Symmetry Breaking by Electric Discharges in Water and Formation of Light Magnetic Monopoles in an Extended Standard Model (Part I)

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By Lochak (theory) and Urutskoev (experiment) the hypothesis has been suggested that during electric discharges in water (fluids) light magnetic monopoles can be created which according to Lochak should be considered as a kind of excited neutrinos. Based on a quantum field theoretic development of de Broglie's and Heisenberg's fusion ideas and the results of preceding papers a transparent proof is given that such magnetic monopoles can occur during discharges. In the theoretical description these circumstances are formulated within the scope of an extended (effective) Standard Model and the monopoles with vanishing electric charge arise from neutrinos whose states are modified by the symmetry breaking caused by the discharge. In the introduction some technical implications are referred to. The article is divided into two parts.

Key words: Supersonic Spark Discharges in Water; Nuclear Transmutations

1. Introduction

In the past decade electric discharges in fluids were reported by Urutskoev et al. which obviously induce low energy nuclear reactions, in particular nuclear transmutations [1 – 4]. These experiments were repeatedly confirmed by various groups and carefully analyzed [4]. But they could not be explained in conventional theory [4].

1.1. Extension of the Conventional Standard Model

Therefore it was speculated that low energy nuclear transmutations might be triggered by low mass magnetic monopoles by analogy with the catalysis of proton decay in high energy physics by (hypothetical) heavy magnetic monopoles [4, 5].

However, the heavy non-Abelian (topological) monopoles do not seem to be very suitable for physical applications. They are too heavy for playing any role in the present day accessible energy ranges, their constructions are based only on approximate solutions of the associated field equations [6], and their topological stability [7] might be rather inconvenient considering them as possibly transient phenomena. A straightforward transfer of the catalysis idea to low mass magnetic monopoles and to low energy phenomena therefore seems not to be desirable and should not be attempted for mathematical reasons.

A more economical and physically reasonable way of treating magnetic monopoles was pioneered by Lochak. Twenty years ago Lochak showed that massless Dirac fermions can couple to magnetic vector potentials and can in this way reveal their magnetic monopole property [8 – 10]. As neutrinos have small masses and do not show strong magnetic interactions with matter, Lochak's massless fermionic magnetic monopoles cannot be directly identified with them. Softening the zero mass condition Lochak thus proposed his fermionic monopoles to be identical with excited neutrinos [11, 12].

Such an assumption has an immediate consequence: As point particles cannot be internally excited, the magnetically excited neutrinos must be composites. This is in accordance with another discovery by Lochak. After having formulated his equation for massless (light) magnetic monopoles, he showed that from de Broglie's photon theory either electric photons or magnetic photons can be derived, both of which are composed of two fermions [13]. Therefore in the discussion of monopole phenomena the application of de Broglie's fusion idea [14] should or even must be included.

Furthermore in electrodynamics the fields of electric and magnetic bosons are linked by duality transformations which forestall the independence of these bosons and their associated charges [15]. But in contrast, non-

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Abelian theories, in general, do not admit selfduality [16]. So in that case electric charges and magnetic charges and their associated bosons should be truly independent physical quantities. This is of great importance because photons are represented by mixtures of $U(1)$ and $SU(2)$ fields in the Standard Model and thus the inclusion of the weak isospin is unavoidable. The extension of de Broglie's fusion idea to the full electroweak theory is therefore imperative.

As in de Broglie's photon theory magnetic and electric photon states cannot exist simultaneaously and the whole theory only refers to single composite particle states [17]. The theoretical formalism of de Broglie's fusion idea must be generalized. In this way a field theoretic version of de Broglie's and Lochak's discoveries is required which should lead to an extended electroweak Standard Model as an effective theory for electric and magnetic electroweak bosons as well as for fermions. This was advocated by Lochak [18].

To treat these problems we use a model which is based on a relativistically invariant nonlinear spinor field theory with local interaction, canonical quantization, selfregularization, and probability interpretation [19]. This model implies that in the sense of de Broglie and of Heisenberg the present 'elementary' particles are assumed to possess a fermionic substructure. The model is expounded in detail in [17] and [19, 20]. It allows to perform nonperturbative calculations and its mathematical treatment is in accordance with the basic ideas of the (nonperturbative) algebraic representation theory of quantum fields. In this approach the Standard Model is considered as an effective theory derived by weak mapping theorems [20], which implies the chance to study processes beyond the conventional Standard Model.

By purely theoretical reasoning it was demonstrated in [21] that in the spinor field model electric and magnetic electroweak boson states can coexist if the CP-symmetry of the vacuum is violated. These findings are in accordance with the phenomenological observation that the existence of magnetic monopoles and dyons implies CP-symmetry breaking [22 – 24], and it was shown in a preceding paper, that the formal way of theoretical symmetry breaking in [21] reflects the experimental situation mathematically [25]. As monopoles are to be identified by their fields, the analysis of fields generated by symmetry breaking is a first step in the investigation of a possible extension of the (effective) Standard Model. *Again like in the case of the derivation of the effective dynamics by weak mappimg for conserved symmetries, the calculations for symmetry breaking must be done nonperturbatively as otherwise no meaningful results can be obtained.*

It is interesting to note that this field theoretic symmetry breaking has a mathematical counterpart: In the algebraic formulation of quantum field theory the behaviour of a system can be expressed by an infinite set of inequivalent representations which are generated by an infinite set of inequivalent vacuum states [26]. This algebraic method has been successfully applied in quantum field theory of solids. There the various groundstates of matter constitute the set of inequivalent vacuum states, generated by different symmetry properties of the system [27 – 29]. The algebraic treatment frequently leads to a completely different behaviour of a system with broken symmetry compared with that of the corresponding system with conserved symmetry, a result which cannot be obtained by application of the (quantum mechanical) Fock-representation ([30], Sect. 1e).

In the above mentioned model the method of introducing CP-violation is completely different from the corresponding method in the conventional theory. In consequence of this difference of the methods, the results differ considerably, too. While the formal phenomenological method of the Standard Model is to explain the decay of K-mesons [31], due to the new vacuum the algebraic method applied to the above model leads to a completely new formulation and structure of the whole theory.

For our calculations a good understanding of the conventional experience and results of discharge research and the influence of symmetry breaking on electroweak processes is necessary. For brevity these topics are treated with numerous quotations from literature in Section 2 and 3. The Section 3 of Part I and Sections 1 and 2 of Part II published separateely are partly based on the results of preceding papers [21, 25, 32, 33] and it is unavoidable that for brevity we have to refer to the results obtained in these papers without giving renewed deductions.

In Section 2 of Part II, we treat the problem whether within the scope of an extended Standard Model the appearance of magnetic monopoles can be proved. For this search I also refer to the papers [19] and [20]. Although the wave functions of the excited neutrinos are not known to the last detail, the essential points of a proof of the existence of a neutrino-like magnetic monopol with zero electric charge can be outlined in this section.

1.2. Technical Implications of Magnetic Monopoles

In Part II, Equation (52), it will be shown that the magnetic charge of the monopol is proportional to $(r_\nu^*)^{-1/2}$ where r_ν^* is the radius of the neutrino substructure. Assuming for this radius the experimental limit of the lepton extension of 10^{-16} cm, the magnetic charge must have a very large value which could strongly influence all processes in the surrounding of the monopol. In literature the appearence of magnetic monopoles is frequently referred to as 'strange radiation' and the proof of their existence might be helpful in elucidating the reason for the failure of industrial equipments at emergency situations.

Reexamining the course of the accident at Chernobyl, Urutskoev et al. came to the conclusion that the official version *"about the origin of the explosion of the Chernobyl nuclear power plant (CNPP) is shown to contradict significantly the experimental facts available from the accident. The period of reactor runaway in the accident is shown to be unexplainable in the framework of the existing physical models of nuclear fission reactor. A hypothesis is suggested for a possible magnetic mechanism, which may be responsible for the rise-up of the reactor reactivity coefficient at the fourth power generating unit of CNPP in the course of testing the turbine generator by letting it run under its own momentum"* [34].

By performing discharge experiments in the laboratory Urutskoev et al. discovered similarities between the explosion process at CNPP and their experiments which strengthened their opinion that in these processes magnetic monopoles play an essential role [35]. A list of other possible effects induced by magnetic monopoles is given in [36].

Of particular technical interest concerning intentional and unintentional discharges is the action at distance transmitted by magnetic monopoles. This was concluded from the CNPP accident and assumed to be responsible for the chemical explosion catastrophe AZF in Toulouse which were simulated by Urutskoev in experiments afterwards ([36] Sect. 4.2a), too.

2. Supersonic Spark Discharges in Water

The experimental standard arrangement of Urutskoev [4], is enclosed in a cylindrical hollow steelcase which contains the electrical equipment for the discharge. The inner wall of the hollow steelcase is of polyethilen. Within this container the concentrical, cylindrical electrodes are located. The external electrode (cathode) is formed by the outer hollow cylinder while the inner hollow cylinder acts as the inner electrode (anode). (In various experiments the form of the anode etc. is modified which does not essentially influence the results.)

The interior of the steelcase is filled with highly purified water including the hollow cylinders of the electrodes. The geometrical data are: the diameter of the external electrode is 12 mm, the diameter of the inner electrode 6 mm, the high of the cylinder 50 mm, the diameter of the inner wall 20 mm, and the volumen filled with water 14 – 18 cm^3. In terms of charges the electric energy of the capacitor is given by $W^{\mathrm{e}} = 50$ kJ, and can be expressed by $W^{\mathrm{e}} = 1/2(U_1 - U_2)Q$ with $(U_1 - U_2) = 5$ kV [4].

For the number of electrons N_{e} one gets with $Q = N_{\mathrm{e}}e$ the value $N_{\mathrm{e}} = 1.25 \times 10^{20}$. This number of electrons is required for charge compensation during the discharge. If the decline of the tension of the capacitor during the discharge is neglected, the mean kinetic energy of the electrons is 5 keV.

The investigation of discharges was started in the early 1900s by J. S. Townsend publishing his now classical theory about the mechanism of spark discharge (in gases) on the basis of measurements made at high values of E/p, the ratio of field strength to pressure, and low values of pd, the product of pressure and gaplength [37]. As for water in its various phases the physical behaviour can be described by the van der Waal's equation. i. e. a gas equation, it seems to be reasonable to discuss the discharges in water by means of the formalism of gas dynamics. In particular the way in which a discharge can be triggered can be classified by the Townsend parameters, mainly by the pd value.

"At pressures about atmospheric (roughly). in gaps of about 1 cm and longer that is of pd $> 10^3$ *Torr cm, a spark discharge can occur. The voltages required for the breakdown at such high values of pd are quite high. Running from tens to hundreds of kV"* ([38] p. 324).

For the arrangement of Urutskoev et al. the mean voltage acting on the electrons is 5 kV and for $p = 760$ Torr and $d = 0.6$ cm one gets $pd = 456$ Torr cm which obviously is too small for setting off sparks in gases.

2.1. Water as Remarkable and Extraordinary Fluid

"It has been known since Faraday's early researches that the presence of water vapour in dis-

charge gaps greatly facilitates the passages of sparks" (Grey Morgan in [39] p. 665).

Sparks are localized discharges which run through thin channels in the medium. Such discharges are ignited by single electrons which accidentally are emitted from various places of the cathode, and it can be assumed that they occur inspite of the small *pd* value of Urutskoev's arrangement which is no suitable parameter for sparks in water.

The extraordinary character of these sparks is enhanced by the observation that sparks are released a million times quickier in water than in gases [39], and that by the discharge in water considerable higher temperatures are attained than in gases. *"The spark discharge is a rapid transient process not a steady one, and is aptly described by the colloquial phrase a spark jumps"* ([38] p. 324).

"The fundamentals of the (enlarged) theory of spark discharges were developed by Loeb, Meek, and Raether above 1940. The theory is based on the concept of the growth of a thin ionized channel (streamer) between the electrodes. The streamer follows the positively charged trail left by the primary intensive avalanche" ([38], p. 327). Theoretically this process was formulated by Drabkina and Braginski. The statements of Braginskis paper *"Theory of the development of a spark channel"* ([40], p. 188), were verified in detail by experiments, for instance by Koppitz [41].

Unfortunately, Drabkinas and Braginskis investigations have not been applied to water or water vapour. Nevertheless, with the knowledge of these papers some general conclusions can be drawn with respect to the possibility of low energy nuclear reactions.

The first statement is: While in gas discharges temperatures up to 10 000 K can be attained, by discharges in water or water vapour up to 50 000 K can be obtained [41]. But even for such temperatures the thermal energy of a proton does not suffice to penetrate the Coulomb barrier of a titanium nucleus. Titanium has six unoccupied shell model states for protons open for a closure of a complete shell of the magic number 28. To initiate a proton capture into one of these unoccupied shell model states would at least require 10.5 keV thermal energy of the proton or temperatures of above a million degree K [42].

Also a beam concentration is not possible. According to Braginskis theory spark channels cannot be sufficiently concentrated although in his theory the magnetic field pressure is incorporated, i. e. a possible pinch effect is not effective enough.

But in sparks another mechanism is active which is connected with the rise of the conductivity in the spark channel. *Owing to this effect the development of the spark is accompanied by a supersonic flow of the discharge current* [38, 40, 43], *which manifests itself by a loud thunder of the corresponding supersonic pressure wave in experiments*.

The sparks themselves are a rather complicated interplay of the primary electron avalanche and reflections of the waves on the electrodes. In any case an avalanche is a primary and inescabable element of any breakdown mechanism ([38], p. 328). Such a mechanism is all the more complicated as the gap distance between the electrodes becomes larger. In particular the theory of lightnings operates with various steps of the discharge. However, according to the experiments of Raether for $d = 3$ cm one can assume that the primary avalanche causes already the electrical breakdown [44].

The data about the supersonic velocity of such a discharge depend on the various physical parameters and vary between 1.27×10^7 cm s^{-1} in air [45] and up to 5×10^9 cm s^{-1} for streamer formation which is connected with avalanche propagation. For comparison: At 20 K the velocity of sound in water amounts to 1.4×10^5 cm s^{-1} [46].

The first evidence of shock waves produced by spark discharges was reported in 1947 ([38], p. 344). The theory of gas dynamics expansion of the spark channel taking into account the shock wave and the energy release caused by time dependent discharge currents, was first developed by S. J. Drabkina in 1951 [47].

Of utmost interest in our discussion is the model of an avalanche which is pictured in Figure 1 ([38], p. 330).

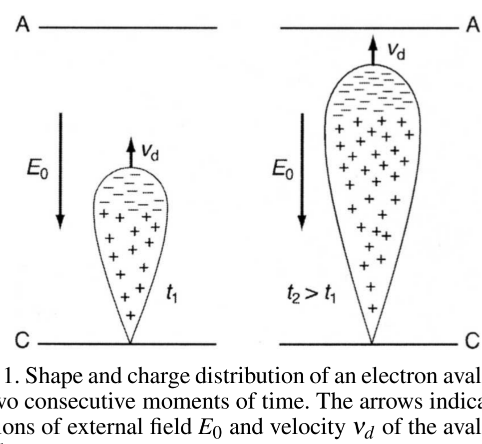

Fig. 1. Shape and charge distribution of an electron avalanche at two consecutive moments of time. The arrows indicate directions of external field E_0 and velocity v_d of the avalanche head.

From this model it follows that in one and the same discharge not only electrons but also ions participate. For simplicity we assume that the whole discharge takes place in only one initial spark channel.

The head of the avalanche is formed by electrons, that means that an enormous number of electrons will hit the anode on a hot spot. From discharge time of Urutskoev it follows that for bridging the gap a supersonic mean velocity of $v = 0.25 \cdot 10^8$ cms^{-1} is necessary. Without a detailed investigation of the energy transfer through the channel into the surrounding we consider in a rough manner the energy for vapourizing the whole water content. For vapourizing 1 g $\equiv$ 1 cm^3 water the energy transfer of 2257 J is necessary which for 14 cm^3 amounts of $31,598$ J ≈ 31.6 kJ.

The vapourizing takes place at the constant temperature of 100 K. With this temperature no nuclear reaction can be initiated. So there remains still 20 kJ for the impact of electrons on the anode material. Although the corresponding energy transfer from the electrons to the hot spot material and its surrounding will not suffice to induce local nuclear reactions, this transfer will suffice to completely deprive the titanium atoms of their bound electrons, i. e. it leads to a melting process of a thin layer of titanium atoms in the anode.

The melting temperature of titanium is 1670 ℃. The corresponding energy which in this case must be transferred to one atom of the layer is 3/2 kT which corresponds to approximately 10^{-12} eV. If the hot spot is approximately a layer of 1 cm^2, it contains 10^{16} atoms. Then for the melting of this layer the electrons must transfer the energy of 10 keV.

According to the picture taken from [4] (see Fig. 2) the discharge produces effects which are physically analogous to the production of soap bubbles consisting of a fluid soap film being blowed up by air pressure.

By electron bombardement of the surface of the titanium anode which leads to surface melting, a thin film of titanium atoms is produced and the bubbles are blowed up by the pressure of vapourized water.

The first stroke caused by electrons is followed by a second stroke which hits the anode and which belongs to the trail of the avalanche consisting of ions. The latter ions are simply protons stemming from the dissociation of water vapour. Up to a certain degree water is always dissociated in its fluid phase and its vapour. This dissociation leads to protons and OH$^-$ ions. As by the impact the protons of the trail and the melted titanium film are in direct contact, a capture of protons by the titanium kernels cannot be excluded. The fact

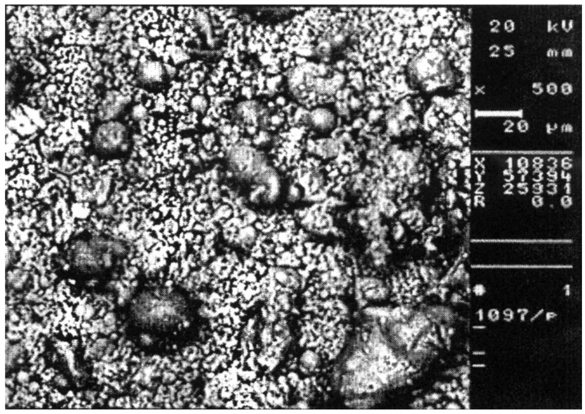

Fig. 2. Typical micrograph of an arbitrary section of the sample of the titanium foil remainder after electric blasting. The characteristic scale is indicated in the right corner [4].

that solely protons can react with the titanium kernels implies that for repeated captures starting with the titanium kernels only the states on the isotonic step ladder of Ti^{48}_{22} can be reached. The latter transfer reactions happen within 10^{-22} s and fix in this way the time scale for this kind of reactions (direct reactions) which are due to strong forces. A definition and discussion of such direct reactions which include transmutations is given in [48].

But the effective occurrence of such captures depends on the ability of the protons to overcome the Coulomb barrier. Owing to the supersonic velocity of the avalanche the protons of its trail have a considerable energy. The observed supersonic velocities of avalanches in gases are $v = 5 \times 10^9$ cm s^{-1} and may be even higher in water vapour. Such velocities lead to proton kinetic energies of $E_\mathrm{P} > 1$ MeV which are sufficient to pass the Coulomb barrier. The minimum energy for traversing the Coulomb barrier is $E = 10$ keV for protons ([42], p. 332). The gradual absorbtion of two protons by the titanium kernel leads to Cr^{50} which is nearly a stable element (apart from double β-decay).

After this generation of Cr^{50}, from the trail of the avalanche further protons hit the newly created element. The latter are also able to penetrate its Coulomb barrier and can initiate a further resonance capture. By such a resonance capture of a proton the element Mn^{51} can be created with a decay time of 46.2 min for conserved symmetry. Time enough to capture a further proton which leads to Fe^{52} with a decay time of 45.9 s or 8.27 h for conserved symmetry, too. All further captures produce increasingly unstable elements in the isotonic step ladder. Note that the weak decay times are modified by symmetry breaking and get smaller for the discharges under consideration.

So it is obvious that by the impact of the protons on the anode unstable nuclei will be generated. Their weak decays will be accelerated by symmetry breaking and are accompanied by neutrino production. *Possibly such neutrinos are then candidates for becoming magnetic monopoles*.

3. Processes Connected with Neutrino Emission

Neutrinos can be created in weak processes, where fermions undergo weak transmutations assisted by exchange bosons. In contrast to the electromagnetic exchange boson the weak vector bosons are not massless but are heavy particles. Thus the probability that a weak process can take place depends on the mass spectrum of these exchange bosons. This also holds if by symmetry breaking the mass spectrum of these bosons is modified. The appearence of neutrinos therefore depends on this mass spectrum.

For conserved symmetries the transition probability for the exchange of a weak charged vector boson is inversely proportional to the fourth power of its mass [42] and for ordinary W-bosons with mass 80 GeV this gives a very or even infinitely small value. Hence, in this case the chance of an associated neutrino generation is vanishingly small.

In water, however, this situation is drastically changed if electroweak bosons are considered as composites. The corresponding mass spectrum is given by the mass formulas (67) in [25] and by an isospin symmetry breaking parameter a_{A} denoted in [25]. In this formula for all mass values only one symmetry breaking parameter a_{A} occurs. In order to obtain physically meaningful results the latter parameter has to be adjusted. It is obvious that this adjustment must be done with respect to the most important vector boson, i. e. the photon. Then one obtains for $a_{\mathrm{A}} = -\mu_{\mathrm{A}}^2$ a vanishing photon mass, i. e. $(m_{\mathrm{A}}^0)^2 = 0$ and with this choice of a_{A} the mass spectra (67) in [25] go over into the system

$$(m_{\mathrm{A}}^b)^2 = \begin{pmatrix} 2\mu_{\mathrm{A}}^2 \\ 0 \\ 2\mu_{\mathrm{A}}^2 \\ 0 \end{pmatrix}, \qquad (m_{\mathrm{G}}^b)^2 = \begin{pmatrix} \mu_{\mathrm{G}}^2 - \mu_{\mathrm{A}}^2 \\ \mu_{\mathrm{G}}^2 + \mu_{\mathrm{A}}^2 \\ \mu_{\mathrm{G}}^2 - \mu_{\mathrm{A}}^2 \\ \mu_{\mathrm{G}}^2 + \mu_{\mathrm{A}}^2 \end{pmatrix}, \qquad (1)$$

$b = (1,2,3,0)$, 1 and 2 numbers of 'charged' bosons.

In the boson equations in [21] and [25] the electromagnetic interactions are not directly covered but appear later in effective theories only. Therefore the pure spinor field interactions in these equations cannot be a good approximation for charged composites and for a proper mass calculation of the charged W-bosons their electromagnetic self-energy must be included. Without extensive calculations we are taking this into account by adding to the spinor mass spectrum (1) an additional term of the elctromagnetic self-mass S_{SE}.

As in [21] the weak boson states were calculated without the participation of electro-magnetic forces, there cannot be any distinction between electric and magnetic and charged and neutral vector bosons. Therefore we assume $\mu_{\mathrm{G}} = \mu_{\mathrm{A}}$ for simplicity. This means that the 'mechanical' mass of the charged G^1 and the A^2-bosons vanishes. Thus in the case of symmetry breaking the mass of these bosons can only have an electromagnetic origin.

In classical electrodynamics a meaningful self-mass can only be derived if mechanical stresses (Poincaré stresses) stabilize the charge distribution. In the spinor field model these stabilizing forces are provided by the spinor field itself which leads to the lowest-order bound states in [21]. But a detailed study of the self-mass problem has not been done. So we are forced to use a classical consideration for a preliminary calculation of this electromagnetic self-mass.

We calculate the electromagnetic mass of a charged vector boson by considering it as a classical small homogeneously charged sphere. Its electrostatic energy reads referred to the symmetry conserving vacuum denoted by index V and fixed radius R_0 [49],

$$S_{\mathrm{SE}}^{\mathrm{V}} = \frac{3}{5}\frac{e^2}{R_0}, \qquad (2)$$

where the radius R_0 is chosen in such a way that the electric self-energy for vanishing mechanical self-energy equals the empirical value of 80 MeV. Then in water this boson charge is screened which leads to

$$S_{\mathrm{SE}}^{\mathrm{W}} = \frac{1}{\varepsilon} S_{\mathrm{SE}}^{\mathrm{V}}, \qquad (3)$$

where the index W denotes the CP-symmetry breaking water as ground state.

3.1. Weak Transitions

In Section 2 it was shown that the protons in the trail of the avalanche can undergo direct reactions within 10^{-22} s with titanium kernels during the supersonic impact on the anode. In particular the elements

$$V^{49}_{23}, \quad Cr^{50}_{24}, \quad Mn^{51}_{25}, \quad Fe^{52}_{26} \tag{4}$$

can be generated from Ti^{48}_{22} by closing nuclear shells or forming resonance states. Apart from Cr^{50} which possibly shows the double β-decay without neutrino emission (which is of no interest in our context), the other elements are unstable by ordinary weak transitions and this tendency is possibly increased by weak capture of avalanche electrons. The weak processes do not interfere with the direct proton reactions and go with another time scale than the latter ones. Although they are much slower than direct reactions, they are of physical interest as they create the neutrinos which are the canditates for monopoles.

In this context it is important to note that the question whether or not one of the various weak transmutations can happen, depends on the nuclear energy balance. Dominated by the masses of the nuclei it is reasonable to assume that these energy balances undergo no major changes under CP-symmetry breaking. Hence, the results of nuclear science for conserved symmetries about the prevailing occurrence of certain weak processes hold in the case of CP-symmetry breaking, too. One gets [42]

$$\begin{aligned} &V^{49}_{23} \to Ti^{49}_{22}, && \text{electron capture,} \\ &Mn^{51}_{25} \to Cr^{51}_{24}, && \beta^+ \ \text{decay,} \\ &Fe^{52}_{26} \to Mn^{52}_{25}, && \beta^+ \ \text{decay.} \end{aligned} \tag{5}$$

But in contrast to the CP-invariant nuclear balances which determine the kind of transition, the transition probabilities themselves are heavily influenced for CP-symmetry breaking by a modification of weak boson masses.

3.2. Electron Capture

Its reaction equation reads

$$e^- + p = \nu + n. \tag{6}$$

The avalanche electrons impinge on the titanium foil with a maximal velocity of about 5×10^9 cm s^{-1}. For these electrons holds: if v $\ll$ c these electrons dissipate their energy exclusively by inelastic collisions with the material of the anode and no bremsstrahlung is emitted ([50], Eq. 15.31). For the maximal velocity this inequality is not very well satisfied, but for the average velocity of the avalanche electron it holds quite well.

Furthermore, without boson emission the motion of the avalanche electrons is accompanied by their time dependent electric and magnetic fields which are subjected to the boundary condition for a transition between a dielectric (water) and an (ideal) conductor (titanium). So due to these conditions the current flow in the anode which is generated by the impinging electrons is forced to run in a thin surface layer (skin effect) [50].

The corresponding decay rate is given according to ([42], Eq. 4.96) as

$$\lambda = \frac{c}{(\hbar c)^4}\left(\frac{1}{\pi}\right)(2{,}4\, G_F)^2 |\psi_e(0)|^2 M^2 Q_{ec}^2 \tag{7}$$

for electron capture starting from any kind of bound states. For simplicity we consider only superallowed transitions with $M^2 \sim 1$. The value of Q_{ec} is given by $(E+\Delta E)$ [42]. Furthermore G_F must be related to the weak coupling constant g_1. This quantity is the weak counterpart to the electrical charge. The latter is defined by $e^2 = (\alpha_e \hbar c)$, while the weak coupling constant is given by $g_1^2 = (\alpha_w \hbar c)$, where α_e is the electrical fine structure constant and α_w is the weak fine structure constant, respectively. With $\alpha_w = g_w^2/(4\pi) = 1/29$ ([51], Eqs. 10.38, 10.42) one obtains

$$G_F = \frac{\sqrt{2}}{8}\left(\frac{g_w}{m_w c^2}\right)^2 (\hbar c)^3. \tag{8}$$

Substitution of (8) into (7) yields

$$\lambda = (2.4)^2 2^{-3} |\psi_e(0)|^2 c \left(\frac{g_w}{m_w c^2}\right)^4 (\hbar c)^2 Q_{ec}^2. \tag{9}$$

The value of the decay constant (9) for water can be related to the corresponding value for conserved symmetry, i. e. vacuum. Denoting

$$\lambda_W := \lambda(\text{water}), \quad \lambda_V := \lambda(\text{vacuum}) \tag{10}$$

one gets

$$\lambda_W = \frac{\lambda_W}{\lambda_V} \quad \lambda_V. \tag{11}$$

With (9) the fraction in (11) can be explicitly evaluated if one takes into account the invariance properties of the quantities contained in (9) under CP-symmetry breaking.

The invariance of the nuclear energy balance has already been discussed above.

For the coupling constant g_w the following invariance argument can be given if one equivalently considers the invariance of g_1:

$$g_1^2 := \left(\frac{g_\mathrm{w}^2}{4\pi}\hbar c\right) = \left(\frac{1}{29}\hbar c\right) = \left(\frac{1}{29}197.3\right) \ \mathrm{MeV\,fm}. \tag{12}$$

Concerning this value of the weak coupling constant g_1, it should be noted: the coupling constant g_1 has the same dimension as the electrical charge e, i. e. g_1 must be proportional to e. The $U(1)$ symmetry which allows the algebraic definition of charge, is not destroyed by electroweak symmetry breaking, i. e. e as well g_1 must have invariant values under electroweak symmetry breaking. So one can apply the value (12) to the case of broken symmetry too.

Furthermore, if by definition for conserved as well as for broken symmetry the same electronic wave functions are applied in (9), and if one defines $m_\mathrm{u} \to m_\mathrm{V}$ for vacuum and $m_\mathrm{u} \to m_\mathrm{W}$ for water, one obtains from (9) and (11)

$$\lambda_\mathrm{W} = \left(\frac{m_\mathrm{V}c^2}{m_\mathrm{W}c^2}\right)^4 \lambda_\mathrm{V}. \tag{13}$$

Now, in accordance with the above exposition, it is

$$m_\mathrm{V}c^2 = S_\mathrm{SE}, \quad m_\mathrm{W}c^2 = \frac{1}{\varepsilon}S_\mathrm{SE}. \tag{14}$$

For V_{23}^{49} one gets from [52] $\lambda_\mathrm{V} = \tau^{-1} = (330\ \ \mathrm{d})^{-1}$ and with $\varepsilon = 80$ for water (13) leads to

$$\begin{aligned} \lambda_\mathrm{W} &= \varepsilon^4 \lambda_\mathrm{V} \\ &= \varepsilon^4 (60 \times 60 \times 24 \times 330)^{-1}\ \ \mathrm{s}^{-1} \\ &\to \quad \tau_\mathrm{W} = 10^{-1}\,6.9\ \ \mathrm{s}. \end{aligned} \tag{15}$$

The very small value (15) concerns the time for the capture of *one* electron by *one* nucleus in the layer. But this value is not changed if according to our assumptions the electron spreads out over the whole layer. Furthermore, as owing to the skin effect, the spreading of the electrons is confined to a thin surface layer of the anode, a remarkable dependence of the values (15) on the thickness of the anode foil is not to be expected.

3.3. Proton Conversion

Although no free neutrons are present in the discharge, for the neutrons and protons bound in the nuclear kernels local neutron decay and local proton decay can occur. With respect to the accompanying neutrino production the latter processes might be able to compete with neutrino emission by electron capture. Thus to decide which process dominates the weak transitions an estimate of neutron and proton decay has to be given. In contrast to electron capture, neutron decays and proton decays are internal processes within one and the same nucleus, i. e. no extended wave functions of the neutron and proton are involved. For this case standard formulas have been derived ([42], Eq. 4.88. According to [42],

$$\lambda\,[\mathrm{s}^{-1}] = \frac{2}{\pi^3\hbar}\left(\frac{2.4G_\mathrm{F}}{(\hbar c)^3}\right)^2 |M|^2 \int_{m_\mathrm{e}c^2}^{\Delta mc^2} (\Delta mc^2 - E)^2 (E^2 - m_\mathrm{e}^2 c^4)^{1/2} E\,\mathrm{d}E, \tag{16}$$

where Δmc^2 is the energy difference between initial and final nuclear masses.

For a rough estimate we consider superallowed transitions $|M|^2 \sim 1$ and put $m_\mathrm{e}c^2 \sim 0$ approximately. Then the decay constant gives an upper limit of possible decay processes which suffices for a comparison with electron capture. With $a_\Delta \equiv \Delta mc^2$ (13) goes over into

$$\lambda\,[\mathrm{s}^{-1}] = \frac{8}{\pi^3\hbar}\left(\frac{2.4G_\mathrm{F}}{(\hbar c)^3}\right)^2 \int_0^{\Delta mc^2} (a_\Delta - E)^2 E^2 \mathrm{d}E. \tag{17}$$

By substitution of (8) into (17) and integration over E one obtains

$$\lambda\,[\mathrm{s}^{-1}] = \frac{2}{\pi^3\hbar}(2.4)^2 \frac{2}{64}\left(\frac{g_\mathrm{w}}{m_\mathrm{w}c^2}\right)^4 (4\pi)^2 a_\Delta^5 \frac{1}{30}. \tag{18}$$

Equations (17) and (18) show that such decay processes depend on the nuclear energy balances, which already has been discussed above. There it was explained that these energy balances are not modified by CP-symmetry breaking compared with the symmetry conserving case. Hence, the treatment of (18) can be done along the same lines as of (9). Therefore Formula (11) can be applied to neutron decay too. In the same manner the spontaneous weak proton decay within the nucleus can be treated. In both cases the results of the chart of nuclides for conserved symmetries can be adopted. The step by step occupation of originally empty titanium (resonance) levels by protons leads to elements which are unstable against proton decay and from the chart [52] follows: All elements of the isotonic step ladder above Cr_{24}^{50} show β^+-decay, i. e. *in this isotonic step ladder only proton decay but no neutron decay occurs*.

This process is characterized by the weak transition

$$p \to n + e^+ + \nu, \tag{19}$$

and one can apply (11). The vacuum values are [52]

$$\begin{aligned} &\mathrm{Mn}_{25}^{51} : \tau_V = 46.2 \ \text{min}, \quad \mathrm{Fe}_{26}^{52} : \tau_V = 45.9 \ \text{s}, \\ &\mathrm{Co}_{27}^{53} : \tau_V = 240 \ \text{ms}, \quad \mathrm{Ni}_{28}^{54} : \tau_V = 143 \ \text{ms}. \end{aligned} \tag{20}$$

With (11) the following values for decay times in water result:

$$\begin{aligned} &\mathrm{Mn}_{25}^{51} \to \mathrm{Cr}_{24}^{51}, \quad \tau_W = 10^{-4} \times 1.066 \ \text{s}, \\ &\mathrm{Fe}_{26}^{52} \to \mathrm{Mn}_{25}^{52}, \quad \tau_W = 10^{-6} \times 1.12 \ \text{s}, \\ &\mathrm{Co}_{27}^{53} \to \mathrm{Fe}_{26}^{53}, \quad \tau_W = 10^{-9} \times 5.26 \ \text{s}, \\ &\mathrm{Ni}_{28}^{54} \to \mathrm{Co}_{27}^{54}, \quad \tau_W = 10^{-9} \times 3.41 \ \text{s}. \end{aligned} \tag{21}$$

Before drawing any conclusion from (21) attention must be paid to the fact that the β^+-decay takes place within a two-step process.

In the first step a proton colliding with a nucleus is supposed to be captured by it to form a transmuted nucleus. After the proton has been absorbed by this nucleus its energy is rapidly redistributed among the constituents of this nucleus and a considerable time elapses on the average before in a second step a decay mode develops which leads for instance finally to neutrino emission.

But it must be recognized that not all encounters between protons and nuclei end up with a transmuted nucleus formation. A considerable proportion of reactions takes place directly without an intermediate stage, but at the same time there is a high enough probability for the formation of a transmuted nucleus which leads to sharp resonance effects at low energies if the Coulomb barrier can be penetrated by the proton.

In a rough way the probability for the formation of a transmuted nucleus can be expressed by

$$W = \frac{n_F \sigma_g}{F}, \tag{22}$$

where σ_g is the content of a surface area of a projection of the nucleus on a plane orthogonal to the incident proton beam and where n_F is the number of projections of all nuclei on F which itself is the content of the area of a hot spot defined by the proton beam traversing this plane.

This simple consideration already shows the problem of defining numbers of generated neutrinos as under discharges the hot spots on the anode partly lose their crystallographic order, i. e. a definite number of target nucleus projections on the hot spot becomes impossible.

So the chart of nuclides only guarantees that the elements in the isotonic step ladder of Ti_{22}^{48} *with considerable proton surplus can exist as resonance states with various finite life-times, but a numerical calculation of the associated neutrino output cannot be based on this information as the chart of nuclides gives no hind how many resonance states can be generated during the discharge*.

Thus the question whether electron capture or compound decay dominate the neutrino production needs further studies in detail (see Part II). Independently from the above problem from (5) it clearly follows that the number of generated neutrinos is closely related to the number of transmuted elements.

Indeed, the experiments of Urutskoev et al. show that by the discharge a lot of transmuted elements is generated which are outside the step ladder of Ti_{22}^{48}*. Hence, according to our results of Section 2, these elements must at least partly develop from the original resonance states by weak decay. Without relating in detail the occurrence of the transmuted elements in [4] to the elements in (5) one can say: Such rearrangement weak transitions are the source of neutrinos which are emitted under symmetry breaking conditons.*

A more detailed discussion of Urutskoev's transmutations observations will be done elsewhere, but for the problem under consideration it holds:

From the theoretical point of view a definite number of the output of neutrinos in these processes is of minor interest. Principally, for the proof of the existence of a magnetic monopole by symmetry breaking it suffices that only a single neutrino is transformed into a magnetic monopole, and this line of research will be followed in Part II.

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