The decays of heavy nuclei as support for nuclear string model

March 8, 2021

Matti Pitkänen

Email: matpitka6@gmail.com.
http://tgdtheory.com/public_html/.
Recent postal address: Rinnekatu 2-4 A 8, 03620, Karkkila, Finland.

Abstract

That final state nuclei from the fission of heavy nuclei possess a rather high spin has been known since the discovery of nuclear fission 80 years ago but has remained poorly understood.

The recent surprising finding was that the final state angular momenta for the final state nuclei are uncorrelated and must therefore emerge after the decays. This represents a challenge for TGD inspired model of nuclei as nuclear strings, and one ends up to a rather detailed model for what happens in the fissions.

The TGD proposal is that the generation of angular momentum is a kind of self-organization process. Zero energy ontology (ZEO) and h_{eff} hierarchy indeed predicts self-organization in all scales. Self-organization involves energy feed needed to increase $h_{eff}/h_0 = n$ serving as a measure for algebraic complexity and as a kind of universal IQ in the number theoretical vision about cognition based on adelic physics.

The observation that the final state nuclei have angular momenta $6-7$ $\hbar$ suggests that self-organization increase the values of h_{eff} to nh, $n \in \{6,7\}$. Quantization of angular momentum with new unit of spin forces the generation of large spins. Also zero energy ontology (ZEO) is involved: ZEO provides a new element to the description of self-organization and a model for quantum tunnelling phenomenon.

Contents

1 Introduction

Nuclear string model is more than20 years ago old applicationof TGD [K2]. The model identifies nuclei as string-like objects i.e. flux tubes carrying nucleons represented as space-time sheets topologically condensed at the larger flux tube. Nucleon space-time sheets are also connected by short flux fube bonds carrying quark and antiquark and having total quantum numbers of a pion or ρ meson. The model has several variants but is surprisingly successful. The basic prediction is that nuclear reactions and decays should have a topological description based on reconnection as basic reaction vertex.

I encountered a highly interesting link to a popular article (`https://cutt.ly/XlLnNB5`) to a work of a large international research group studying the fission of heavy nuclei. The article "*Angular momentum generation in nuclear fission*" [C1] (`https://cutt.ly/hlLn86c`) by Wilson et al reporting the research findings is published in Nature (February 24). Unfortunately, the article is behind the paywall.

The work involved studying the fragments that resulted from fission of several types of unstable elements, such as uranium-238 and thorium-232. That the final state nuclei from the fission of heavy nuclei possess a rather high spin has been known since the discovery of nuclear fission 80 years ago but has remained poorly understood.

The recent surprising finding was that the final state angular momenta for the final state nuclei are uncorrelated and must therefore emerge after the decays. This represents a challenge for TGD inspired model of nuclei as nuclear strings, and one ends up to a rather detailed model for what happens in the fissions.

Also other other elements of the new physics predicted by TGD are involved. The first element is the identification of dark matter as phases of ordinary matter labelled by effective Planck constant [K1] $h_{eff}/h_0 = n$, ($h = 6h_0$ [L2]), with n identified as the dimension of extension of rationals determined by the degree of a polynomial characterizing a given region of the space-time surface by $M^8 - H$ duality [L13, L14]. Also zero energy ontology (ZEO) [L12] is involved: ZEO provides a new element to the description of self-organization [L10] and a model for quantum tunnelling phenomenon as a pair of BSFRs with the time-reversed period between them identified as tunneling period.

The first guess was that flux tubes, which have much longer length than nuclear size, could explain the mysterious finding that in nuclear decay the fragments manage to generate their angular momenta after the reaction: the flux tubes would make possible the exchange of angular momentum required by angular momentum conservation. The prediction would be that the flux fragments have opposite angular moment but the discovery was that they angular momenta are independent.

A more realistic guess is that the nuclear flux tubes themselves correspond to MB and that the generation of angular momentum is a kind of self-organization process - something usually not expected to be possible at the level of nuclear physics.

1. Zero energy ontology (ZEO) and h_{eff} hierarchy indeed predicts self-organization in all scales [L10] and time reversal plays a key role in this process: dissipation with a reversed arrow of time looks like self-organization for an observer with the standard arrow of time.

2. Self-organization involves energy feed needed to increase $h_{eff}/h_0 = n$ serving as a measure for algebraic complexity and as a kind of universal IQ in the number theoretical vision about cognition based on adelic physics [L5, L6]. The energy feed would be from the vibrational excitations of the flux tube to the rotational degrees of freedom.

3. The observation that the final state nuclei have angular momenta $6 - 7$ $\hbar$ suggests that self-organization increases the value of h_{eff} to nh, $n \in \{6, 7\}$. The quantization of angular momentum with unit $\hbar_{eff}$ forces the rotation.

2 TGD based model for the scission of heavy nuclei

In TGD nuclei are modelled as closed nuclear strings [K2]. The counterpart for an elongated nucleus would be a loop looking like a highly flattened square, possibly having helical linking making it a helical knot. This suggests a description of the scission as a reconnection of the flux tube - in the approximation of the flux tube as a closed string this would be basic string vertex.

Also the analogy with DNA is useful. In TGD Universe DNA [L7, L22, L20, L21, L18] and also other basic information molecules are accompanied by flux tubes carrying dark protons (ordinary protons with $h_{eff} = nh_0 > h$) controlling them: dark means that the protons at the flux tubes. The elongation of the nucleus could be analogous to the process of DNA unfolding.

The opening of the helical DNA double strand in transcription forces the rotation of DNA: same would happen for the nuclei. If the value of h_{eff} as a unit of angular momentum increases to say $h_{eff} = 6h$, the torque generating the rotation is necessary to realize minimal non-vanishing value of angular momentum.

2.1 Findings

The fragments resulting in the scission of heavy nuclei possess relatively high rotational angular momenta, which are typically 6-7 using $\hbar$ as a unit. Why the nuclei should have so large angular momenta looks like a mystery. There are many theories for how this angular momentum is generated. The natural guess is that the angular momentum is possessed by the fragments already before the scission. This predicts that the fragmentshave opposite angular momenta.

The recent experiments [C1] studying the gamma ray spectrum emitted by the nuclei convincingly demonstrate that the angular momenta for the fragments are independent and therefore must be generated after the scission. This looks very strange from the point of view of angular momentum conservation.

What comes first in mind is that the gamma ray emission takes care of angular momentum conservation. The generation of angular momenta is however analogous to a self-organization process and in standard physics framework it looks strange that this would take place for nuclei.

The classical model proposed by the experimenters relies on an analogy with a rubber band. The nuclei resulting in the splitting of heavy nuclei to two parts are proposed to be highly elongated before the scission.

In the splitting of a rubber band the resulting ends of the rubber band generate opposite torques giving them angular momenta. The energy liberated as the fragment returns from an excited state to an approximately spherical shape would be transferred to rotational energy. Here the proposed analogy is soap bubble with surface tension and pressure difference determining its dynamics: minimal energy corresponds to a spherical shape. The emission of gamma rays would take care of the conservation of the angular momentum.

Elongation makes possible the scission (on could also compare the decay to a decay of water droplet). What could be the mechanism of the elongation?

2.2 Nuclear string model briefly

TGD based description of nuclei is as nuclear strings containing nucleons along string [K2]. Nucleons from sequences at the magnetic flux tube so that a string like object is in question. Rubber band is indeed analogous to a string.

1. Nucleons correspond to space-time sheets topologically condensed at magnetic flux tube and connected by flux tube bonds representing scaled down pion or ρ meson quantum numbersexcept that the mass is p-adically scaled down to MeV range.

2. There are three options for what nuclear string could mean:

   (a) Neutrons and protons from separate nuclear strings and the flux tube bonds correspond to neutral pionor ρ. Thiswould conform with the treatmentof protons and neutrons in the nuclear shell model.

   (b) Protons and neutrons reside at the same flux tube.

   (c) Neutronlike space-time sheets are not actually ordinary neutrons but correspond to a proton + negatively charged pion-like flux tube bond connecting protons together.

   One can also consider the possibility that there are several closed linked and knotted loops present in the nucleus. Reconnections between the loops could generate knotting and linking. For instance, alpha particle could correspond to such a loop.

3. The analogy with strings suggests as the first guess a correlation between masses and angular momenta of the fragments idealized by the mass formula $J = kM^2$. Here k would be determined by the nuclear string tension.

4. Nuclear reactions would proceed by reconnection of flux tubes which for ideal closed strings define the basic vertex. Same applies to nuclear decays. A closed loop representing say alpha particle would be emitted via a reconnection process.

2.3 Nuclear string model for scission

Consider now the scission of heavy nuclei in this framework.

1. Suppose that in standard configuration nuclear strings are flux tube tangles - kind of flux tube spaghettis. This would correspond to the analogy with a bee nest used in the popular article. The Universe of the TGD is fractal and flux tubes appear in all scales. Galaxies, stars, planets, etc would involve flux tube tangles. Even DNA and other linear bio-molecules would involve flux tubes.

   A flux tube as a volume filling spaghetti is an object analogous to blackhole-like. Since the thickness of the flux tube can vary having values determined by p-adic length scale hypothesis, a hierarchy of blackhole-like entities are predicted [L9]. Ordinary blackholes would have flux tube thickness equal to proton Compton length and consist of nuclear strings. Also stars could be analogous to blackholes. In the case of Sun the thickness of the flux tube would be of order electron Compton length [**?**, L11].

   Also nuclei would be analogous to mini blackholes. If they are volume filling, the reconnections could occur all the time and the topology would be highly dynamical involving changes of knottedness and decay to disjoint and linked knots.

Consider first the decay of the nucleus in the general case.

1. In the general case, the flux tube spaghetti is knotted. How can the decay to two separate tangles proceed? An arbitrary reconnection does not lead to two separate sub-tangles but changes only the knotting and linking. Even if this happens, the subtangles remain knotted and linked and the decay is not possible without further reconnections.

   If the nucleus manages to evolve by reconnections to two mutually unknotted and unlinked sub-knots, the situation changes. The nucleus would decompose to 2 sub-knots connected by a pair of parallel closely spaced flux tubes for which the reconnection can take place and yield two final state nuclei. A decomposition into a connected sum of two knots would precede the decay in the general case.

2. The hypothesized elongated nucleus could correspond to a more specific situation. A maximally elongated nucleus would correspond to an opened flux loop with a shape of say flattened square. The flux loop could also be helical and stability might favor this. Rubber band analogy would be therefore justified. The scission would correspond to the splitting of this flux loop by reconnection. It is however enough to assume the formation of two separate knots connected by pair of parallel flux tubes close to each other.

The generation of the rotational angular momentum after the decay would correspond to a generation of a rotation of the flux tube as a string-like entity. A helical configuration analogous to DNA double strand is highly suggestive. The elongated nucleus would correspond to this kind of configuration.

The splitting would kick the stringy flux tube to an excited state. The liberated energy would generate the rotational motion. Why the motion would be collective rotation is not at all obvious.

The emission of gamma rays having spin would take care of angular momentum conservation. This however requires that gamma rays tend to have parallel spins. It is not obvious why this should be the case.

2.3.1 DNA opening as analogue for the scission process

Why the fragments generate angular momenta? Flux tubes appear in all scales in TGD Universe. In particular, the TGD based model for DNA invovles besides ordinary DNA strand also dark DNA strand parallel to it and identifed as a magnetic flux tube carrying dark proton sequence [L7, L22]. Genetic code is realized for dark DNA as dark proton triplets: this realization involves only protons and codons are entangled 3 proton states which do not allow reduction to letters. These dark proton sequences can be regarded as dark nuclei. The nuclear realization of the genetic code would be the fundamental one and the chemical realization would be kind of mimicry.

The model predicts also the dark counterparts of RNA, amino-acids and tRNA as dark proton triplets. One cannot completely exclude the possibility that the genetic code is realized already at the level of ordinary nuclei. This motivates the question whether the opening of the ordinary DNA double strand controlled by dark DNA strand might provide a useful analogy for understanding what happens in the scission.

1. The opening of DNA double strand in the replication or transcription must eliminated the helical linking of strands to give pair of parallel straight strands so that the replication can take place. The opening requires the rotation of strands and generates angular momentum.

2. Could the parallel flux tube portions form an analog of DNA double strand? Amusingly, the spin and isospin states of nucleon give rise to 4 states so that 3 nucleons would form analogs of genetic codons. The "dark" realization as entangled 3-nucleon states is however more plausible.

   DNA/protein unfolding as a self-organiation process is a biological analog for the step leading to an elongated state. The return to the highly tangled state after reaction would be analougs to DNA/protein folding.

2.3.2 Does non-standard value of h_{eff} explain the values of final state angular momenta?

One should also understand the large angular momenta of the final state nuclei and why these values are around $6\hbar$.

1. The intermediate state in the first BSFR would correspond to a dark nucleus having $h_{eff} = nh_0 > h = 6h_0$. This could be true also after BSFR and the angular momentum could be reduced to its standard value in the final state. This suggests that the angular momentum is quantized with $\hbar_{eff}$ as unit.

2. The observation that the angular momenta are around $6h$ suggests that in the final state one has $\hbar_{eff} = Nh$: $N \in \{6, 7\}$. This would explain why the rotational angular momentum must be generated.

   In standard quantum theory it is very difficult to understand why the emitted ordinary gamma rays could have correlated spins so that the total spin would be N units. If the emitted dark gamma rays are dark they would have angular momentum unit $\hbar_{eff} = N\hbar$ and would decay to ordinary gamma rays.

3. A connection with the notion of dark 3N-protons and 3N-photons of TGD inspired quantum biology [L7, L16, L18] is highly suggestivbe. Dark 3N-protons would be cyclotron condensates analogous to nucleons as color triplets behaving like a single particle. 3N-photons would be analogous to Bose-Einstein condensates of 3N photons [L20, L21]. The mechanism leading to these states would be Galois confinement possible in TGD framework [L3, L17, L19].

4. Since the energies of quantum states quite generally increase with h_{eff}, the increase of h_{eff} would require a "metabolic energy" feed. The excitation of the stringy degrees of freedom could provide this energy and transform to rotational energy. One could think that in the scission the flux tube as string is heated to high temperature and this energy is liberated to collective rotational motion. The minimal value of the angular momentum would be $\hbar_{eff} = N\hbar$ and would force coherent rotation.

2.3.3 ZEO based view about scission

It is also interesting to consider the description of the scission process could be in zero energy ontology (ZEO) [L12].

1. Quite generally, tunnelling phenomenon in nuclear reactions could correspond to a pair of "big state function reductions" (BSFRs) [L11]. BSFR is the counterpart of the ordinary SFR and changes the arrow of time [L12, L19]. The intermediate period with an opposite arrow of time would correspond to the tunnelling in nuclear reactions.

   This model emerged from a model "cold fusion" as nuclear reactions for dark nuclei with protons and neutrons having nonstandard value of h_{eff} increasing their Compton lengths [L1, L4, L15, **?**].

2. When the state of the system is near the threshold for scission, the system is quantum critical and experiences long scale quantum fluctuations with varying balue of h_{eff}. Given fluctuation increases the Compton radius of nucleons by factor $h_{eff}/h = n/6$. Nuclear string would be scaled up in size. This might be true even for ordinary nuclear reactions. Nuclear binding energies would be scaled down like $1/h_{eff}$. After the second BSFR, h_{eff} would return to the original value, perhaps in a stepwise manner.

3. The decay process leading to an elongated nucleus as an intermediate state could emerge in the first BSFR leading instantaneously to the elongated state. In ZEO quantum states are superpositions of classical time evolutions and at the classical level this looks to an observer with a standard arrow of time classically like a deterministic time evolution leading from a roughly spherical initial to a highly elongated state. This interpretation explains the strange looking findings of Minev et al for state function reductions in an atomic system [L8] [L8].

   The state to which the classical time evolutions of the superposition apparently lead would correspond to the elongated nucleus. Actually it would be the initial state of the time reversed time evolution. The classical model of the authors would describe this period.

4. Second BSFR would re-establish the original time direction and correspond to the splitting of the elongated state to fragments in the manner already described.

REFERENCES

Theoretical Physics

[B1] Minev ZK et al. To catch and reverse a quantum jump mid-flight, 2019. Available at: `https://arxiv.org/abs/1803.00545`.

Particle and Nuclear Physics

[C1] [...]Ziliani S Wilson JN, Thisse D. Angular momentum generation in nuclear fission. *Nature*, 590:566–570, 2021. Available at: `https://www.nature.com/articles/s41586-021-03304-w`.

Books related to TGD

[K1] Pitkänen M. Criticality and dark matter. In *Hyper-finite Factors and Dark Matter Hierarchy.* Available at: `http://tgdtheory.fi/pdfpool/qcritdark.pdf`, 2019.

[K2] Pitkänen M. Nuclear String Hypothesis. In *Hyper-finite Factors and Dark Matter Hierarchy: Part II.* Available at: `http://tgdtheory.fi/pdfpool/nuclstring.pdf`, 2019.

Articles about TGD

[L1] Pitkänen M. Cold Fusion Again . Available at: http://tgdtheory.fi/public_html/articles/cfagain.pdf., 2015.

[L2] Pitkänen M. Hydrinos again. Available at: http://tgdtheory.fi/public_html/articles/Millsagain.pdf., 2016.

[L3] Pitkänen M. About $h_{eff}/h = n$ as the number of sheets of space-time surface as Galois covering. Available at: http://tgdtheory.fi/public_html/articles/Galoisext.pdf., 2017.

[L4] Pitkänen M. Cold fusion, low energy nuclear reactions, or dark nuclear synthesis? Available at: http://tgdtheory.fi/public_html/articles/krivit.pdf., 2017.

[L5] Pitkänen M. Philosophy of Adelic Physics. In *Trends and Mathematical Methods in Interdisciplinary Mathematical Sciences*, pages 241–319. Springer.Available at: https://link.springer.com/chapter/10.1007/978-3-319-55612-3_11, 2017.

[L6] Pitkänen M. Philosophy of Adelic Physics. Available at: http://tgdtheory.fi/public_html/articles/adelephysics.pdf., 2017.

[L7] Pitkänen M. An overall view about models of genetic code and bio-harmony. Available at: http://tgdtheory.fi/public_html/articles/gcharm.pdf., 2019.

[L8] Pitkänen M. Copenhagen interpretation dead: long live ZEO based quantum measurement theory! Available at: http://tgdtheory.fi/public_html/articles/Bohrdead.pdf., 2019.

[L9] Pitkänen M. Cosmic string model for the formation of galaxies and stars. Available at: http://tgdtheory.fi/public_html/articles/galaxystars.pdf., 2019.

[L10] Pitkänen M. Quantum self-organization by h_{eff} changing phase transitions. Available at: http://tgdtheory.fi/public_html/articles/heffselforg.pdf., 2019.

[L11] Pitkänen M. Solar Metallicity Problem from TGD Perspective. Available at: http://tgdtheory.fi/public_html/articles/darkcore.pdf., 2019.

[L12] Pitkänen M. Some comments related to Zero Energy Ontology (ZEO). Available at: http://tgdtheory.fi/public_html/articles/zeoquestions.pdf., 2019.

[L13] Pitkänen M. A critical re-examination of $M^8 - H$ duality hypothesis: part I. Available at: http://tgdtheory.fi/public_html/articles/M8H1.pdf., 2020.

[L14] Pitkänen M. A critical re-examination of $M^8 - H$ duality hypothesis: part II. Available at: http://tgdtheory.fi/public_html/articles/M8H2.pdf., 2020.

[L15] Pitkänen M. Could TGD provide new solutions to the energy problem? Available at: http://tgdtheory.fi/public_html/articles/proposal.pdf., 2020.

[L16] Pitkänen M. How to compose beautiful music of light in bio-harmony? https://tgdtheory.fi/public_html/articles/bioharmony2020.pdf., 2020.

[L17] Pitkänen M. The dynamics of SSFRs as quantum measurement cascades in the group algebra of Galois group. Available at: http://tgdtheory.fi/public_html/articles/SSFRGalois.pdf., 2020.

[L18] Pitkänen M. Is genetic code part of fundamental physics in TGD framework? Available at: https://tgdtheory.fi/public_html/articles/TIH.pdf., 2021.

[L19] Pitkänen M. Negentropy Maximization Principle and Second Law. Available at: https://tgdtheory.fi/public_html/articles/nmpsecondlaw.pdf., 2021.

[L20] Pitkänen M and Rastmanesh R. New Physics View about Language: part I. Available at: http://tgdtheory.fi/public_html/articles/languageTGD1.pdf., 2020.

[L21] Pitkänen M and Rastmanesh R. New Physics View about Language: part II. Available at: http://tgdtheory.fi/public_html/articles/languageTGD2.pdf., 2020.

[L22] Pitkänen M and Rastmanesh R. The based view about dark matter at the level of molecular biology. Available at: http://tgdtheory.fi/public_html/articles/darkchemi.pdf., 2020.