Astrobiology News June 2016: Our Magnetic Sun

When we think about the Sun's role in nurturing life on Earth, we naturally tend to focus on the Sun's light and heat. After all, both are critical to Earth's biosphere; however, the Sun has a less less obvious attribute that nevertheless has a huge impact on the development and sustainment of life on Earth – its complex and ever-changing magnetic field. The Sun is a huge ball of plasma. No, I'm not talking about that stuff in your blood, but rather the fact that gas in the Sun is ionized, such that negatively-charged electrons and positively-charged atomic nuclei move about, creating magnetic fields that in turn affect how the charged particles move. The Sun's magnetic field produces explosions of charged particles from the Sun that cause "space weather", resulting in beautiful aurorae, as well as the occasional disruption of satellite communications and radiation potentially harmful to astronauts.

About 4 billion years ago, the Sun was dimmer than it is today and the Earth received only about 70% of the energy it does presently - the Earth should have been covered in ice, but geologic evidence indicates it was warm with liquid water. This is known as the *Faint Young Sun Paradox.* Although we can't travel back in time to study our young sun, we have access to a plethora of stars in our galaxy that are similar to our Sun and in different stages of evolution. We can study these stars to piece together a picture of our own Sun's history.

NASA's *Kepler* mission, responsible for the detection of thousands of exoplanets orbiting other stars, also yielded observations of many stars resembling our Sun "only" a few million years after its birth. Such young stars frequently produce very powerful flares – bursts of light and radiation. *Kepler* data showed these stars produce many "superflares", explosions experienced by our Sun once every 100 years or so, but up to ten times a day for the young stars. Tempestuous solar storms of this magnitude would have compressed the Earth's own protective magnetic field, allowing energetic charged particles to penetrate Earth's atmosphere and initiate reactions that warmed the planet. Recent research suggests that such reactions may even have driven the chemistry necessary for life on the young Earth.[1]

Molecular nitrogen makes up about 78% of Earth's atmosphere today, but it made up about 90% of Earth's atmosphere 4 billion years ago. Although molecular nitrogen is chemically pretty inert, the research suggests that the young Earth's bombardment from solar storms may have dissociated nitrogen and carbon dioxide molecules enabling the production of nitrous oxide ("laughing gas") as well as other molecules such as hydrogen cyanide (HCN). Nitrous oxide is a powerful greenhouse gas - about 300 times more effective at warming the atmosphere than carbon

[1] Airapetian, V.S., et al., Nature Geoscience, 9, 452-455 (2016)

dioxide, and HCN is an important molecule for life – chains of these compounds produce various amino acids.

I'm writing this on the summer solstice (June 20th, this year). Hopefully, many of you are taking advantage of the long hours of sunlight in the northern hemisphere. Here are some "sun fun facts" to share around the pool or at the beach!

(1) The Sun converts 4.5 million tons of mass to energy every second, equivalent to the mass of a million elephants every second (and it still has enough fuel for another 5 billion years.)
(2) The Sun's energy production each second is enough to supply the electrical needs of the USA for 50 million years.
(3) On average, the energy released in a fusion reaction at the Sun's center takes about 1 million years to reach the Sun's surface.
(4) Don't panic but as you read this sentence about a quadrillion (a thousand trillion) solar neutrinos will zip through your body.
(5) The Sun's outpouring of energy is equivalent to 100 billion hydrogen bombs exploding each second.
(6) An area of the Sun's surface the size of a postage stamp shines with the power of 1.5 million candles.
(7) Giant arcs of plasma called prominences shoot out from the Sun's surface for 310 thousand miles — that's more than the distance from the Earth to the Moon.
(8) The smallest visible sunspots have an area of about 500 million square miles.
(9) The Sun gives off a stream of electrically charged particles called the solar wind. The Sun pumps more than a million tons of material into the solar wind every second.
(10) Hans Bethe, a German astronomer who worked in America, discovered how stars generate their power by the process of nuclear fusion during a train trip. In 1938, Bethe started to jot down some ideas while returning to Cornell University from a conference. By the time the train reached its destination, Bethe had mapped out the main features of the theory.

Until next month,

Grace

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