby stars with giant planets.

How does the Sun's metallicity (high relative to stars without planets and low relative to stars with planets) affect life on Earth? Assuming the Sun and its planets formed together from the same molecular cloud about 4.6 billion years ago, then the metallicity of that birth cloud supplied a very important initial condition to the formation of the planets—for Earth is made almost entirely of



An edge-on Protoplanetary Disk in the Orion Nebula. The outer (dark) portion of the disk will undergo additional gravitational collapse to form whatever planets the system will eventually contain. The radiation from the central star can be seen in the middle of the disk.

HST – WFPC2

M.J. McCaughrean (MPIA), C.R. O'Dell (Rice University), NASA

metals. If a lesser metal abundance were available early on smaller terrestrial planets would have resulted.

The formation of gas giant planets, such as Jupiter, is a bit more complicated.

Astronomers believe a large rocky core (about 10 to 15 times Earth's mass) would first be necessary. Once in place, the core's gravity would gravitationally accrete and retain abundant hydrogen gas from the

protoplanetary disk, and runaway growth would result. This must be accomplished within about 10 million years, after which most of the gas is lost. If the gas is lost before the growth process is completed, then a gas giant will not form.

Because their dependence on metallicity is different, terrestrial and gas giant planets cannot be expected to form together from an arbitrary initial metallicity. Some systems may contain a terrestrial planet, but no gas giants. The presence of a gas giant in a circular orbit enhances the habitability of a system by protecting the inner rocky planets by deflecting comets away from the inner solar system and by the delivery of water from asteroids to the inner rocky planets during the formative phase early on. On the other extreme, a system may end up with too many gas giants, thus destabilizing other planetary orbits with their large gravitational influence.

The high mean metallicity of the Sun relative to stars without giant planets probably correlates with the minimum metallicity required to build Earth-size terrestrial planets along with giant planets in large circular orbits. On the other hand, the very low metallicity of the Sun relative to stars with giant planets is probably related to the increased instability of planetary orbits in the circumstellar habitable zones of systems forming from metal-rich molecular clouds.

These solar anomalies don't have to be attributed to anything in particular. You could shrug your shoulders and say something like, "what a coincidence," or "it's just chance." But, these answers are not very satisfying. Because the Sun plays an essential role in allowing and sustaining life on Earth, to conclude that the values of some of the Sun's parameters required fine-tuning to permit such life seems reasonable.

As astronomers are learning more about the solar system's surroundings and are able to better place the Sun in its proper context, they are showing the Sun to be rare indeed. They are also discovering that the conditions required for life are far more numerous and narrow than commonly believed. These findings, along with the many examples of fine-tuning in chemistry, biochemistry, physics, and cosmology, argue against chance explanations. A non-chance explanation called intentional design implies both mind and will. And I call that intentionality a God thing.

** --Excerpted from G. Gonzalez, "Rare Sun," Facts for Faith 2 (2002) 14-21*

Guillermo Gonzalez received his Ph.D. from the University of Washington, where he served in a Post Doctoral position and Assistant Professor until August 2001, when he accepted a position at Iowa State University in Ames, Iowa. Dr. Gonzalez was one of the founding members of the Seattle chapter of Reasons To Believe and remains an ex-officio member. He has authored and co-authored Articles in the RTB quarterly Journal FACTS For FAITH and also the RTB Newsletter Connections. He authored the cover article in the October 2001 issue of Scientific American, entitled "[The Galactic Habitable Zone](#)." He is also prominently featured in the article on that subject in Space.com.

Did You Know?

1. That there are other RTB Chapters in the Northwest! - IT'S TRUE! – Chapters are getting started in Vancouver and Victoria, BC, as well as in Spokane, WA. If you have friends or family in these communities who would be interested in getting involved, PLEASE contact us or them.
 - Seattle, WA - Stan Lennard
 - Web Site www.reasons.org/chapters/seattle
 - Email mimi@TPN.com
 - Spokane, WA - Ray Luse
 - Web Site www.reasons.org/chapters
 - Email rluse@shmc.org
 - Vancouver, BC – Bruce Smith
 - Web Site www.reasons.org/chapters
 - Email brsmith@telus.net
 - Victoria, BC - Douglas Ledding
 - Email Canada@reasons.org
2. Dr. Hugh Ross is coming to the Seattle area on the weekend of Sept. 18th. He will be speaking at Northshore Christian Church in Everett and also at other locations here.
3. Reasons To Believe has a great new web based two hour call-in radio program each week at 11:00 AM Tuesdays. The show archives can be heard at any time during the week 24/7. The latest science news related to the Creation/Evolution debate and the Old/Young Earth question is discussed by real scientists. If you decide to listen weekly, you won't be sorry. Consider having young people listen regularly so that they can equip themselves to discuss these issues intelligently with their friends.
 - [Listen to Creation Update](#)
4. We have produced a free full color flyer entitled What the Big Bang says About the Existence of God and the Design of the Universe. If you would like a copy please contact us at joagreen@aol.com

<http://www.reasons.org>