“The Need to Measure Low Energy, anti-Neutrinos (E_ν<0.782 MeV) from the Sun”

O. Manuel
(University of Missouri - Rolla)

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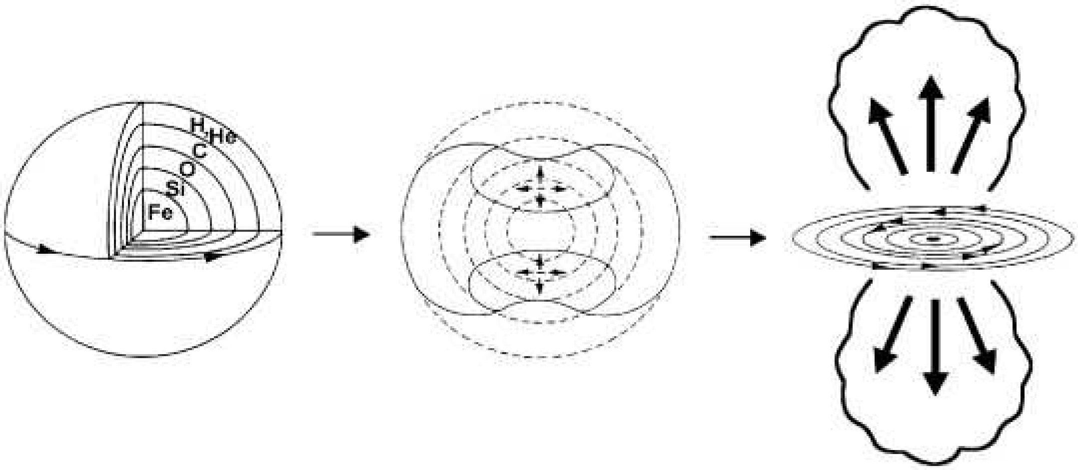
www.ballofiron.com, www.umr.edu/~om
om@umr.edu

Short-lived nuclides and linked elemental and isotopic variations show that a single supernova made the solar system [1-6].



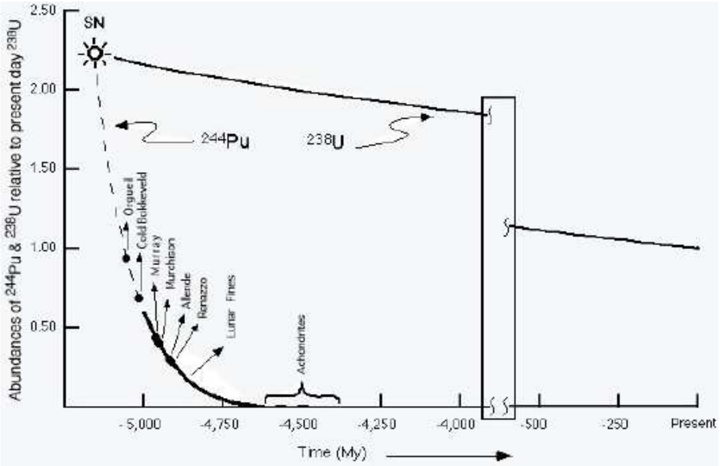
A massive spinning star becomes chemically layered near the end of its life, when asymmetric collapse occurs to conserve angular momentum.

The infall of low-Z elements causes an axially directed super-nova explosion, producing a rapidly expanding bipolar nebula with an equatorial accretion disk.

The sun forms on the SN core; cores of inner planets form in the Fe-rich region around the SN core; Jovian planets form in the outer SN layers.

Reprint handout from Proceedings of the 2002 SOHO/GONG Conference [6] gives a summary of the experimental data.

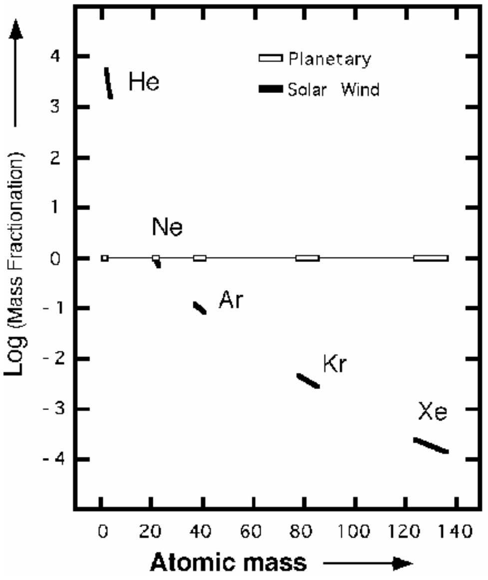
Combined ^{244}Pu-^{136}Xe and U,Th-Pb age dating shows that a supernova explosion produced our actinide elements 5 Gy ago, at the birth of the Solar System [7].



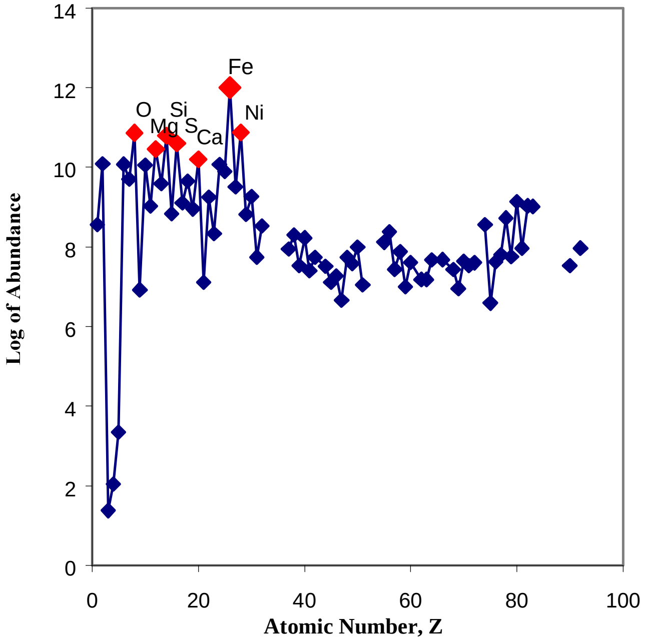
This is also shown in the reprint handout from the Proceedings of the 2002 SOHO/GONG Conference [6].

Light (L) isotopes are enriched relative to heavy (H) ones at the solar surface by a fractionation power law, $f = (H/L)^{4.56}$ [5].

Mass Separation of Isotopes in Elements Emitted from the Solar Surface



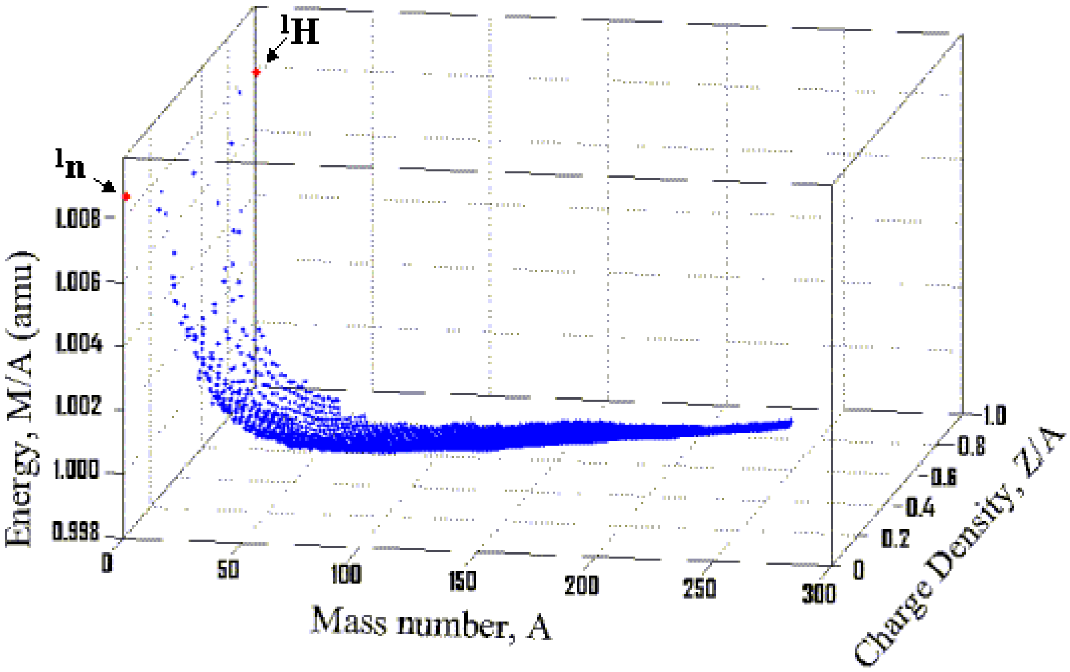
Composition of the Sun after Correction for Mass Fractionation



When elemental abundance in the photosphere is corrected for this mass separation, the most abundant elements in the Sun are Fe, Ni, O, Si, S, Mg and Ca the same elements that comprise 99% of ordinary meteorites [8].

How Can The Sun Shine If Mostly Fe?

Systematic Properties of Nuclides Reveal the Core Source of Solar Luminosity



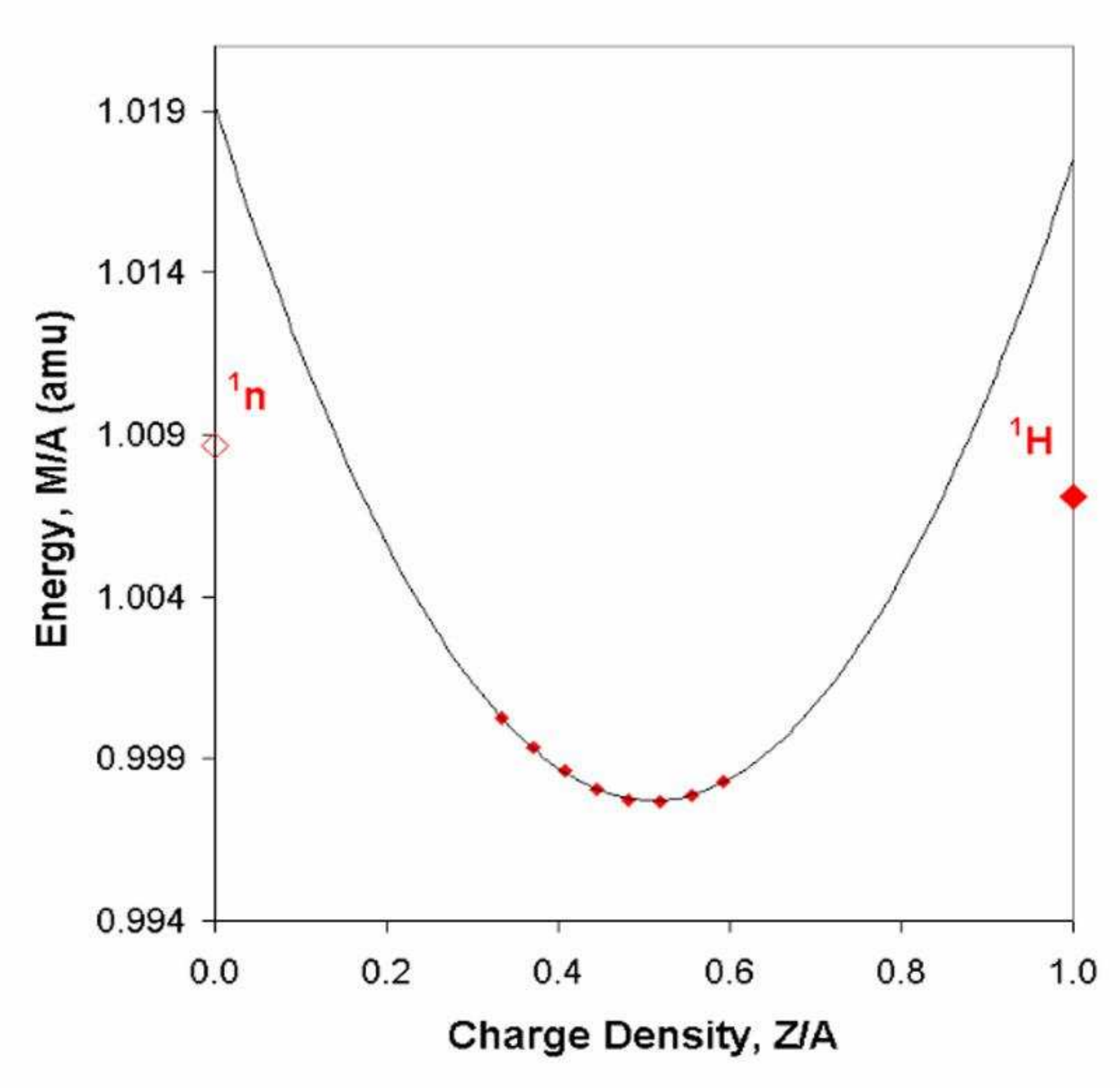
The Cradle of the Nuclides*

At every mass number, repulsion between neutrons at $Z/A = 0$ increases M/A to $M/A = M(^{1}_{0}n) +$ 10-22 MeV [9,10]. These reprints from the J. Fusion Energy will be distributed at the meeting.

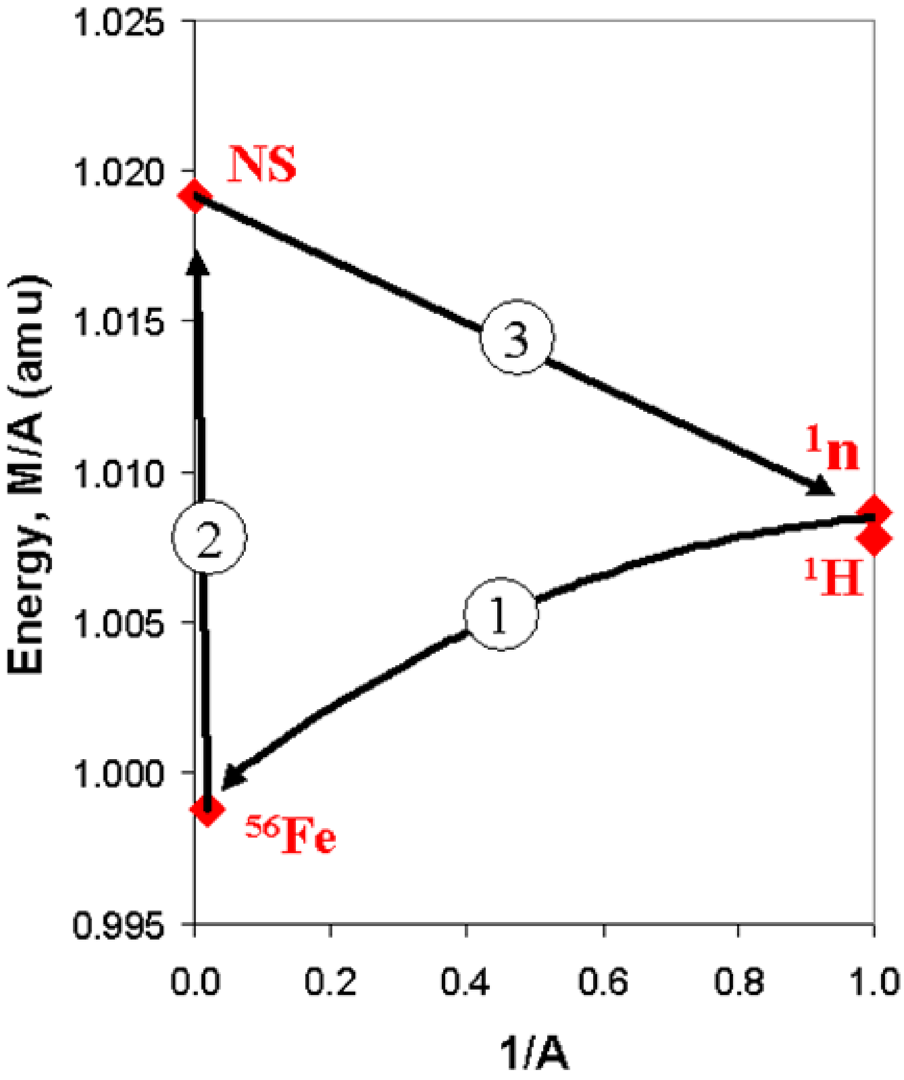
* Nuclear wallet cards, 6th edition (2000) National Nuclear Data Center, Brookhaven National Laboratory, 74 pp.

For example, at A = 27 the mass parabola yields
M/A = $M({}_0^1n)$ + 10 MeV at Z/A = 0

After subtracting Coulomb energy, the mass
parabola has a minimum at
Z = 13-14, where there are
182 attractive n-p interactions and only
169 repulsive n-n and p-p interactions [9].



Fusion and Dissociation of Nuclei in Stars



Nuclear evolution in the Sun and other stars, illustrated on a plot of M/A *vs.* 1/A. **1.** First generation stars fuse ^{1}H into heavier nuclides. **2.** At the end of their lives, material in the core is compressed into a neutron star (NS). Our Sun formed on this product. **3.** The NS acts as a giant nucleus, decaying by neutron emission (Q = 10-22 Mev per neutron; $t_{1/2} \approx 10^{10}$ years). **4. = 1.** Most of the neutron decay product, ^{1}H, is consumed by fusion as it moves upward, carrying lighter nuclides to the solar surface. This fusion repeats step **# 1.** Each year, 3×10^{43} H^+ ions reach the solar surface and leave in the solar wind.

Source of Solar Energy (SE)

- Neutron emission from the solar core (>57% SE)

  $< {}_0^1n > \rightarrow {}_0^1n + \sim 10\text{-}22$ MeV

- Neutron decay or capture (<5% SE)

  ${}_0^1n \rightarrow {}_1^1H^+ + e^- +$ **anti-ν** $+ 0.782$ MeV

- Fusion and upward migration of H^+ (<38% SE)

  $4\ {}_1^1H^+ + 2\ e^- \rightarrow {}_2^4He^{++} + 2\ \nu + 27$ MeV

- Escape of excess H^+ in the solar wind (100% SW)

  Each year 3×10^{43} H^+ depart in the solar wind

In the first reaction, neutron emission releases **1.1% - 2.4%** of the nuclear rest mass as energy. By comparison, hydrogen fusion releases a maximum of about **0.8%** of the rest mass as energy (0.7% if the end product is helium), and fission releases **0.1%** of the rest mass as energy [10].

How to Test for Low Energy anti-Neutrinos (E_ν<0.782 MeV) coming from the Sun

Look for inverse β-decay induced by low-energy ν_{anti} coming from the Sun, e.g.,

$$^{3}He \geqslant {}^{3}H; \quad {}^{14}N \geqslant {}^{14}C; \quad \text{or} \quad {}^{35}Cl \geqslant {}^{35}S.$$

The latter reaction in the Homestake Mine [11] might produce measurable levels of ^{35}S with an 87-day half-life. Alternatively, this might be extracted from underground deposits of salt (NaCl) and detected by counting or by AMS (Accelerator Mass Spectrometry).

References:

1. O. Manuel, D. D. Sabu (1977) "Strange xenon, extinct superheavy elements, and the solar neutrino puzzle", *Science* **195**, 208-209.
2. R. V. Ballad, L. L. Oliver, R. G. Downing, O. K. Manuel (1979) "Isotopes of tellurium, xenon, and krypton in Allende retain record of nucleosynthesis", *Nature* **277**, 615-620.
3. D. D. Sabu, O. K. Manuel (1980) "Noble gas anomalies and synthesis of the chemical elements", *Meteoritics* **15**, 117-138.
4. O. K. Manuel (1981) "Heterogeneity in isotopic and elemental compositions of meteorites: Proof of local element synthesis", *Geokhimiya* **12**, 1776-1800.
5. O. K. Manuel, Golden Hwaung (1983) "Solar abundance of the elements", *Meteoritics* **18**, 209-222.
6. O. Manuel, S. Friberg (2003) "Composition of the solar interior: Information from isotope ratios", in *Proceedings of 2002 SOHO 12 /GONG + 2002, Local and Global Helioseismology: The Present and Future* (Editor: Huguette Lacoste, ESA SP-517 SOHO/GONG, Noordwijk, The Netherlands) 345-348.
   http://www.umr.edu/~om/abstracts2002/soho-gong2002.pdf
   http://www.umr.edu/~om/abstracts2002/soho-gong2002.ps
7. P. K. Kuroda, W. A. Myers (1996) "Iodine-129 and plutonium-244 in the early solar system", *Radiochim. Acta* **77**, 15-20.
8. W. H. Harkins (1917) "The evolution of the elements and the stability of complex atoms", *J. Am. Chem. Soc.* **39**, 856-879.
9. O. Manuel, C. Bolon, A. Katragada, M. Insall (2002) "Attraction and repulsion of nucleons: Sources of stellar energy", *J. Fusion Energy* **19**, 93-98.
   http://www.umr.edu/~om/abstracts/jfeinterbetnuc.pdf
   http://www.umr.edu/~om/abstracts/jfeinterbetnuc.ps
10. O. Manuel, E. Miller, A. Katragada (2003) "Neutron repulsion confirmed as energy source", *J. Fusion Energy* **20**, 197-201.
    http://www.umr.edu/~om/abstracts2003/jfe-neutronrep.pdf
    http://www.umr.edu/~om/abstracts2003/jfe-neutronrep.ps
11. R. Davis, Jr., D. S. Harmer, K. C. Hoffman (1968) "Search for neutrinos from the Sun", *Physical Rev. Lett.* **20**, 1205-1209.