Hidden variable theory supports variability in decay rates of nuclides

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Abstract

PROBLEM*- The orthodox expectation is for decay rates to be strictly constant for all types of decay (β+, β-, EC, α). However empirical results show strong evidence for nuclides having variable decay rates, typically evident as periodicity. The volume of data available suggests this is a real phenomenon, not merely a spurious outcome of measurement errors. However the problem is complex because the data are conflicted for different decays. Furthermore, there is no coherent theory for why the phenomenon should exist in the first place. The effect is not required or predicted by quantum theory. Consequently it is a significant challenge to explain how the variability might arise, what factors could be involved, and how the underlying mechanisms of causality might operate. This lack of explanation contributes to the phenomenon often being dismissed as erroneous.* ***PURPOSE****- This paper develops a theoretical explanation of the variability of nuclide decay rates.* ***APPROACH****- The non-local hidden-variable solution provided by the Cordus theory was used, specifically its mechanics for neutrino-species interactions with nucleons.* ***FINDINGS****- It is predicted that the β-, β+ and electron capture processes are induced by pre-supply of neutrino-species, and that the effects are asymmetrical for those species. Also predicted is that different input energies are required, i.e. that a threshold effect exists. Four simple non-contentious lemmas are proposed with which it is straightforward to explain why β- and EC would be enhanced and correlate to solar neutrino flux (proximity & activity), and α emission unaffected. It is shown that the concept of a neutrino-species asymmetry makes sense of the broad patterns evident in the empirical data.* ***IMPLICATIONS****- The results support the variability of decay rates, on theoretical grounds. The type of decay (β+, β-, EC, α) is found to be a key variable in this theory, as is the type of neutrino species and its energy. Past experiments have generally not recorded the variables sufficiently. Future empirical tests of nuclide decay rates need to be more specific about the identity of the external environmental, neutrino-species, both the energy and flux thereof. It is also necessary to be more specific about the decay path. The different decays have to be considered separately, not lumped together, nor classified primarily by element (e.g. U, Pb, Cl, etc.) but rather by type of decay process (β+, β-, EC, α). A more radical implication is that hidden-variable theories offer profoundly new perspectives on fundamental physics, and can explain complex phenomena that are inconceivable from within the zero-dimensional point framework of quantum theory.* ***ORIGINALITY****- The novel contribution is the provision of a theoretical explanation for why decay rates would be variable. A detailed mechanism is presented for neutrino-species induced decay. Also novel is the prediction that the interaction is asymmetrical, and that the energy requirements are different for the various types of decay. The explanation is qualitatively consistent with the empirical evidence.*

Keywords: variable decay rate; nuclides; neutrino; asymmetry; physical realism

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1 Introduction

The orthodox expectation is for decay rates to be strictly constant for all types of decay (β+, β-, EC, α). One reason for this position is that there is neither necessity nor no obvious mechanism within the standard model to support variability. However empirical results show strong evidence for variable decay rates. This is evident in the wide variety of results obtained when measuring the decay of the single free neutron (β-) in different experiments [1] [2]. The nuclides also show variability in decay rates, and this sometimes also shows periodicity. The conventional perspective is to interpret the variability as some yet-to-be-discovered systematic error of measurement. However the volume of data available suggests this is a real phenomenon, not merely a spurious outcome of measurement errors. The effect is not required or predicted by quantum or any other theory, but neither can those theories prove that decay rates must be fixed.

Consequently, if decay rates truly were variable, then it implies that some deeper mechanics, current hidden to quantum theory, would be involved. However the problem is complex because the data are conflicted for different decays. The empirical data, reviewed below, strongly indicate variability at the level of individual studies, but the overall trends across multiple studies are confusing and difficult to unravel. Furthermore, there is no coherent theory for why the phenomenon should exist in the first place. Those who interpret variability in the empirical data are unable to explain how the variability might arise, what factors could be involved, and how the underlying mechanisms of causality might operate. As a result the field is in a state of ambiguity. The lack of explanation contributes to the phenomenon often being dismissed as erroneous.

There is value in prospecting for new theories of decay that might make better sense of the empirical evidence. While any such candidate theory may be partly conjectural, such is the nature of theory-building. It is important that fresh ideas can be evaluated and tested, and the field moved to a more coherent footing whether that be rejection or acceptance of variability. This paper prospects for a possible explanation of the variability. Unusually, it does this from the perspective of a non-local hidden-variable design called the Cordus theory. It develops an earlier proposition that neutrino-species interactions can induce decay in nucleons [3], and goes on to show that variations in decay of nuclides can be explained by similar mechanics.

2 Empirical evidence for and against variable decay rates

Empirical evidence for variable decay rates

Many studies have found evidence for the variability of decay rates in a variety of nuclides. That such rates are variable is indisputable, but the issue is whether the phenomena are spurious or have a deeper causality. If spurious, one would expect to find systematic measurement errors, and the results of different researchers to be in conflict. To some extent such conflict does exist, but much less than the finding of consistent results. Nor has it been possible to specifically identify the purported measurement errors. Consequently on balance one has to be open-minded to the possibility that the phenomena may be real.

In support of the idea that a deeper mechanism might be involved, many researchers have noted that not only are the rates variable, but they also have periodicity. A common empirical finding is that the variability in decay rates is correlated with the seasonal variability in distance to the Sun, or less occasionally with other variables such as cosmic ray flux. There is ample empirical evidence for this, as follows:

^{32}Si (β-) [4] [5]

^{36}Cl (β-, EC+ β+) [4] [6]

^{40}K (EC), [7] found a strong annual periodicity compatible with changes in the cosmic ray flux

^{60}Co (β-) [8],

^{85}Kr (β-) [9]
^{90}Sr (β-) [8] [9]
^{90}Y (β-) [8]
^{108}Ag [9]
^{226}Ra (α, β-) [5] [9]
^{133}Ba (EC) [8] [9]: this nuclide showed a strong annual effect but also much greater variability than others
^{137}Cs (β-) [9]
^{152}Eu (EC β+, β-) [9]
^{154}Eu (β-)[9]

The decay rates have a period of about a year and increase when the Earth is closer to the Sun. At first it was unclear whether this might be due to seasonal variations in climate, or some other terrestrial environmental factor (moisture, temperature, etc.), but subsequent experiments reduced that likelihood [6]. The cause of the effect is currently unknown and the various candidates are: (a) changes in the flux of solar neutrinos due to distance (the Sun is thought to produce neutrinos rather than antineutrinos), (b) solar activity, (c) changing flux of relic, cosmic, or galactic neutrinos due to the position of the Earth in its orbit, (d) anisotropy of space, (e) that the results are merely statistical anomalies, though this seems unlikely given the strength of the data.

There is evidence that the pattern of variability changes with time, and does so differently for different nuclides (β-) [9]. Periodicities other than annual have also been observed, but the causes of these are more difficult to attribute. Correlations to day and lunar cycles have been identified using ^{90}Sr (β-) + ^{90}Y (β-) [8]. An inverse correlation has also been observed with solar activity, e.g. a decrease in the decay rate ^{54}Mn (EC, β+) during a solar flare [10]. Those observations suggested a neutrino type particle was involved, as opposed to a charged particle or electromagnetic radiation, due to the timing and the position of the Earth. The speculated cause was that the solar flare changed the neutrino flux, though those authors acknowledged that the relationship between solar activity and neutrino flux is uncertain. However this may have been spurious correlation as other observations at the same time determined no change in decay rates for ^{90}Sr (β-), ^{90}Y (β-), ^{60}Co (β-) or ^{239}Pu (α), nor at other times of sudden solar activity [11]. Those same authors observed sudden unexplained changes in decay rates at other times, but these were rare and not associated with any particular solar event [11]. However these observations do not rule out a solar association, because different decay types were measured, and different nuclides. It is possible that EC decays could be affected differently to β- or α [11]. Variability of decay rate has also been found in radon ^{222}Rn (α) [12], but the period is of the order of decades rather than annual, and also a time-of-day period. The tritium ^{3}H (β-) decay also shows periodic variability of 27 days [13]. Other possible factors for variable decay rates include shape of the nuclide, e.g. body foil vs. sphere, though the observed effect was not large [14]. The proposed mechanism was that the shape affects the flux of decay particles (e.g. neutrinos). Another proposal has been that solar magnetic fields, which are directional, affect neutrino flux [9].

Contrary evidence

Other studies offer contrary findings. For ^{232}Th (α), [7] noticed a periodicity of 300 days, but attributed this to instabilities in the measurement equipment. Those same authors found strong annual periodicity in ^{40}K (EC). In another case [15] disfavoured correlation between decay rates and Earth–Sun distance. They used combinations of nuclides: (a) ^{22}Na (β+ and EC) + ^{44}Ti (EC), (b) ^{108}Ag (EC) + ^{121}Sn (β-), (c) ^{133}Ba (EC) + ^{241}Am (α). However they considerably complicated the results by lumping together nuclides with different decay processes. They were only checking for correlation between the data and one other hypothesis, the Jenkins seasonal curve, which they did not find. All the same, there was noticeable periodic variability in their data, especially for the (a) and (c) combinations of nuclides, though the significance of that was not tested against alternative hypotheses at the time. That was subsequently tested and found significant [16]. Thus, while the periodicity may be annual, it is not necessarily in phase with perihelion. It has been speculated that this might be due to neutrino generation by the Sun having its own internal variability for reasons not entirely clear [16].

Likewise, while no significant deviations in decay rates were observed for Earth–Sun distance on the Cassini spacecraft [17] [18], that experiment used ^{238}Pu (α), which is significant in the present context for reasons which will be elaborated. That experiment was not ideally configured for decay studies so complex models were necessary with many assumptions. Other experiments confirm the non-variability of ^{239}Pu (α) [8].

Others have found no statistically significant variability for ^{137}Cs (β-) for a range of oscillation periods (including one year) [19]. That does not mean no variability, only that it did not correlate to a specific constant period. They only took data for a little more than half a year, which may be sufficient if the effect size was large, but otherwise may be inadequate to detect a small effect. That experiment was conducted underground in Gran Sasso, the shielding of which provides several orders of magnitude reduction in cosmic rays and neutrons. Other evidence also supports the non-variability of ^{137}Cs (β-) [20].

However another interpretation is possible: that not all nuclides or decay processes have the same susceptibility to variation, and ^{137}Cs (β-) may be one of those that with low susceptibility. This is consistent with the evidence that ^{137}Cs (β-) does not show periodicity in the same situations where ^{133}Ba (EC) does [21] [20].

Disconfirmatory evidence for the Jenkins period has been presented for ^{36}Cl (β-, EC β+) [22], who used a different type of detector (liquid scintillation) than Jenkins (Geiger–Müller), and reopened the debate about possible detector factors (thresholds, stability, internal attenuation), see also [20], and environmental factors. Some of these studies also reduced the strength of the case for nuclide-specificity [21], whereas other strengthened it [20]. The decay rates for β+ under antineutrino loading (generated by a reactor) have been examined and found to be non-periodic with reactor status for ^{22}Na (β+) ^{22}Ne, ^{54}Mn (EC) ^{54}Cr, ^{137}Cd(β-) ^{137}Ba, ^{152}Eu(EC+ β+) ^{152}Sm, ^{152}Eu (β-) ^{152}Gd [21]. The measurements were over a short period, and involved correspondingly complex analytical methods. Energy threshold effects were not considered. Others who have found no significant effect of heliocentricity on nuclear decay rates are [23], who studied meteorites that had landed on Earth. They examined ^{36}Cl (β-, EC+ β+), ^{235}U (α), ^{238}U(α).

Nature of the problem with variable decay rates

The field is still establishing whether or not decay rates really are periodic. This is a perplexing area since the data in support look impressive, as do the data against. The existing discourse in the literature tends to expect that *all* decay rates (β+, β-, EC, α) will be affected, e.g. by solar distance, or *none* at all, though there are exceptions [8]. Authors generally also expect *all* nuclides to be similarly affected. They typically also expect the effects to be seen with *both* neutrinos and antineutrinos, i.e. an assumption of symmetry, for an exception see [21]. There is also an implicit assumption that decay rates should not depend on the type of detector, for an exception see [22], or the energy of the neutrino-species.

The research group of Jenkins et al concluded that: *'(a) not all nuclides exhibit variability in decay constants; (b) among nuclides that do exhibit this variability, the patterns of variability (e.g., amplitude and phase of any oscillation) are not all the same; and (c) for nuclides that do exhibit variability, the patterns themselves may vary over time'* [20]. This implies multiple confounding factors. It is a significant challenge to explain how variable decay rates might arise. As they stated: *'we still have not determined a mechanism by which solar neutrinos would affect the weak interaction associated with beta-decays, [and] the development of a model where the neutrinos could affect both alpha- and beta decays becomes even more difficult'* [16].

Gap in the body of knowledge

Most authors frame the problem in terms of neutrinos of solar origin. However it is prudent to take a less restrictive starting premise, and restate it as a need to explain the relationships of causality whereby multiple factors (solar neutrino flux may be one), may cause different nuclides to display different decay characteristics (including different susceptibility and periodicity).

As this shows, it is unclear what the actual variables are, and a theoretical understanding of the relationships of causality between those variables is even more elusive. Part of the reason why orthodox physics disbelieves variable decay rates is that there appears to be no reason why the rates should be variable, nor is there any plausible theory whereby the variability might be understood.

It must also be noted that it is not even known, in an ontological sense, why the different nuclides have different stability in the first place. Obviously nuclear binding energy is not the primary variable as it is imperfectly correlated with nuclide life, and it totally fails to predict the nuclides that do not exist. Even if binding energy and life were perfectly correlated, it is still unknown why binding energy changes as it does through the table of nuclides. This makes it exceedingly difficult to explain why any additional variability should arise within one nuclide. So ultimately an explanation of the variability in decay rates will have to connect to an explanation of the table of nuclides.

It is pertinent to note that the free neutron also has a variable decay rate, and the reasons for that are also unknown [2]. Furthermore it is apparent that neutrino-species do induce decay, at least for some nuclides, since this is the operating principle for certain types of detectors. These mechanics are also unknown.

In summary, the evidence shows that decay processes have variability beyond that which can be attributed to measurement or statistical error. Neutrinos have been suggested as a factor, but orthodox theories of physics do not predict such an effect, so the causal mechanics of any such induced-decay processes are totally unknown.

3 Methodology

Purpose

The empirical evidence shows variability of decay rates, for which there is a need to find candidate explanations, whether practical or theoretical. While a definitive explanation would be ideal, the complexity of the situation suggests that a progressive approximation to an answer may be easier to achieve. Hence it is worth having candidate explanations (as opposed to complete solutions) that can be evaluated, and discarded or worked on further as appropriate. The purpose of this paper is to prospect for a candidate theoretical explanation of the variability of nuclide decay rates.

Approach

The non-local hidden-variable (NLHV) design provided by the Cordus theory was used, specifically its mechanics for neutrino-species interactions with nucleons. This theory proposes that particles have internal structure comprising two reactive ends that emit discrete forces [24]. For an example see Figure 1. In contrast quantum theory assumes particles are zero-dimensional (0-D) points. Further details about the proposed Cordus structure of particles are provided in the reference. The Cordus theory is unorthodox in its assertion that matter particles have internal structures. This is not a reason to disqualify the theory, as no proof exists, despite many attempts via the Bell and Leggett type inequalities [25] [26], that totally excludes the possibility that reality might be described by a hidden variable theory.

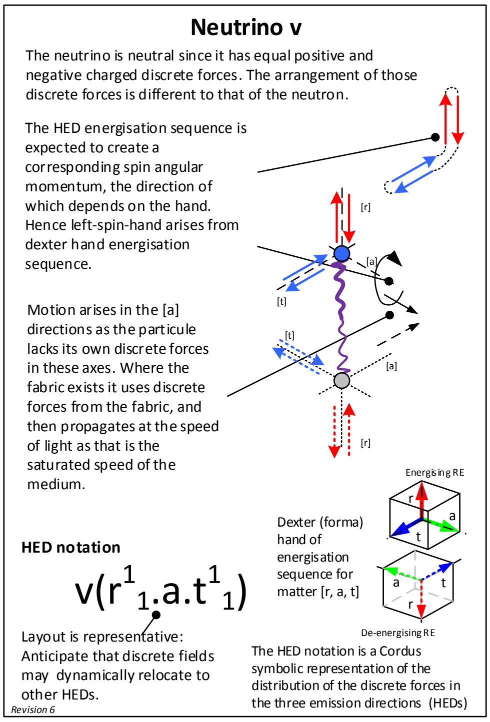

Figure 1: Predicted structure of the neutrino. From (Pons et al., 2014c), reproduced by permission.

Prior work has developed the Cordus theory to explain several features of matter, mass-energy equivalence, and decay. Explanations are available for much of the matter-production route including pair production & annihilation [27], asymmetrical genesis [28], the strong nuclear force [29], and the nuclides (H to Ne) [30]. The theory also offers a comprehensive explanation of the decay processes at the fundamental level. It explains the beta decay processes, including correctly predicting the outputs and giving an qualitative indication of the energy requirements [31]. The unstable exponential life of the free neutron, in contrast to the stability within the nucleus, is explained [3].

The theory uses a mechanics to represent the transformations of the discrete fields that occur in the decay process. This is called the HED (hyperfine fibril emission directions) mechanics. It is a method for examining how the discrete force structures of the particules change and are reassigned to new particule identities during the decay process. The Cordus theory proposes that the identity of a particule is determined by its emitted pattern of discrete forces. Interactions between particules, or within a particule in the decay situation, cause those discrete forces to be redistributed, and hence the identity of the emergent particules is also changed. The underlying principles of the HED mechanics are conservation of charge, conservation of matter-antimatter hand, and mass-energy equivalence. For further details of the HED mechanics see [31] [3]. See Table 1 for HED notations for various particules.

Symbol	Particule Identity	Cordus structure of discrete fields in HED notation	Comment
n	neutron	$n(r_1^1 .a_1^1 .t)$*	Shown for bound state, where * denotes overt part.

p	proton	$p(r^{1}_{1.1}.a_1.t_1)$*	* denotes overt part.
e	electron	$e(r^{1}.a^{1}.t^{1})$	
$\underline{e}$	antielectron	$\underline{e}(r_{\underline{1}}.a_{\underline{1}}.t_{\underline{1}})$	positron
v	neutrino	$v(r^{1}_{1}.a.t^{1}_{1})$	
$\underline{v}$	antineutrino	$\underline{v}(r_{\underline{1}}^{\underline{1}}.a.t_{\underline{1}}^{\underline{1}})$	
y	photon	$y(r^{\updownarrow}.a.t)$	$^{\updownarrow}$ denotes oscillating discrete force, extended and withdrawn
z	discrete force complex	$x_{\underline{1}.1}^{1.\underline{1}}$ or ↑↓ where ↑= $x_{\underline{1}}^{1}$ and ↓= $x_{1}^{\underline{1}}$.	x is one of the HED axes [r.a.t]
2y	a pair of photons	↑↑↑ = $[r_{\underline{1}}^{1}.a_{\underline{1}}^{1}.t_{\underline{1}}^{1}]$	corresponds to an electron-antielectron pair
i	quantity, e.g. of photons	-	

Table 1: Symbolic HED notation of various particules.

The HED mechanics have been applied to the decay process, and as already identified, successfully reproduce the conventional or *forward* decay processes: neutron decay β-, proton decay β+, and electron capture (EC) [31] [3]. The mechanics have also been applied to the *inverse* decays, i.e. those situations where a neutrino or antineutrino (hence *neutrino-species*) has been pre-supplied. The theory predicted that in certain situations the provision of the neutrino-species would induce the decay, i.e. accelerate the process [32]. Thus under this NLHV theoretical framework (a) input of neutrino-species can induce decay, as opposed to only being by-products after the event, and (b) neutrino-species interact asymmetrically with the proton and neutron. The present paper takes these neutrino-species induced-decay processes and applies them to the problem of variable decay rates for nuclides.

4 Results

4.1 Asymmetrical neutrino-species interactions with nucleons

The predicted inducements for β-, β+ and electron capture are summarised in Table 2, which is adapted from [32]. Note that z represents a charge- and hand-balanced pair of discrete forces, and is interpreted as an energy requirement. It is conceptually alike to quantum theory's *vacuum fluctuation*.

Decay family	Forward decays	Inverse decays: Neutrino v pre-supplied	Inverse decays: Antineutrino $\underline{v}$ pre-supplied
neutron decay	(β-) conventional neutron decay n => p + e + $\underline{v}$	(vβ-) Inducement to decay, no input energy required. n + v => p + e (Eqn 2)	($\underline{v}$β-) No inducement n + $\underline{v}$ + 2z => p + e + 2$\underline{v}$ (Eqn 3)
proton decay	(β+) conventional proton decay p + 2y => n + $\underline{e}$ + v	(vβ+) No inducement => p + v + 2y => n + $\underline{e}$ + 2v (Eqn 5)	($\underline{v}$β+) Inducement to decay, requires input energy (z): p + $\underline{v}$ + z => n + $\underline{e}$ + 2y (Eqn 6)

			Alternatively with input photons (4y): p + 2v̲ + 4y => e̲ + 6y + z (Eqn 7)
electron capture (EC)	p + e => n + v	(vpe) Inducement to decay, requires input energy (2z) p + e + v + 2z => n + 4y + v̲ (Eqn 10)	(v̲pe) Inducement to decay. One process needs no input energy (Eqn 11), and another does require input energy (z) (Eqn 12) p + e + v̲ => n + v + v̲ => n + 2z (Eqn 11) p + e + v̲ + z => n + 4y (Eqn 12)

Table 2: Input asymmetrical interactions between neutrino species and decay processes. Equation numbers as per [32], where derivations are also provided.

Specific predictions of this theory are:

1. β- neutron decay is predicted to:
    a. Be induced by input of neutrinos, but not antineutrinos,
    b. Not require input energy.
2. β+ proton decay is predicted to:
    a. Be induced by input antineutrinos rather than neutrinos,
    b. Require input energy.
3. EC is predicted to:
    a. Be induced by either species.
    b. Have multiple processes (or channels).
    c. Each process has different input energy requirements, which may be nil in the case of one of the antineutrino induced processes

4.2 Explanation for variable nuclide decay rates

The above result is interesting because of its relevance to the nuclide situation. The mechanics predict that an asymmetrical neutrino-species induced decay occurs for isolated nucleons. It is reasonable to expect that the effects will also apply, to some extent, to collections of multiple nucleons bound together, i.e. to the nuclides. Thus it is conceptually possible to envisage a mechanism whereby impacting neutrino-species would affect decay processes differently. In this framework the loading of neutrino-species would affect the decay rate. Also, the theory predicts that the processes require different levels of input energy, or none, and this plausibly corresponds to an energy threshold requirement for the nuclide.

Lemmas

A partial solution to the problem of variable decay rates of nuclides can therefore be anticipated. First, it is necessary to make some assumptions:

Lemma 1*: Let β- neutron decay be enhanced by input neutrino flux, as per Eqn 2, let β+ proton decay be enhanced by input antineutrinos as per Eqn 6 though with extra energy input, and let proton-electron capture (EC) be enhanced differently by input neutrinos (Eqn 10) and by antineutrinos (Eqn 11, 12) and be sensitive to input energy.*

This lemma has been covered in the body of this paper and supported in [32] and needs no further discussion.

Lemma 2*: Let these reactions, which have been derived for individual nucleons, apply also to the nucleus as a whole, but with different degrees of susceptibility depending on nuclide characteristics. Also let there be other factors, such as energy and density thresholds, that are specific to individual nuclides.*

It is apparent, from the empirical attributes of the table of nuclides, that the whole nuclide is more than the aggregation of its nucleons. Thus a nuclide that has twice as many nucleons as another will not necessary decay twice as fast. This is not contentious. Consequently it is reasonable to expect that if decay rates really are variable, then different nuclides may have different variability.

Lemma 3*: Let α emission have a different causation to β+, β-, and EC, and consequently a different susceptibility to inducement agents.*

This need not be contentious since α decay is a process where a sub-part of the nucleus is ejected, whereas the other decays occur at the level of individual nucleons. A separate part of the Cordus theory explains the nuclides (H to Ne) [30] and while that explanation does not yet extend to the heavy elements, it already shows that the internal structure of the nucleus can be explained as a loop of nucleons, hence *nuclear polymer*. Thus α emission is understood within the Cordus theory as the polymer pinching off a unit of two protons and two neutrons. The Cordus theory interprets this process as a *disassembly* of the nuclear polymer, rather than the *remanufacturing* that occurs with the other decays. It is easy to see why α emission would not be especially susceptible to neutrino-species: because the process does not require the addition or removal of discrete forces or handed structures. Consequently this theory expects that α emission will have different causes to β+, β-, and EC decays.

Lemma 4: *Assume that the Sun produces primarily neutrinos, and that the flux received on Earth varies with the annual season and (unidentified) generation processes within the Sun. Further assume that the neutrino production is not necessarily in phase with perihelion.*

This lemma is not contentious.

Application

These four simple lemmas are generally non-contentious, or at least plausible in terms of the Cordus theory. With these lemmas it is straightforward to explain why β- and EC would be enhanced and correlate to solar neutrino flux (proximity & activity), and α emission unaffected.

We have to rely on lemma 2 to take care of ^{137}Cs (β-), and lemma 3 for those few cases of α emission that do show periodicity. The solar flare data are too ambiguous to include. The contrary findings of {Norman, 2009 #517} are accommodated in lemma 4. The non-variability of ^{22}Na (β+) under artificial antineutrino loading is also potentially explained in terms of the energy barrier within Eqn 6.

There are several cases that are not immediately accommodated, such as the short periodicity effects, e.g. ^{3}H (β-). However the Cordus nuclear theory also shows that $_1H_2$ has an unusual structure quite unlike any of the other nuclides [30], so it is plausible that that it would behave very differently. The non-periodicity of ^{54}Mn (EC) under artificial antineutrino loading is problematic, though it might be explained as EC with antineutrinos (Eqn 12) having a greater threshold effect (lemma 2) than with neutrinos (Eqn 10).

5 Discussion

Outcomes

It is predicted that the β-, β+ and electron capture processes are induced by pre-supply of neutrino-species, and that the effects are asymmetrical for those species. Also predicted is that different input energies are required, i.e. that a threshold effect exists. The theory predicts that different decay types are affected differently by the input of energy and neutrino-species. Four simple non-contentious lemmas are proposed with which it is straightforward to explain why β- and EC would be enhanced and correlate to solar neutrino flux (proximity & activity), and α emission unaffected. It is shown that the concept of neutrino-species having asymmetrical interactions with the nucleus does makes sense of the broad patterns evident in the empirical data.

Implications

The results support the variability of decay rates, on theoretical grounds. Conventional physics interprets the decay processes to be independent of the external environment, hence constant half-lives. The present theory proposes that picture is too simple, and the constancy is only approximate.

The type of decay (β+, β-, EC, α) is found to be a key variable in this theory, as is the type of neutrino species and its energy. Past experiments have generally not recorded the variables sufficiently. At present the literature invariably reports, especially in abstracts and conclusions, only on the nuclides used, without identifying the decay process. The latter information is buried in the method, often to the point of obscurity. This is symptomatic of the belief that any inducement mechanism would affect all decays equally. Future empirical tests of nuclide decay rates need to be more specific about the decay path. The different decays have to be considered separately, not lumped together, nor classified primarily by element (e.g. U, Pb, Cl, etc.) but rather by type of decay process (β+, β-, EC, α). This is important as some of these nuclides decay by multiple different decay processes in series, and therefore these would be induced differently. It is also necessary to be more specific about the identity of the neutrino-species in the external environmental (neutrino vs. antineutrino), and both the energy and flux thereof. This is expected to be a challenging requirement given the practical difficulty of measuring these parameters.

Originality

The novel contribution is the provision of a theoretical explanation for why decay rates would be variable. A detailed mechanism is presented for neutrino-species induced decay. It shows that the concept of a neutrino-species asymmetry, based on a NLHV design, is able to make sense of the broad patterns evident in the empirical data. Another contribution is the identification that *type of decay* (β-, β+, EC, α) is likely a more important parameter than the nuclide. In contrast the conventional perspective is that either all decay rates will be variable, or none. The idea of variable decay rates is not new, but the present contribution is the provision of a specific and detailed mechanism for neutrino-species induced decay. Also novel is the prediction that the interaction is asymmetrical to the type of inducement (v, $\underline{v}$), and that the energy requirements are different for the various types of decay (β-, β+, EC). The explanation is qualitatively consistent with the empirical evidence.

An ontological contribution is also made in showing that hidden-variable theories in general, or at least the Cordus theory in particular, offer profoundly new perspectives on fundamental physics, and can explain complex phenomena that are inconceivable from within the zero-dimensional point framework of quantum theory.

Limitations and opportunities for falsification

This theory is unorthodox, as already acknowledged, but that is a feature rather than a limitation. Taken together with the other Cordus papers, all of which are logically consistent with each other, shows that the principle can explain a wide range of physical phenomena. This does not prove the theory, but it does show that this candidate new physics has explanatory power and good external construct validity.

The induced decay processes, as predicted in [32] and used here, are theoretical predictions rather than verified facts. The theory is specific in its predictions, see Table 1, and thereby makes many falsifiable predictions. Many of these could be within the range of empirical testing now or in in the future, and hence a means exists whereby the veracity of this theoretical development may be tested and the proposals falsified.

There are also many opportunities for further theoretical development. The above decay processes have been predicted for individual nucleons rather than the more complex situation of the nucleus. Hence there is a need to better understand how the decay of the nucleon occurs in the context of the nucleus as a whole. This is a formidable challenge as the structure of the atomic nucleus is unknown, and few if any of the features of the table of nuclides can be explained adequately with conventional theories or models. The only extant theory that can explain the stability – instability - non-existence of the nuclides (H to Ne) is the Cordus theory [30]. It does this by proposing that the nucleus comprises a polymer of nucleons, with the nucleons having the two-ended Cordus structure. The stability of any one nucleon therefore appears to be a function of what type of bonds connect it to its neighbours, and where it is in the overall polymer shape. A useful research question would be to develop a mathematical formalism of this structure, for the purpose of delivering a quantitative explanation of nuclide lifetimes and for testing the neutrino-species perturbation proposed here. Other research could be directed to applying the HED mechanics to different situations. For example, in a parallel development to the present paper it has already been used to yield a solution to the problem of genesis asymmetry [28].

Contrast with existing explanations

The conventional perspective is that the neutrino-species are merely outputs of the β- and β+ processes. Even so, quantum theory cannot explain why the neutrino-species should exist, or how they emerge from the nucleon. This limitation is partly a consequence of the assumption that particles comprise 0-D points, a premise that makes it irrelevant to ask why or how the neutrino-species engage with the nucleon. In contrast the Cordus theory proposes that particles do have internal structure, explains why the neutrino-species is emitted at the forward decays, then deduces that the neutrino-species have an active but asymmetrical causal role in the induced decay process, hence that decay rates ought not to be strictly constant. Specific predictions are made that are testable and falsifiable.

6 Conclusions

A candidate theoretical explanation of the variability of nuclide decay rates is provided, starting from the Cordus theory, which is a candidate non-local hidden-variable solution based in physical realism. The theory identifies the variables that would affect decay under this framework, these variables being type of decay (β+, β-, EC, α), provision at the input stage of a neutrino or antineutrino, and the amount of input energy required (assessed qualitatively). The theory also provides a mechanics that explains how these variables interact to cause different decay processes.

The theory predicts that the β-, β+ and electron capture processes may be induced by pre-supply of neutrino-species, and that the effects are asymmetrical for those species. Also predicted is that different input energies are required, i.e. that a threshold effect exists. Four simple non-contentious lemmas are proposed with which it is straightforward to explain why β- and EC would be enhanced and correlate to solar neutrino flux (proximity & activity), and α emission unaffected. It is shown that the concept of a neutrino-species asymmetry does make sense of the broad patterns evident in the empirical data. The results find against the constancy of decay rates, on theoretical grounds, and show that and there is a plausible theory whereby the variability can be explained.

Graphical summary

An overall summary of the theory is shown in Figure 2, represented in systems engineering notation [33].

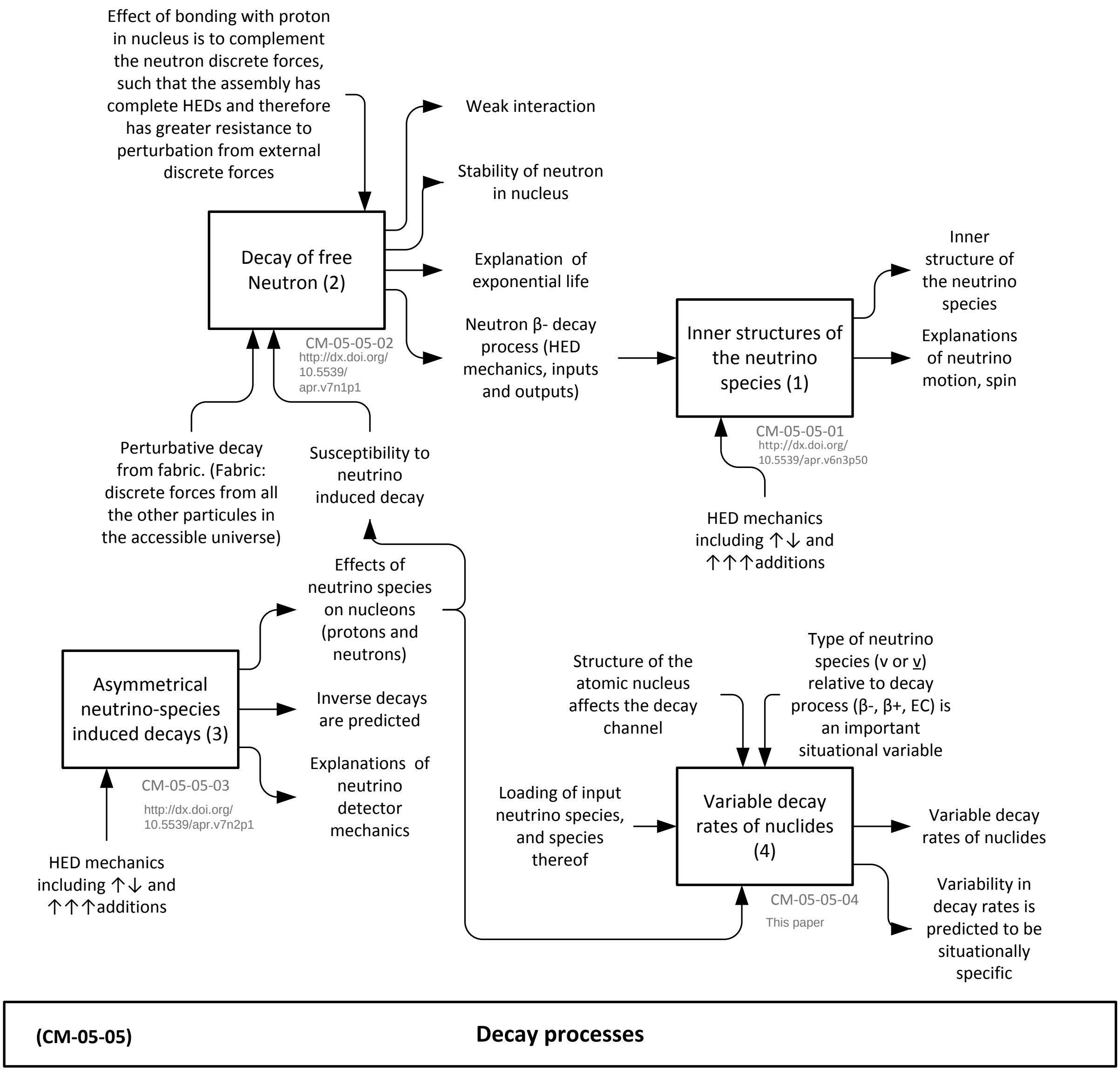

Figure 2: Graphical summary of the theory.

Author Contributions

All authors contributed to the creation of the underlying concept, development of the ideas, and editing of the paper.

Conflict of interest statement

The authors declare that there is no conflict of interests regarding the publication of this article. The research was conducted without personal financial benefit from any third party funding body, nor did any such body influence the execution of the work.

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