

Neutrino Calorimetry

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Neutrino flux detection does not require an ionization event as they are detected constantly exchanging energy via a Raman process. The neutrino flux constantly interacts with matter by the overwhelming pressure of the large number of field-matter interactions. These interactions overtake the poor weak force coupling to matter producing a measurable neutrino Raman energy exchange. *paper submitted to the Journal Condensed Matter Nuclear Science*

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I. INTRODUCTION

Neutrinos unlike photons pass through enormous volumes of matter, moving at the speed of light with a wave front spanning 10^{-11} meters or less where they will sample more than 10^{31} atomic sites per cm^2/sec . Unlike the photon, neutrinos can only weakly polarize the nucleons by the weak interaction, however, they have a far greater range with far greater numbers. Taking a collection of metal samples .02 to .45 kg. and laying them on an insulating foam, in the dark, free of drafts with a substantial free air volume, and measure their temperatures to $.01^\circ \text{C}$ one will find that they never come into equilibrium. A low carbon steel cabinet with a $\sim .002\text{m}$ thick wall with a relatively large free volume was used for the measurements because of its good thermal conductivity of iron and a captured molar volume of air close to that of the molar content of the samples. Metals were used because of their good heat transfer characteristic. The measured temperature of the metal samples will vary around the ambient air temperature over a range of $\pm .02^\circ \text{C}$ or more. The thermal flux attributed to the individual samples for heating or cooling was found to be in the range $> \pm 0.0005 \frac{\text{Joules}}{\text{sec. kg}}$.

Detecting neutrinos requires understanding how massless fields transfer energy to matter. One long standing question that had to be answered is how do neutrinos lose energy so they do not become an end point sink locking up the free energy of the universe in an inescapable prison? One hint about how this end point was avoided comes from the measured neutrino refraction by the weak force (Wallace and Wallace, 2018) that opens the door to an energy loss mechanism. Unlike the photon which can polarize a dielectric and does not lose energy until a transition threshold is reached, the neutrino has a different polarization mechanism with a magnetic character. The weak interaction polarization does not have a charge affecting E-field component, but rather a transient mag-

Table I **Some thermal data from Aug. 2026 in degrees C. As the air temperature varied these offsets did not vary much except if there was an external event that altered the neutrino flux, then the entire set would respond. The 1:13am and 1:22am readings bracket the solar midnight response of cooling in all samples except for the Ti64. The carbon is a dense high purity graphite. Uncertainty in reading temperature is $.005^\circ C$.**

time	Ti64	BiSn	C	Al	316ss	air
21 Aug						
9:10am	$+.04^\circ$	$-.07^\circ$	$-.05^\circ$	$+.13^\circ$	$-.01^\circ$	18.54°
3:15pm	$+.03^\circ$	$-.06^\circ$	$-.04^\circ$	$+.13^\circ$	$-.01^\circ$	18.58°
11:15pm	$+.04^\circ$	$-.09^\circ$	$-.05^\circ$	$+.12^\circ$	$-.02^\circ$	18.53°
22 Aug						
1:13am	$+.04^\circ$	$-.11^\circ$	$-.08^\circ$	$+.10^\circ$	$-.04^\circ$	18.53°
1:22am	$+.03^\circ$	$-.12^\circ$	$-.08^\circ$	$+.10^\circ$	$-.05^\circ$	18.51°
9:17am	$+.04^\circ$	$-.08^\circ$	$-.05^\circ$	$+.13^\circ$	$-.02^\circ$	18.53°
11:06pm	$+.03^\circ$	$-.08^\circ$	$-.05^\circ$	$+.14^\circ$	$-.01^\circ$	18.58°

netic field that can interact with a propagating mode via longitudinal spin waves (Wallace, 2009a) (Wallace, 2009b). The magnetic perturbation can produce an irreversible process with no low threshold limit unlike light because of the magnetic coupling to the low energy longitudinal spin waves that readily interact with thermal phonons (Wallace, 2009a) (Wallace, 2009b).

The neutrinos are massless fields like the photon and can interact with matter in two ways like the photon: direct transitions and Raman scattering. Direct high energy neutrino transitions are detected in large water volumes containing scintillation detectors. Because of the high flux density of neutrinos Raman scattering of neutrinos can also be detected with a calorimeter sensitive to a range of neutrino energies. This process also allows neutrinos to gain energy. This is an analog to the anti-Stokes Raman process of photon interaction with matter.

II. SIMPLE EXPERIMENT

The question that triggered this work was whether geo-neutrinos could be detected? Geo-neutrinos principally are lower energy neutrinos below 1 MeV in energy from long lifetime beta decay processes. In current practice detecting geo-neutrinos (anti-neutrinos) was only possible with great difficulty. It was thought the low moment of inertia of an unscreened interstitial proton within a metal may respond to a weak magnetic perturbation cause by an incomplete weak interaction (Wallace and Wallace, 2024). We had some niobium metal whose surface was charged hydrogen from an electro-discharge wire cutting

process. It was felt this metal might be sensitive to sampling the low energy neutrino flux that had energies less than .5 MeV expected from geo-neutrinos or the sun. A simple RF spectral test was made finding a new unexplained low frequency noise band in the 1 to 2 Mhz range. This surface charged hydrogen rich metal was configured with an antenna to cancel any external RF fields and only detect fields generated within the sample. This noise measurement technique is not well developed so another test was performed. The result implied that a thermal night vision scope with a sensitivity of $.02^\circ C$ might be sensitive enough to detect an above ambient temperature. This test also provided a positive result on the same sample. The simplest approach then was to use thermocouples with a precision voltmeter to detect this heating. We were fortunate to select a sample that heated making the identification simple as we had other samples which cooled. The temperature range of interest was as great as $\pm .3^\circ C$ that can be measured with a resolution approaching $\pm .001^\circ C$.

To prove neutrinos were heating and cooling samples only required samples held within sturdy metallic containers. External RF fields are screened out and monitored to very low levels as there are no other stable fields left to upset a local thermal equilibrium but for neutrinos. In the modern physics menagerie of particles and fields there are the undetected axions, gluons, quarks, along with gravitons. Quantum mechanics when integrated with a corrected version of special relativity generates no other massless field solutions other than the photon and neutrino (Wallace and Wallace, 2017). By elimination, the only particle penetrating our detector in sufficient numbers without causing ionization are the neutrinos.

Our initial calibration point was knowledge that at solar midnight neutrinos would be focused by the earths core to produce an enhancement around 1:18am local time (Abe and et. al., 2016) (Wallace and Wallace, 2018). This, was not the only signal that was found to repeat at night. During September and October it was found the denser core of the Milky Way was also focused just before dawn. That signals varied significantly night-to-night because a different cut of the Milky Way was taken each night and the varying thermal environment of the sensor. Also, as the earth's tilt changes different portions of the earths core are sampled with the changing focus. These were small responses as focusing only produced a flux enhancement of $\sim 3\%$ and it was not a particularly good standard being weak.

Over the course of a few months of taking data with different samples and measurement equipment we found there were major noise sources active that affected our measurements, particularly on hot summer days. These noise sources could not be traced to the large trunk power lines over 500KVA when a portable unit was taken to these lines, it did however detect variations associated

with geological structures in the area and thunder storms. The last major source that was causing major cooling responses indicative of reactor activity during hot days rather than astrophysical events which should not be limited to working hours. The naval reactors in the Norfolk harbor could be the source as it not the usual practice to change power levels in commercial reactors.

A. The Calorimeters

Our stationary measurement were mostly carried out in a below grade room at a temperature of $18^\circ \pm 1^\circ C$. All that is required is a $6\frac{1}{2}$ digit voltmeter, E thermocouples ($\sim 60 \mu Volts/^\circ C$ at $20^\circ C$), and a container that baffles drafts while allowing a thermal flux going to or from the samples. The offset of individual thermal couples can be corrected with an isothermal copper block for calibration. External fluxes that are heating the sensor will show a timing differential between the air thermocouple and the thermocouple within sample. The thermocouple within the sensing sample will show the response ahead of the air thermocouple. This allows the separation of neutrino events from the general thermal changes external to the apparatus, see Figure 1.

The neutrino flux effect on the thermocouples can be reduced by using a pair of matched differential thermocouples with one sampling the metal sample and the other sampling the nearby air. Everything in the signal chain will be affected by the neutrino flux and should be kept to a minimum and differential matched.

III. EXCITATION

Two processes that must be understood are the incomplete weak interactions where a transient magnetic moment $\delta\mu$ is generated.

$$\bar{\nu} + n \rightarrow p + e^- \quad \pm \delta\mu \rightarrow \bar{\nu}' + n \quad - 1.293 MeV$$

$$\nu + p \rightarrow n + e^+ \quad \pm \delta\mu \rightarrow \nu' + p \quad + 1.293 MeV \quad (1)$$

where $\pm \delta\mu$ is the excitation

Direct physical scattering between a high energy neutrino and electrons or nucleons though rare are high energy events, producing ionization that are detected with photo multiplier tubes in large volumes of water or ice. Incomplete scattering events by a neutrino occurs when a nucleon is temporarily excited before returning to its ground state. This is the equivalent polarization process, analogous to photon polarization that results in refraction. The magnetic excitation leads to neutrino refraction. The result is Raman radiation exciting a magnetic

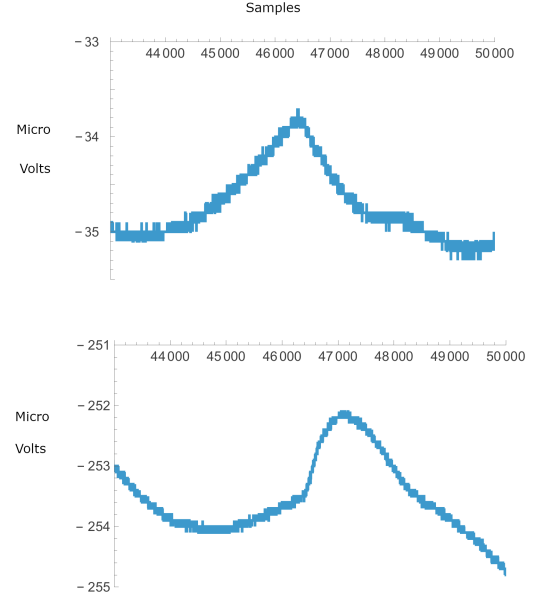


Figure 1 Sharp heating peak at 4:50pm on 24 Oct. 2026. A few times a week sharp peak events are detected with the top graph showing an aluminum sensor block heating which contains the positive half of a paired differential set of thermocouples with the negative half in the air adjacent to the block. The lower graph is of single thermocouple in the air near the block. The sampling rate is one per .5 seconds and the sensor shows about a 4 minute advance on the single air thermocouple. The $\sim 1 \mu Volt$ heating response corresponds to about $\sim +.02^\circ C$. This is probably not a man made event as those events usually have some duration. This could be due to some event in the sun, a nova, or some rapid fault motion within the earth. The amplitude is about the same as seen in the concentration of flux focused by the sun at solar midnight, however, these are low energy neutrinos with energies probably below 1 MeV.

spin wave or the absorbing of some of the thermal energy from the scattering nucleon by the neutrino. This implies different target materials will react differently to neutrino scattering dependent on the neutrino's energy and this is evident as some samples heat while other are cooled, see Table I. The heat transfer produces information about both the energy of the neutrinos and the nucleon. Unlike traditional Raman scattering with optical photon, neutrino Raman scattering operates in an entirely different energy range.

The different sample metals used as detector have differing energy dependent sensitivity to the neutrino flux. The calorimetry data is complicated by the fact that both heating and cooling reactions are summed in the sample being studied. The energy spectrum of sensitivity can

only be discovered in detail by using a number of different beta decay sources to calibrate the sensitivity of the different detector materials over a wide energy range.

IV. STATIONARY DATA COLLECTION

Fortunately, there are natural sources of neutrino emission for a coarse calibration. We had contacted three state universities about their beta radiation sources and none were willing to part with any information. A mobile unit can pin point those sources even though we were not supplied with their location, composition or strength. Commercial nuclear plants are either on or off and that supplied some data, but naval reactors are more active and they are probably the main source of the large day time flux changes during the summer heat.

There are two basic sources of confusion in collecting the thermal flux data. Neutrino fluxes from various sources are not well behaved and can show large variations. The 24 hour repeating astrophysical sources that are enhanced once a day by the refractive effect of the earth's mass: the sun and the central region of the Milky Way are weak and this show significant day-to-day variations, see Figure 2.

A systematic error in data taking is a requirement for a stable thermal environment that does not interfere with the thermal flux from the sensor. The sensors are easiest maintained in a room or a cave with little or no temperature variation. Measurements are made with a resolution $\sim \pm 0.001^\circ C$ so any active thermal control becomes a problem. Data is taken using a differential set of type E thermocouples one within the sensor material and the other sampling the air near to the sensor. Typically, the sensors are housed in a mild carbon steel electrical utility cabinet which can be shielded from drafts by being placed in an open large empty cooler. One calibration run was done to a nearby ^{60}Co source at a university using both an aluminum and Ti64 small sensors, $\sim .1$ mole, that produced a response of $-1.0 \mu Volt$ with an uncertainty of $\pm 0.05 \mu Volt$ as the sensor was driven by the radiation facility. The negative sign of the deviation was indicative of neutrinos with an energy greater than 1 MeV as expected for ^{60}Co . This was based on the fact that normal response for these detectors is a positive voltage generated by the large low energy solar flux of neutrinos below .5 MeV, and the low energy geo-neutrinos from ^{40}K decay.

A. Sun and Milky Way

The sun and Milky Way should be the main source of low energy neutrinos as reactor neutrino energies should peak above 5 MeV. As objects in the sky are always on the one method of detecting any changes from sources

in the sky is to follow the intensity as a function of the direction to the earth's center and its projection in the sky. Neutrinos being massless, refract, and the earth can slightly focus their signal that can give an enhancement of $\sim 3\%$ (Abe and et. al., 2016) (Wallace and Wallace, 2018). The surprise in the data was it was the higher energy neutrinos that were the most strongly refracted by the earth. Higher the neutrino energies have shorter wave lengths that are closer to the scale of the nucleons that they interact with, see Figure 2 and Table I.

B. Storms

Isolated thunderstorms and storm fronts provide two different sources of neutrinos. Isolated thunderstorms have to be close to the detector to produce a positive response, however, storm fronts which extend more than a hundred miles can be detected at twice that distance. A sample of three days when storms around Virginia were active is found in Figure 3. The large negative response indicates that the neutrino production was high energy over 1 MeV with low energy neutrinos from decay products in storm of Oct 1, 2026.

C. Reactors

There are three major reactor sites in Virginia: Lake Anna I and II distance of 100 km, Surry Power Station I and II at 233 km, and Norfolk harbor 277 km. Recently in the last month Lake Anna II was taken out of service for refueling and that produced a significant drop in the measured high energy neutron flux at our stationary detectors.

V. MAPPING DATA COLLECTION

Data taken on multiple units using a variety of material sensors and different electronics gave some confidence that the detected signals were due to neutrino's Raman interaction with matter. The variation in the detected neutrino flux at our site is usually well behaved at night as compared to the daylight hours. At night there were two reproducible events during our observing period that can be seen above noise: the local minimum, cooling, by the high energy neutrinos at the solar midnight when the earth focuses to solar flux from the earth's far side as previously seen in Japan (Abe and et. al., 2016). At our site prior to the fall equinox the central core of the Milky Way is in focus a few hours later.

During the daylight hours there are a number of nuclear reactors within a 300 mile radius that includes the harbor at Norfolk that are the most likely sources of high energy neutrino emission on hot days to run air conditioning. These do cause a problem with a mobile unit

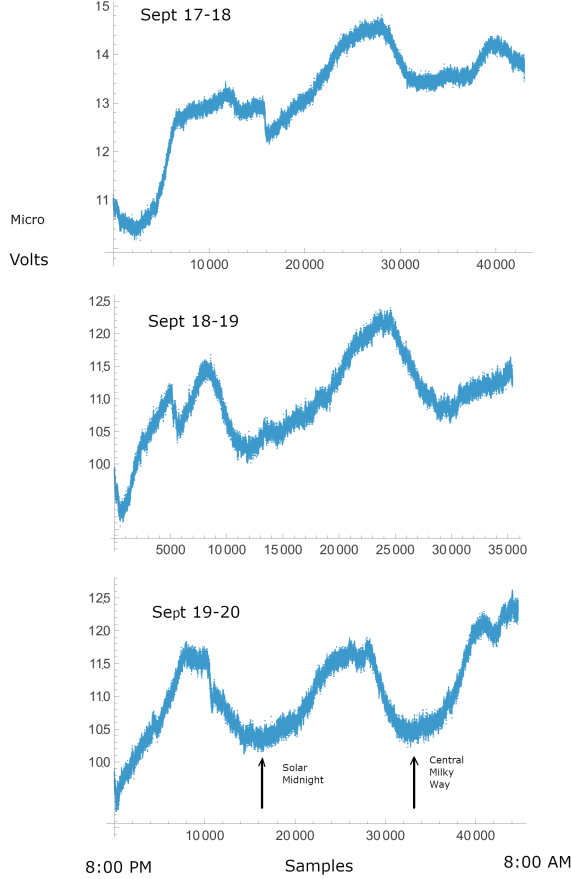


Figure 2 Raw calorimetry data taken over three nights with an aluminum sensor. This was done because the Super-Kamiokande collaboration reported a $\sim 3\%$ increase when the sun was opposite the detector on the other side of the earth, solar midnight. Since the scintillation detector was most sensitive to higher energy neutrinos a dip would be expected in our detectors at the same time of night. What was found were two dips one around sample 18000 that corresponded to solar midnight and a second at close to sample 35000. When the sky chart was checked the second dip corresponded to region near the center of Milky Way being focused. In these 12 hour scans there is other activity that are not as easily identified. Also the response changing night-to-night should not be surprising as each night a different slice of the sky will be enhanced that will not repeat for a year. It appears the higher energy neutrinos are preferentially focused as their wavelengths approach nuclear sizes.

when mapping as they supply an unwanted input. Data taken on the portable unit was done on a single machine operated in car, to measure a ^{60}Co source at a nearby hospital and survey local geophysical sources from their ^{40}K emissions. The portable unit was useful in eliminating power lines as signal sources.

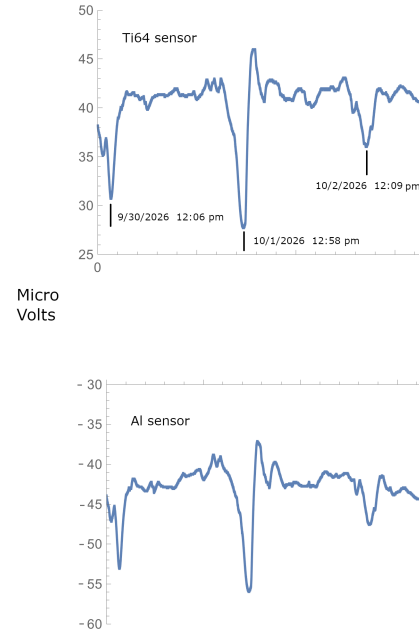
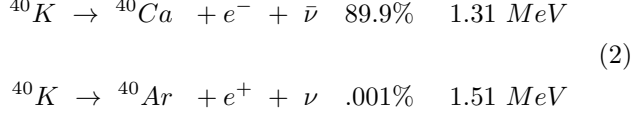


Figure 3 300,000 samples of raw data, from the morning of Sept 30 to the afternoon of Oct. 3 using two sensors. Strong lightning storms with extended fronts were present on three successive days within 150 miles of our site around noon of each day. Reactor events also produce strong negative responses. Only on the afternoon of 1 Oct. was a large positive response detected that would indicate a local storm. The error bars in the data are $\pm 1 \mu\text{ volts}$

A. Local Hills and Mountain

The easiest mobile collection sources in the Valley of Virginia are the folded limestone hills which were laid down in shallow seas with layers of limestone interleaved with thin layers of silt and mud stone that indicate a shallow sea with outflows from streams and rivers. When sampling data above the water table there is an increase of low energy anti-neutrinos showing a positive temperature rise in the sensor. Higher the hills, greater the signal as long as they are not capped with sandstone. When traveling across or next to a river or below the water table the signal vanishes as the potassium salts that are deposited in shallow seas are dissolved away by the ground water. The changes are abrupt and strong with even small elevation changes of 12 meters or more next to springs and creeks. The Blue Ridge range which has limestone on the western face and ancient original shield with green stone on the eastern face shows the sharpness of the divide, Figure 4. There is sharp drop after leaving the mountain when crossing South River. The top of the mountain is capped with the older material.



Even though the natural abundance of ^{40}K is only .0117% in the deposited potassium salts, the mass of limestone beds in which it is contained is great enough that it is a significant nuclear source that is easy to detect. The valley limestone is primarily a low energy anti-neutrino source with the bulk of its anti-neutrino energies being below 1 MeV.

In the most recent publication on anti-neutrino sources detected by the Super-Kamiokande group (Collaboration, 2026). An estimate of the relative sensitivity of their detectors can be made and on an equal time interval between the Super-Kamiokande, $\sim 10^{-16} \text{ J/sec}$, to the neutrino calorimeter, $\sim 10^{-4} \text{ J/sec}$ produces a ratio 10^{12} as the calorimeter is more sensitive. When corrected for the mass difference between the two detector that ratio of sensitivity grows to $\sim 10^{25}$ in favor of the calorimeter.

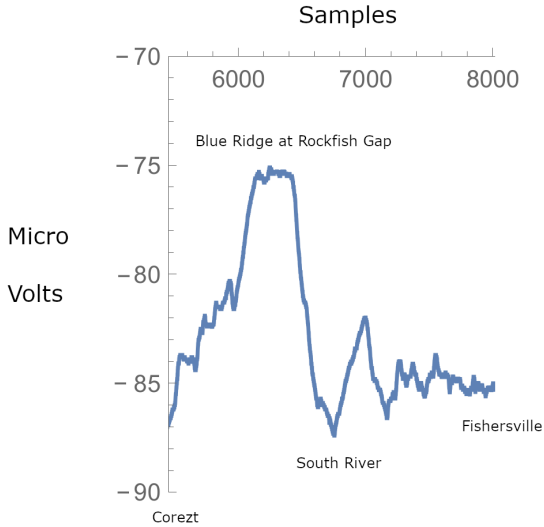


Figure 4 A moving record from Mile Marker 107 to Mile Marker 91 on Interstate 64 traversing the Blue Ridge Mountain at Rockfish Gap that took 14 minutes. The short duration minimizes the probability of any significant changes in the neutrino flux from either domestic or astrophysical sources. The strong positive response in the aluminum sensor is consistent with a low energy neutrino source produced by ^{40}K . The error bars in the data are $\pm 1 \mu \text{ volts}$.

B. Hospital ^{60}Co

The one local radioactive material storage site at a hospital produced a high energy neutrino response that is expected from ^{60}Co . The site was well back from the road.

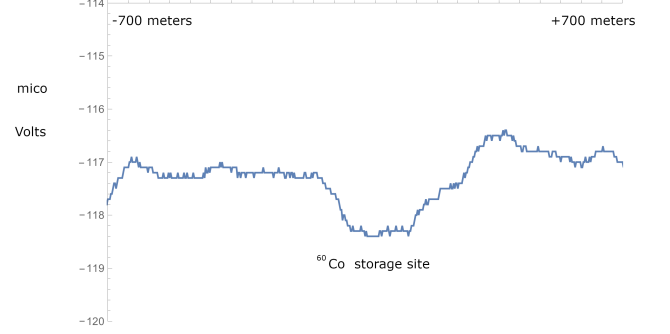


Figure 5 Raw calorimetry data taken while driving by a ^{60}Co and radioactive isotope storage facility at local hospital. The approach was no closer than 150 meters from the road where the detector (Al coupon) passed 24 Sept. 2026 4 PM EST. Signal level of $-1 \mu \text{Volt}$ was detected well above noise and indicates neutrino energies greater than 1 MeV consistent with ^{60}Co .

VI. ESTIMATING FLUX

The differential thermocouple sensor are mounted in a sealed mild steel electrical cabinet to stop local drafts with one thermocouple buried within the metal that is used as a sensor and the other sampling the air in the cabinet. The flux, $f(t)$ Joules/sec, that is either deposited in a sample, M moles, or extracted by the neutrino flux in a sensor with a heat capacity, c_s and air's heat capacity, c_a . Where h is the convective heat transfer coefficient, temperature of the sensor is T_s , the air within the cabinet is at T_a , and the sensors surface area is A in m^2 . The change in heat of the sensor, q_s , can be represented by the first order time dependent equation.

$$\frac{\partial q_s}{\partial t} = \int M f(t) dt - hA(T_s - T_a) \tag{3}$$

$$\frac{\partial^2 q_s}{\partial t^2} = M f(t) - hA \left(\frac{1}{C_s} \frac{\partial q_s}{\partial t} - \frac{1}{C_a} \frac{\partial q_a}{\partial t} \right) \tag{4}$$

$$C_s \approx C_a \tag{5}$$

When $\frac{\partial^2 q_s}{\partial t^2} = 0$

$$f(t) = \frac{hA}{MC} \left(\frac{\partial q_s}{\partial t} - \frac{\partial q_a}{\partial t} \right) \approx \frac{hA}{MC} \frac{\Delta T}{\Delta t} \quad (6)$$

Where $\frac{\Delta T}{\Delta t}$ can be taken from recorded event data. So that the deposited energy flux from an event can be computed.

Even though the absolute temperature of the sample under test can be measured, to produce an estimate of the total flux requires a complete heat transfer analysis that starts with the sensor and includes the geometry of the cabinet and its transfer properties to the outside environment. Passive flow calorimetry requires a detailed understand of the heat transfer at each interface geometry. This is a difficult task. Measuring event flux changes can be much simpler with changes as much as $.3^\circ C$. These fluxes are an integration of both the positive and negative contributions to the sensor's thermal state that adds a complication of extracting the total neutrino flux.

VII. A NEW NUCLEAR WINDOW

The only dependence found between the positive and negative measured thermal states to nuclear properties was whether the nucleons in the sensor was close to one of the magic ground state shell filling numbers: 2, 8, 20, 28, 50, 82, and 126 (Mayer, 1964). The BiSn eutectic which had a very strong negative bias fell on the shell filled condition at 126 for neutrons and 82 for protons as for tin the protons fell on 50. For aluminum which was the strongest positive bias with 13 protons and 14 neutrons fell between the shell filling numbers 8 and 20. The nuclear ground state shell theory is a weak model but there maybe some basis in the ground state structure that determines the nature of the Raman transitions that will dominate for a particular element. The ground state structure varies between the two limits for *Bi* verses *Al* from completely filled states with total spin of zero compared to a set of partially filled states whose spins seem to be active. In this work only a few solids were examined that did not include powders, liquids or organic material that were not as easily handled when monitoring heat transfer.

VIII. DISCUSSION

Once neutrinos were detected in 1956 they became a major problem for physics. They did not seem to decay and did not interact strongly enough with matter to reduce their numbers. They became an energy sink that could not be recovered. With the solar neutrino flux data showing the numbers to be half of what was expected a model was put forward allowing the neutrino to

change forms if it had a mass. We had found there was no need for this model as the actual massless neutrino interaction cross section was one half of what was initial used once energy conservation was enforced on deriving a correct replacement for Schrödinger's equation (Wallace and Wallace, 2017) (Wallace and Wallace, 2020). This correction also gave the spin of the neutrino a value of $\frac{\hbar}{2}$. There is a major problem with the neutrino having mass, it could not be refracted and this did not fit experimental evidence from Japan and Italy (Wallace and Wallace, 2018) where neutrino refraction was detected by the effect of the earth being between the sun and a cylindrical neutrino detector.

The principal result of this work is the experimental evidence that the neutrino like the photon is a massless field. The theoretical basis for the neutrino being a massless field arises from correcting two major errors that have propagated through physics for more than a century. The first is that special relativity is not restricted to a range of $\gamma \geq 1$ but extends to values $\gamma < 1$. Restricting $\gamma \geq 1$ eliminated the ability to deal with energy transfer in a bound state and to correctly express a representation for anti-matter. The second fault is that both the Schrödinger and Dirac equation are not accurate descriptions of nature. The Schrödinger equation is missing two terms that makes it incompatible with relativity and the Dirac equation is a forced first order construction that is inaccurate because a second order description is required to generate the raw material to construct both particles and fields. There is a hierarchy in this derivation where massless fields are derived from a transformation starting with massive particles defined in their own frame of reference. The fields of the photon and neutrinos are descendant properties of the massive particle fields derived much like the taking of Adam's rib to form a women. The self-reference frames for particles requires a volume of space that is statistically isolated from the laboratory frame whose deficit establishes the curved geometry of the laboratory frame that is the basis for gravity.

A compact neutrino detector exposing beta decay sources has numerous applications in controlling the transfer of radioactive material across borders, remote reactor monitoring, studying the sun, Milky Way, super novas, mapping large and small scale mineral distribution, and advancing the study of earthquake precursors and volcanoes for their terrestrial nuclear activity (Carpinteri *et al.*, 2015) (Wallace *et al.*, 2012).

REFERENCES

- Abe, K., and et. al., 2016, Solar neutrino measurements in super-kamiokande-iv , arxiv:1606.07538v1 [hep-ph], super-Kamiokande Collaboration.
- Carpinteri, A., G. Lacidogna, and A. Manuello (eds.), 2015, *Acoustic, Electromagnetic, Neutron Emissions from Fracture and Earthquakes* (Springer Intl., Switzerland).

- Collaboration, T. S.-K., 2026, First observation of electron anitneutrinos from nulear reactors at super-kamiokande, arxiv 2610.03143v1 [hep-ex].
- Mayer, M. G., 1964, Science **145**, 999.
- Wallace, J., 2009a, Electrodynamics in iron and steel, arxiv:0901.1631v2 [physics.gen-ph].
- Wallace, J., 2009b, JOM **61**(6), 67.
- Wallace, J., G. Myneni, M. Wallace, R. Pike, and G. Westphal, 2012, *Terrestrial Nuclear Processes* (Casting Analysis Corp., Weyers Cave, VA.).
- Wallace, J., and M. Wallace, 2017, *“yes Virginia, Quantum Mechanics can be Understood”* (Casting Analysis Corp., Weyers Cave, VA).
- Wallace, J., and M. Wallace, 2018, Refraction, <http://vixra.org/pdf/1809.0582v2.pdf>.
- Wallace, J., and M. Wallace, 2020, *“yes Virginia, Quantum Mechanics can be Understood” 2nd ed.* (Casting Analysis Corp., Weyers Cave, VA).
- Wallace, J. P., and M. J. Wallace, 2024, The origin of the meissner effect and superconductivity, <http://vixra.org/pdf/2204.0024v2.pdf>.
- .