## Converged solar neutrinos heat outer core of Earth to liquid

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## Abstract

This paper presents a new viewpoint to explain why the outer core of Earth is liquid. The conclusion is based on these factors: iron and nickel are the principle elements of core; isotopes **57Fe**, **61Ni** can harvest low energy **14keV** and **67keV** respectively from concentrated neutrinos current, then convert to heat; unlike thermal neutron's optic refractive index **n<1** and very close to **1**, the low energy (**<100keV**) neutrino's can be **n > 2**, so as to form caustic zone inside Earth, confirmed by the fact that night observed value of solar neutrinos is **3.2%** more than day.

### Why the outer core of Earth is liquid?

The outer core of Earth counts from radius **1210km** to **3510km**, and total thickness is about **2300km**, and modern seismic measurements have confirmed that the outer core of Earth is in liquid state.

Of course, the simplest answer is that: too hot can make anything liquid. But how and where does the heating energy come from?

Our textbooks are giving the wrong answer or alternative facts.

My new research result shows the answer should have relation with the mystery neutrinos, especially the very low energy neutrinos.

Don't forget the Sun is producing tremendous neutrinos after wake of fusion reaction. The great nature sets a mechanism to dissipate about **40%** energy from beta decay. Although most solar energy is from fusion reaction, there is still significant energy from **β+** decays that radiate neutrinos and take away about **3%** of total energy.

The recorded solar energy mean density on ground is about **1000W/m$^2$**, thus the max energy density before deduction of atmosphere absorption could be **1500W/m$^2$**, hence the estimation of neutrinos flux energy density on ground is circa **3%*1500 = 45 W/m$^2$**.

The neutrino energy spectrum is in continuum distribution ranging from zero **eV** to the theoretical energy of beta decay.

Current neutrino detection experiments can see **1.8MeV** above solar neutrinos that are from decay of **7Be** or **8B**, yet minority in contrast to the **99.6%** mainstream **pp** reactions that emit neutrinos in circa **210keV** level.

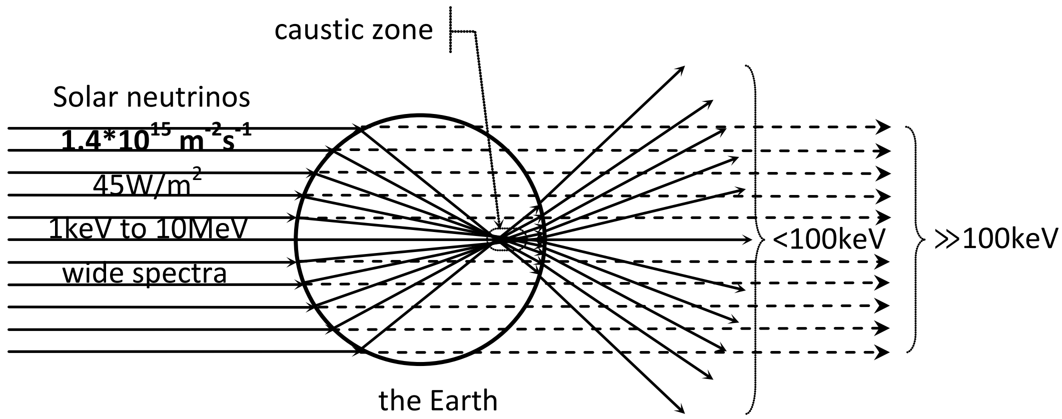
Scientists are still working hard on detection of the **pp** low energy neutrinos by tremendous volume of isotopes **71Ga** or **37Cl**.

According to my research, low energy neutrino has relative higher cross section, despite the known cross section of **1.8MeV** is very tiny **$10^{-42}$cm$^2$ = $10^{-12}$ μb** (micro barns) that means: even travelling light-year level thick lead wall, the loss of neutrinos may be still insignificant.

Generally speaking, the lower the reaction energy, the higher the cross energy, for example, usual chemical reaction with energy transaction from a few **eV**s to **2** digital **eV**s, hence their cross section can easily reach millions barns, in contrast, the **235U** fission cross section **584** barns for thermal neutron, and the famous fusion **D + T = He + n** only **5** barns.

As per above trend, the low energy neutrinos with mili-**eV** up to **100keV** will possess higher cross section and refraction effect with refractive index > **2.0**.

For regular glass ball, the caustic zone is outside of ball as its refractive index **n < 2.0**, but otherwise, e.g. diamond **n = 2.417**, the incident parallel light rays will form small caustic area inside the ball, as illustrated in following figure that could be the situation of the solar low energy neutrinos passing Earth, and the energy density in caustic zone is yet quite high though not focused to a point.




**Remarks**:

1. science illustration only, not to scale.

2. to get inside caustic, the refractive index should be **2.0** above.

**Fig. 1. the convergence of solar low energy neutrinos by Earth**

The major components of Earth outer core are iron and nickel.

Fortunately one of **Fe** (Iron) isotopes has very lower nuclear energy level: it is the **57Fe** which first energy level is only **14keV** and its sibling abundance is **2.1%**.

Detail tabulated official data of **57Fe** can be seen from the government web:

https://www.nndc.bnl.gov/chart/getdataset.jsp?nucleus=57Fe&unc=nds

The term sibling abundance stands for atomic proportion of one isotope among all sibling isotopes of same element family, e.g. iron's all natural isotopes: **54Fe, 56Fe, 57Fe, 58Fe**.

As the nuclear spin change **ΔJ** of transition between ground state (shorted as **GS** later) **Jπ = 1/2-** and first energy level (**Jπ = 3/2-**) is appreciable **ΔJ = 1**, according to selection rules, its allowance degree is still good though not the best case (**ΔJ = 0)**, and a short half life time **98.3ns** of gamma decay does exist as an isomer's feature.

If some neutral current can excite **57Fe** to the first energy level, then the delayed de-excitation gamma decay can release the energy that was harvested from the pass-through neutral current.

Neutrinos neutral current possess such potentiality, but normal neutrinos flux is uneasy to interact with matters unless the flux can be converged or focused so as to increase energy density greatly.

Luckily, our Earth is a good lens for low energy neutrinos and the Sun is a good source of low energy neutrinos.

For neutral current of low energy neutrinos, if its energy **> 14keV**, then within the neutrinos caustic zone, i.e. the iron outer core of Earth, yet still inside Earth, there is high possibility of **57Fe** excitation activity, and the leaving neutrinos carry away the remnant energy after a small deduction of **14keV**.

As neutrinos are fermions, when focusing or compressing, Pauli exclusive principle will regulate the "thick" incompressible fermions flux to form "thin" compressible Bosons stream so as to compact particles as small volume as possible until down to a point by yielding to converging pinch, in straight words, **2** or more even number neutrinos tend to combine as a quasi-particle with integer spin quanta, e.g. **1** (**2** neutrinos), **2** (**4** neutrinos), **3** (**6** neutrinos), etc.

Super high spin boson quasi-particle is always hard to form, but spin under **10**, especially **1** spin Boson is relatively easy.

To excite nuclear for different energy levels, the neutral current should be Bosons current, because the required spin change **ΔJ** is always integer. For example, photons neutral current is just Bosons current, so, it can be used to excite nuclear.

For **2**-neutrino quasi-particle, even each neutrino only carries **7keV**, the quasi-particle Boson can still satisfy the threshold energy **14keV** of **57Fe** first energy level.

As the outer core is so thick **2300km**, the caustic zone of **14keV** neutrinos alone cannot cover such a long distance, but most likely a small zone nearby the end of inner core.

As to how the far end (nearby the stiffer mantle of Earth) being heated, it must be credited to the neutrinos energy absorption of another major element nickel. Luckily the isotope **61Ni** also has a very low energy level **67keV**, **Jπ = 5/2-**, **$T_{1/2}$ = 5.34ns**, and gamma decay to **GS Jπ = 3/2-** needs **Δ J = 1**.

Detail tabulated official data of **61Ni** can be seen from the government web:

https://www.nndc.bnl.gov/chart/getdataset.jsp?nucleus=61Ni&unc=nds

The abundance of **61Ni** is **1.14%**, though less than **57Fe 2.1%**, however, the delayed gamma photon **67keV** is about **4.8** times hotter than the **14keV** of **57Fe**.

In my neutrino optics, the higher the energy of neutrinos, the lower the refractive index, thus the closer to center of Earth, the lower the energy of neutrinos thereby, vice versa, just like as a prism separating natural rays to a spectrum from red to violet, and nomenclature defines it as chromatic aberration.

By the way, think about another shell of Earth: **asthenophere**.

There is a special thin shallow layer under our feet **80km**: asthenophere with rough thickness **120km**, this crust is also very hot and elastic or quasi-liquidic, and that is why geology proposes tectonic plate drift theory.

In this crust, the main elements are diversified, such as **Fe**, **Mg**, **K**, **P**, **S**, **Mn**, **Zr**, **V**, and **U**.

The heating energy is mainly from the focused neutrinos **charged current** accelerating the energy-possible-but-spin-locked beta or double beta decay, such as **40K**, **50V**, **96Zr**, and the decay long chain of uranium. The generated energy is far greater than aforementioned low energy absorption of **14keV** by **57Fe** and **67keV** by **61Ni** from passby converging neutrinos.

In this thin layer, not only by above charged current, but also by **neutral current** interaction in the same way as the outer core, there still are elements that harvest energy from converged neutrinos, such as **55Mn**, the only stable isotope of **Mn**, **125keV Jπ = 7/2-** with **GS Jπ = 5/2-**.

### Why do neutral particle rays tend to refract when crossing 2-medium interface?

We often take the refraction phenomenon as granted. But let me show a rare situation: is a single photon will refract?

In orthodox geometry optics, refraction of light rays will always happen, but in quantum optics, it is not **100%** guaranteed unless there are enough photons in a ray so as to appear some coherent degree more or less.

Hence, one single photon, even in visible waveband, it will never refract when passing through whatever interface of transparent media. It is well known that single photon is hard to separate, but even for an imagined dotted "light ray" with countable separated photons, if the interval space between every **2** neighbor photons is too long, then such a weak ray also does not refract, because photons coherent degree is zero.

Fortunately in our colorful world, this situation hardly occurs, hence refraction phenomena can always be observed anywhere, because either artificial light source or solar visible light always provide enough photons.

For neutrinos flux, above rule is still valid.

Because of coherent interference, neutrinos propagating in matter have an index of refraction **n**, its value can be determined by formula (ref. **1**):

$$\mathbf{n} = \mathbf{1} + \frac{2\pi}{k^2} N f(\mathbf{0})$$

Here **k** is the neutrinos average momentum, **N** is the quantum density of number of scatters per unit volume and **f(0)** is the forward scattering amplitude.

If n > 2 is needed, there must be condition: $\frac{2\pi}{k^2} N f(\mathbf{0}) > 1$**,** and it is not hard to meet for solar neutrinos in low energy band.

This is a well-known result, largely due to a pioneering work of Wolfenstein and the discovery of resonance effects of Mikheyev and Smirnov.

Hence, the lower the neutrino energy, and the higher the quantum density (good coherence), then, the higher the refractive index will be, even larger than **2.0** possible.

Conclusively, refraction is driven by so-called "**coherent force**"!

Of course, gravitation force can also refract neutrinos, but the effect is extremely weak, e.g. the neutrinos from galactic core will be focused by the solar gravitation to **24** astronomical units, i.e. the distance between the Uranus and Neptune orbit radii, as per the authoritative research report. See ref. **2** for details**.**

## Neutrino's matter wave length and flux

Most researchers claim that electron-flavor neutrino' rest mass $\mathbf{m_0}$ is less than **0.12eV**, some literatures even present the accuracy value: $\mathbf{2.1*10^{-4}eV}$ (ref. **3**), and the well accepted speed is just the same with photons, i.e. light speed.

Hence, the matter wave length, aka DeBroglie wave length: $\boldsymbol{\lambda} = \frac{\hbar}{p}$, where **p** is the momentum, $\boldsymbol{\hbar}$ is the reduced plank constant. With relativistic consideration, $\boldsymbol{\lambda} = \frac{\hbar c}{\sqrt{E^2+2Em_0c^2}}$, **E** is the kinetic energy, **c** is light speed.

Let's do some test calculation: for **E = 1MeV** neutrino, **λ = 0.2pm**; for **100keV, λ = 2pm**; for **10keV, λ = 20pm**; for very small energy **2.2eV**, **λ = 0.1μm** (violet); and for **20°C** thermal neutrino (**25meV**), **λ = 8μm** (infrared).

Interestingly the matter wavelength **λ** of thermal neutrinos does fall in infrared waveband that is regarded as comfortable thermal source, is it just a coincidence or does it imply that atmosphere temperature is gauged or determined by ghost-like neutrinos?

By the way, don't be confused with the thermal neutron's matter wavelength **1.8Å** that is too hot, many orders of magnitude higher than **20°C**, if it is electromagnetic wave, i.e. photon.

Given $\mathbf{45W/m^2}$ power density and mean energy **210keV**, solar neutrinos flux can be estimated: $\mathbf{1.4*10^{15}\ m^{-2}s^{-1}}$ or $\mathbf{1.4*10^{11}cm^{-2}s^{-1}}$. Superposing the huge cosmic background relic neutrinos, total low energy neutrino flux will be increased by another many orders of magnitude.

There is countless great number of neutrinos sources out of solar system, especially, in all supernovas, unlike the humble **3%** quota in solar, **99%** of radiation is carried away by neutrinos. But the extreme remote distance from a few to billons light-years will undoubtedly attenuate energy of neutrinos and the flux will be diluted when neutrinos reach our Earth. Anyway, until now, there is no convincible data regarding non-solar neutrinos flux and energy spectrum.

## Any substantial proof of neutrino flux refraction?

In fact, mainstream science community has already indirectly proved that neutrons flux passing through our Earth does be refracted.

The literature "First Indication of Terrestrial Matter Effects on Solar Neutrino Oscillation" (ref. **4**) claims that: the neutrinos flux in night is **3.2%** more than in day.

Unfortunately the experiment team explained that such phenomenon is caused only by **3-**favor oscillation during the long distance travel from Sun to Earth.

As the Sun-Earth distance is changing day by day continuously, e.g. Jan. **4** is the closest day, July **4** is the farthermost day that is **4.9** million **km** farther than the closest distance, and neutrino' **3** favors are supposed to oscillate in some fixed distance period, hence if the team's explanation is true, then the recorded night minus day events during **1** year length should oscillate between top and bottom lines, but their experiments always indicate night events **3.2%** more than day's.

Based on above analysis, I believe it is caused by the Earth refraction effect on neutrinos flux, because Earth's lensing effect can converge neutrinos in night then increase the flux density.

Because the team detects boron isotope **8B** electron neutrino, its energy is about single digital **MeV** level, hence the refractive index must be lesser than those of low energy neutrinos with **2** or **3** digitals **keV** level, therefore the refractive index is probably a little bit higher than **1**, thus, the caustic zone is outside of Earth and far away over the deep night sky, no wonder **3.2%** more events in night can be recorded.

It can be deduced that solar **pp** reaction low energy neutrinos can be refracted more degree than the **8B** neutrinos, hence the caustic zone is more close to ground, then more night events far above **3.2%** increment can be logged, if instrument sensitive to this neutrinos.

For the very low energy neutrinos, because caustic zone is deeply inside Earth, hence in night, the out flux on ground is divergent, and even though, the flux density may be still higher than unfocused parallel flux.

**Conclusions**

It is the converged solar neutrinos that indirectly heat the outer core of Earth to liquid, via the conversion of de-excitation from concentrated neutrinos empowered specific isotopes nuclear excitation energy to photon thermal energy.

The conclusion is based on these factors:

1. iron and nickel are the principle elements of core;
2. isotopes 57Fe, 61Ni can harvest low energy 14keV and 67keV respectively from concentrated neutrinos current, then convert to heat;
3. the optic refractive index of low energy neutrinos could be larger than 2, so as to form caustic zone inside Earth, as per the fact that night observed value of solar neutrinos is 3.2% more than day.

**Literature references**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