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AN IRON-RICH SUN AND ITS SOURCE OF ENERGY*

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Abstract: Mass-fractionation enriches light elements and the lighter isotopes of each element at the solar surface, making a photosphere that is 91% H and 9% He. However, the solar interior consists mostly of elements that comprise 99% of ordinary meteorites – Fe, O, Ni, Si, S, Mg and Ca – elements made in the deep interior of a supernova. Solar energy arises from a series of nuclear reactions triggered by neutron-emission from the collapsed supernova core on which the Sun formed. Solar mass-fractionation, solar neutrinos, and the annual solar-wind output of 3×10^{43} H atoms are by-products of solar luminosity.

1. INTRODUCTION

"The sun is the Rosetta stone of astrophysics," says Göran Scharmer in a news report for the July 2004 issue of National Geographic Magazine [1]. *"But it is a stone that we haven't been able to decrypt entirely."*

Aston [2] provided the key to this puzzle in 1913. That year he noted that the atomic weight of Neon is lighter after diffusing through pipe clay walls. Fifty-six years later, Neon of light atomic weight was found in the surfaces of Moon samples returned by the Apollo mission [3]. Subsequent measurements [4], shown in Figure 1, revealed that lighter mass (L) isotopes of all noble gases in the solar wind are enriched relative to the heavier (H) ones by a common fractionation factor ($\boldsymbol{f}$), where

$$\boldsymbol{f} = (H/L)^{4.56} \qquad (1)$$

When the abundance of elements in the photosphere [5] is corrected for this fractionation, the most abundant elements in the interior of the Sun turn out to be Fe, O, Ni, Si, S, Mg and Ca (Figure 2) - elements that are most abundant in planets close to the Sun. They are also the same, even-numbered elements that comprise 99% of ordinary meteorites [6]. *The probability (P) of fortuitous agreement is $P < 2 \times 10^{-33}$* [7].

The iron-rich Sun explains solar eruptions and magnetic fields [8] and answers the question raised by live ^{60}Fe in the early solar system from a supernova (SN), *"What kind of environment gave birth to the Sun and planets?"* [9]. Fe from the central SN region formed iron meteorites, cores of terrestrial planets, and the Sun's interior [10]. The supernova exploded 5 billion years ago [11]. The Sun formed on the collapsed SN core.

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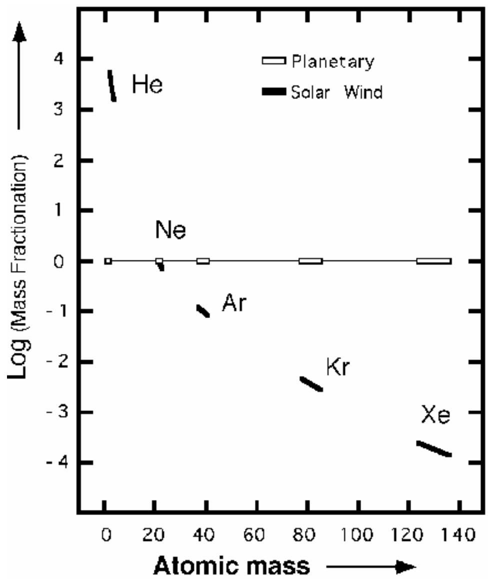

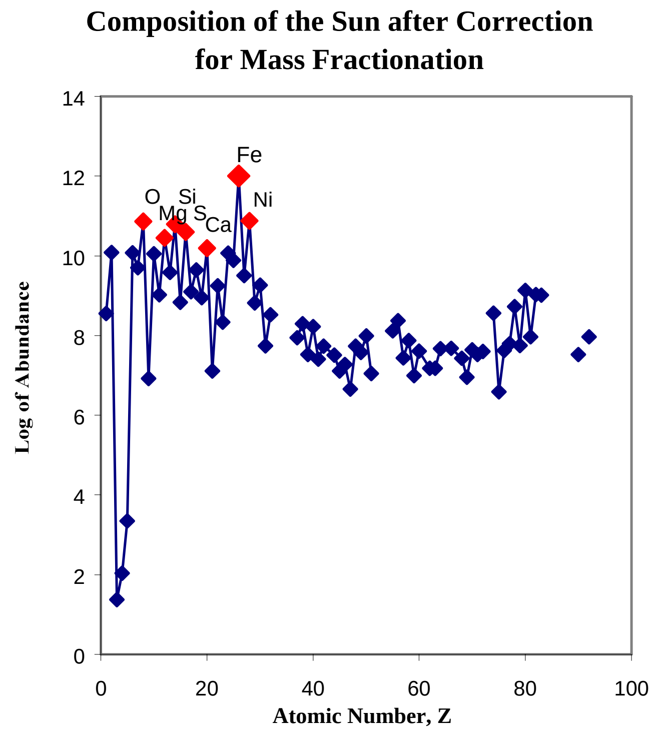

Figure 1. Light isotopes of all noble gases are enriched in the solar wind [4].

Figure 2. Internal composition of the Sun [4] after correcting for mass fractionation.

2. SOURCE OF LUMINOSITY

Nucleons in Fe, Ni, O, Si, S, Mg and Ca are too tightly bound to generate solar luminosity. However systematic properties of the 2,850 known nuclides [12] (Figure 3), when considered in terms of reduced variables like Z/A (charge per nucleon) and M/A (mass or potential energy per nucleon), reveal an inherent instability of the collapsed SN core toward neutron-emission [13-16]. This process releases 10-22 MeV per neutron emitted [16], which then triggers a series of reactions that collectively produce solar luminosity (SL), solar neutrinos, an upward flow of H^+ "carrier" ions that maintains mass separation in the Sun, and then depart in the solar wind (SW):

a) Escape of neutrons from the collapsed solar core

$$<{}_0^1n> \rightarrow {}_0^1n + \sim 10\text{-}22 \text{ MeV} \quad (>57\% \text{ SL})$$

b) Neutron decay or capture by other nuclides

$${}_0^1n \rightarrow {}_1^1H^+ + e^- + \text{anti-}\nu + 0.78 \text{ MeV} \quad (<5\% \text{ SL})$$

c) Fusion and upward acceleration of H^+ by deep-seated magnetic fields

$$4\,{}_1^1H^+ + 2e^- \rightarrow {}_2^4He^{++} + 2\nu + 27 \text{ MeV} \quad (<38\% \text{ SL})$$

d) Escape of excess H^+ that survives the upward journey in the solar wind

$$3 \times 10^{43}\ H^+/\text{year depart in the solar wind (100\% SW)}$$

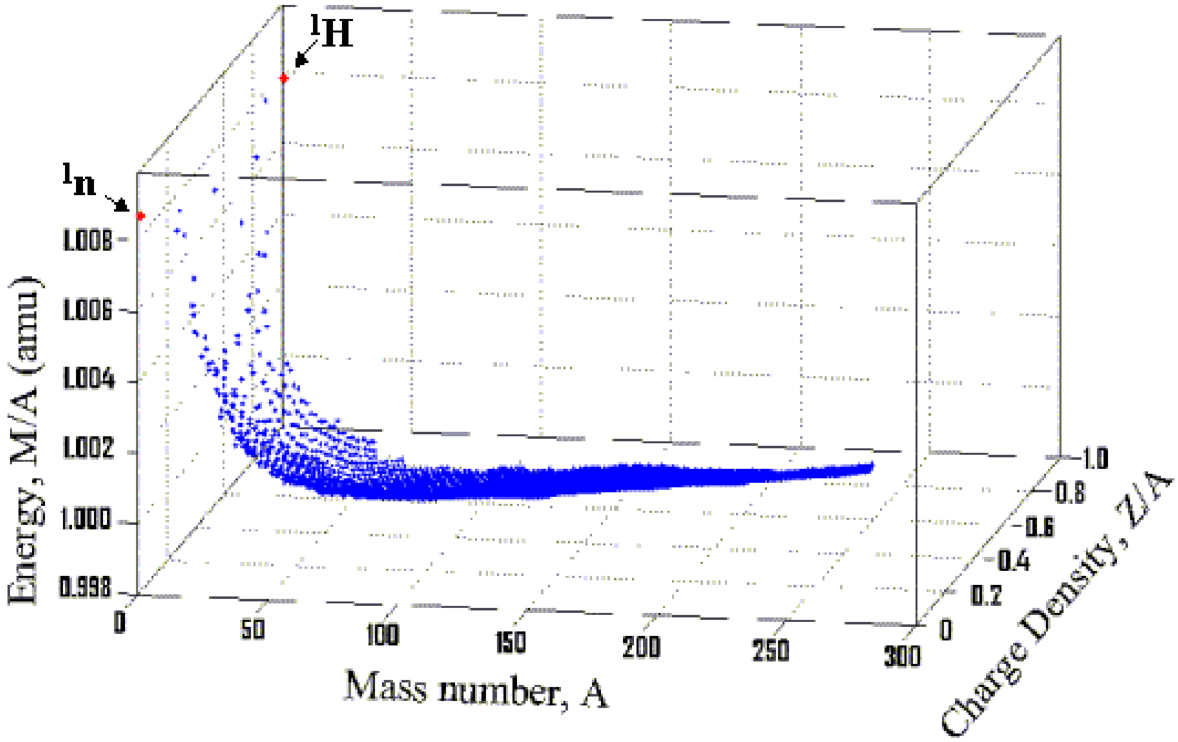

Figure 3. Systematic properties of the 2,850 known nuclides reveal neutron repulsion that drives neutron-emission from the collapsed SN-core on which the Sun formed [15].

In addition to explaining solar luminosity (SL), solar neutrinos, an upward flow of H^+ "carrier" ions that maintains mass separation in the Sun and then departs in the solar wind (SW) [13-16], recent observations suggest that steps a) – d) are ongoing processes in the Sun and other Sun-like stars:

1. The *number of solar electron neutrinos measured is <38%* of the number expected if step (c), H-fusion alone, produced all solar luminosity [17,18].

2. A recent survey [19] of other Sun-like stars during the "Maunder minimum", a period of low sun-spot and magnetic storm activity, found that the *stars appeared to be metal-rich, as expected if mass separation depends on magnetic fields for upward acceleration of the carrier gas (H^+ ions) from the interior of the star* [7].

Regarding observation #1, the electron neutrinos measured in the Charged Current reaction [17,18] at the Sudbury Neutrino Observatory (SNO) represent >87% of the electron neutrinos produced by H-fusion in the Sun if processes a) - d) occur there. If the standard solar model were correct, neutrino oscillations produce the neutral current observed in the SNO experiment.

Regarding observation #2, the "Maunder minimum" refers to the 70-year period from 1645 to 1714 when there was very little sunspot activity during the coldest part of the Little Ice Age in Europe and North America. Wright notes in a news report on their survey of other stars [19] that *"the vast majority of stars identified as Maunder minimum stars . . . are either evolved stars or stars rich in metals like iron and nickel."* [19].

3. CONCLUSIONS

Mass-fractionation enriches light elements and the lighter isotopes of each element at the solar surface, making a photosphere that is 91% H and 9% He. However, the solar interior consists mostly of seven, even-numbered elements of high nuclear stability - Fe, O, Ni, Si, S, Mg and Ca. These elements were made in the deep interior of the supernova that gave birth to the solar system 5 billion years ago. They comprise 99% of ordinary meteorites.

Solar energy arises from a series of nuclear reactions triggered by neutron-emission from the collapsed supernova core on which the Sun formed. Magnetic fields of deep origin accelerate the neutron decay products and generate some radiation energy, in addition to solar mass-fractionation, solar neutrinos, and an annual outpouring of 3×10^{43} H atoms in the solar wind.

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