

# Test of Effect from Future in Large Hadron Collider; A Proposal

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## Abstract

We have previously proposed the idea of performing a card-drawing experiment of which the outcome potentially decides whether the Large Hadron Collider (LHC) should be closed or not. The purpose is to test theoretical models such as our own model that have an action with an imaginary part that has a similar form to the real part. The imaginary part affects the initial conditions not only in the past but even from the future. It was speculated that all the accelerators producing large amounts of Higgs particles such as the Superconducting Super Collider (SSC) would mean that the initial conditions must have been arranged so as not to allow these accelerators to work. If such effects existed, we could perhaps cause a very clear-cut “miracle” by having the effect of a drawn card to be the closure of the LHC. Here we shall, however, argue that the closure of an accelerator is hardly needed to demonstrate such an effect and seek to calculate how one could perform a verification

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experiment for the proposed type of effect from the future in the statistically least disturbing and least harmful way.

We shall also discuss how to extract the maximum amount of information about such as effect or model in the unlikely case that a card preventing the running of the LHC or the Tevatron is drawn, by estimating the relative importance of high beam energy or high luminosity for the purpose of our effect.

## 1 Introduction

Each time an accelerator is used to investigate a hitherto uninvestigated regime such as collision energy or luminosity, there is, a priori, a chance of finding new effects that, in principle, could mean that a well-established principle could be violated, in lower-energy physics or in daily life. The present paper is one of a series of articles [1–5] discussing how one might use the LHC and perhaps the Tevatron to search for effects violating the following well-established principle while the future is very much influenced by the past, the future does not influence the past. Perhaps we can more precisely state this principle, which we propose to test at the new LHC accelerator, as follows: While we find that there is a lot of structure from the past that exists today in its present state – at the level of pure physics – simple structures existing in the future, so to speak, do not appear to prearrange the past so that they are [6–12]. If there really were such prearrangements organizing simple things to exist in the future we could say that it would be a model for an initial state with a built-in arrangement for the future, which is what our model is. However, models or theories for the initial state such as Hartle and Hawking’s no-boundary model [13] are not normally of this type, but rather lead to a simple starting state corresponding to the fact that we normally do not see things being arranged for the future in the fundamental laws and thus find no backward causation [6]. However, we sometimes see that this type of prearrangement occurs, but we manage to explain it away. For example, we may see lot of people gathering for a concert. At first it appears that we have a simple structure in the future, namely, many people sitting in a specific place, such as the concert hall, causing a prearrangement in the past.

Normally we do not accept the phenomenon of people gathering for a concert as an effect of some mysterious fundamental physical law seeking to collect the

people at the concert hall, and thus arranging the motion of these people shortly before the concert to be directed towards the hall. In our previous model [1–5, 7], which even we do not claim to be relevant to the concert hall example, such an explanation based on a fundamental physics model could have sounded plausible. In our model, we have a quantity  $S_I$ , which is the imaginary part of an action in the sense that it is substituted into a certain Feynman path integral, as is the real part of the action, except for a factor  $i$ . In fact, we let the action  $S$  be complex, and its imaginary part  $S_I$ , as for the real part  $S_R$ , be an integral over time,  $S_I = \int L_I dt$ . Thus  $S = S_R + iS_I$ . Roughly speaking, the way that the world develops is to make  $S_I[path]$  almost minimal (so that the probability weight obtained from the Feynman path integral  $e^{-2S_I}$  is as large as possible). Thus, a tempting “explanation” for the gathering of the people would be that many people gathering for a concert provides a considerable negative contribution to the imaginary part  $L_I$  of the Lagrangian during the concert, and thereby, a negative contribution to the imaginary action  $S_I$ . Thus, the solutions to the equations for such a gathering before a concert would have an increased probability of  $e^{-2S_I}$ , and we would have an explanation for the phenomenon of the people gathering for the concert. If we did not have an alternative – and we think better – explanation, then we might have to take such gatherings of people for concerts as evidence for our type of model with an effect from the future; we would, for example, conclude that the gathering of people occurred in order to minimize “an imaginary action”  $S_I$ .

An alternative and better explanation that does not require any fundamental physical influence from the future is as follows: The participants in the concert and their behaviors are indeed, in the classical and naive approximation, completely determined from the initial state of the universe at the moment of the Big Bang, an initial state in which the concert was not planned. Later on, however, some organizers – possibly the musicians themselves – used their phantasy to model the future by means of calendars, etc., and they issued an announcement. We can use this announcement as the true explanation of the gathering of the listeners to the concert. The gathering at the concert was due to some practical knowledge of the equation of motion allowing the possibility to organize events entirely on the basis of the equation of motion and using the fact that the properties of the initial conditions are, in some respects, very well organized (low entropy, sufficient food and gasoline

resources). However, there was no effect from the future, only from the phantasies about the future implemented in memories, which are true physical objects of course, such as the biological memories of the announcement and so on.

Even more difficult examples can be used to explain the fact that our actions are not preorganized “by God”, which may here be roughly identified with fundamental physical influences from the future, such as the biological development of extremely useful organs. Has the development of legs, say, really got nothing to do with the fact that they can later be used for walking and running? Darwin and Walles produced a convincing explanation for the development of legs without the need for any fundamental influence from the future on the past.

If, as would be said prior to Darwin’s time, it were God’s plan (analogous to the concert organizer’s plan) to make legs, this would come very close to the fundamental physics model, provided the following two assumptions were satisfied:

- 1) That this God is not limited or has His memory limited by physical degrees of freedom in contrast to the brains of the concert organizers.
- 2) This God is all-knowing, which means that He has access to the future and does not need a phantasy or simulation to create a model of it.

In the earlier works [2–4] we attempted to find various reasons why this effect from the future might to be suppressed. For instance this effect is definitely suppressed for particles whose eigentimes are trivial in some sense. From the Lorentz invariance, the contribution of an action, which may be to the real part  $S_R$  or the imaginary part  $S_I$  involving from the passage of a particle from one point to another point must be proportional to the eigentime of the passage (i.e., the time the passage would take according to a standard clock located at the particle).

Two examples that dominate the physics of daily life ensure at least one source of strong suppression of the effect from the future: 1) Massless particles such as the photon have always zero eigentimes, thus for photons, the effect is strongly suppressed or killed. 2) For nonrelativistic particles, the eigentime is equal to the reference frame time, and thus the eigentime is trivial unless the particle is produced and/or destroyed. If a particle such as an electron is conserved the eigentime becomes trivial and there is little chance to see our effect at the lowest order with electrons.

Actually, since there is a factor of  $\frac{1}{\hbar}$  in front of the action, one initially expects the effects of  $S_I$  to be so large that we need a large amount of suppression to prevent our model from being in immediate disagreement with the experiment.

We shall discuss some suppression mechanisms in section 3. We shall also discuss reasons why it may be likely that the effects of Higgs particles are much greater than those of already observed particles. The number of Higgs particles is not preserved so that even a non relativistic Higgs particle may contribute  $S_I$ , but we do, of course, expect somewhat relativistic Higgs particles to be produced with velocities of the order of magnitude of that of light, but typically not extremely relativistic, thus there is no reason from the two above mentioned mechanisms that the effect of a Higgs particle should be suppressed.

In contrast, as we shall see, there is a reason why even if the whole effect of  $S_I$  is generally strongly suppressed, a counteracting factor could be caused for the case of the Higgs particle.

Normally it would be reasonable to assume that in the real and imaginary parts, the multipliers of the same field combination, say  $\lambda_R$  in  $\frac{\lambda_R}{4}|\phi|^4$  in  $S_R$  and  $\lambda_I$  in  $\frac{\lambda_I}{4}|\phi|^4$  in  $S_I$ , should be of the same order of magnitude, so that the complex phases for the couplings, such as  $\lambda_R + i\lambda_I$ , should be of the order of unity.

There is, however, one case in which the problems connected with the hierarchy problem make this assumption unlikely to be true: Because of the hierarchy problem it is difficult to avoid considerable fine tuning of the Higgs mass, since its quadratically divergent contributions with a cutoff at the Planck scale  $M_{Pl}$  would shift it considerably. We may only need this fine tuning for the squared term in the real part of the complex mass  $m^2|\phi|^2 = (m_R^2 + im_I^2)|\phi|^2$  in the Lagrangian density. Whether or not only the real part  $m_R^2$  of the square of the mass is tuned or whether also the imaginary part  $m_I^2$  is also tuned may depend on which of the various models is used to attempt to solve the hierarchy problem, and how such a model is implemented together with our model of the imaginary part of the action.

For instance, one of us has constructed a long argument – using a bound state of six top and six antitop quarks – that under the assumption of several degenerate vacua (=MPP) [5, 8, 16], which in turn follows [5] from the model in the present article, we obtain a very small Higgs mass with its order of magnitude agreeing with the weak scale. In this model, which “solves the hierarchy problem”, it is clearly the

real part of the square of the mass, i.e.,  $m_R^2$ , that gets fine tuned, and there would be insufficiently many equations of MPP stating that several vacua have essentially zero (effective) cosmological constants allowing the fine tuning of more than just this real part  $m_R^2$ . In this model, the argument would thus be that the hierarchy problem would remain unsolved for the imaginary part of the coefficient of the mass-square term for the Higgs field  $m_I^2$ , but it is unknown whether this imaginary part  $m_I^2$  should be fine tuned to be small. A priori, it may be difficult for any model to obtain a small real part  $m_R^2$  of the weak scale; thus it is highly possible that also in other models, only the real part  $m_R^2$  is tuned and not the imaginary part. In such cases, the imaginary part  $m_I^2$  of the Higgs mass square could, a priori, remain untuned and be of, the order of some fundamental scale, such as the Planck scale or a unified scale. This would mean that the imaginary part  $m_I^2$  may be much larger than the real part,

$$m_I^2 \gg m_R^2, \quad (1)$$

and thus, the assumption that all the ratios of the real to the imaginary part for the various coefficients in the Lagrangian should be of order unity would not be expected to be true for the case of the mass-square coefficient. Conversely, unless the hierarchy problem solution is valid for both real and imaginary parts we could have

$$\frac{m_I^2}{m_R^2} \simeq \frac{M_{PL}^2}{M_{weak}^2} \simeq \left( \frac{10^{19} \text{ GeV}}{100 \text{ GeV}} \right)^2 \simeq 10^{34}. \quad (2)$$

This would mean that by estimating the effect of  $S_I$  in an analogous way to that for particles with real and imaginary parts of their coupling coefficients being of the same order or given by some general suppression factor, we could potentially underestimate the effects of the Higgs particle by a factor of  $10^{34}$ .

In the light of this estimation for the relative importance of the effect from the future ( $\simeq$  our  $S_I$  effect) on the Higgs particle relative to that on other particles, it is an obvious conclusion that one should search for this type of effect when new Higgs-particle-producing machines such as the LHC, the Tevatron, or the canceled SSC are planned.

If the production and existence of a Higgs particle for a small amount of time gave a negative contribution to  $S_I$ , which would enhance the probability density  $\propto e^{-2S_I}$ ,

one could wonder why the universe is not filled with Higgs particles. This may only be a weak argument, but it suggests that presumably the contribution from an existing Higgs particle to  $S_I$  is positive if it is at all important. Now if the production and “existence” of a Higgs particle indeed gave a positive contribution to  $S_I$ , whereby the probability  $\propto e^{-2S_I}$  for developments in a world containing large Higgs-particle-producing accelerators should be decreased by the effect of their  $S_I$  contribution, then the production and existence of such Higgs particles in greater amounts should be avoided somehow in the true history of the world. If an accelerator potentially existed that could generate a large number of Higgs particles and if the parameters were so that such an accelerator would indeed give a large positive contribution, then such a machine should practically never be realized!

We consider this to be an interesting example and weak experimental evidence for our model because the great Higgs-particle-producing accelerator SSC [17], in spite of the tunnel being a quarter built, was canceled by Congress! Such a cancellation after a huge investment is already in itself an unusual event that should not happen too often. We might take this event as experimental evidence for our model in which an accelerator with the luminosity and beam energy of the SSC will not be built (because in our model,  $S_I$  will become too large, i.e., less negative, if such an accelerator was built) [17].

Since the LHC has a performance approaching the SSC, it suggests that also the LHC may be in danger of being closed under mysterious circumstances. In an introductory article to the present one [1] we offered to demonstrate the mysterious effect of  $S_I$  in our model on potentially closing the LHC by carrying out a card-drawing game, or using a random number generator.

Under the assumption that our model is indeed correct, demonstrating a strong effect on the LHC by a card-drawing game such as its possible closure would serve a couple of purposes:

- 1) Even though some unusual political or natural catastrophe causing the closure of the LHC would be strong evidence for the validity of a model of our type with an effect from the future, it would still be debatable whether the closure was not due to some other cause other than our  $S_I$ -effects. However, if a card-drawing game or a quantum random number generator causes the closure of the LHC in spite of the fact that it was assigned a small probability of the

order of, say  $10^{-7}$ , then the closure would appear to very clear evidence for our model. In other words, if our model was true we would obtain a very clear evidence using such a card-drawing game or random number generator.

- 2) A drawn card or a random number causing a restriction on the LHC could be much milder than a closure caused by other means due to the effect of our model. The latter could, in addition, result in the LHC machine being badly used, or cause other effects such as the total closure of CERN, a political crisis, or the loss of many human lives in the case of a natural catastrophe.

Thus, the cheapest way of closing the main part of the LHC may be to demonstrate the effect via the card-drawing game.

However, in spite of these benefits of performing the card-drawing experiment it would be a terrible waste if a card really did enforce the closure or a restriction on the LHC. It should occur with such a low probability under normal conditions that if our model were nonsense, then drawing a card requiring a strong restriction should mean that our type of theory was established solely on the basis of that “miraculous” drawing. Such a drawing would have the consolation that instead of finding supersymmetric partners or other novel phenomena at the LHC, one would see the influence from the future! That might indeed lead to even more spectacular new physics than one could otherwise hope for! Thus, the restriction of the LHC would not be so bad. Nevertheless, it is of high importance that one statistically minimizes the harm done by an experiment such as a card-drawing game. Also, one should allow several possible restrictions to be written on the cards that might be chosen so that several possible effects from the future may occur. Then one might, in principle, learn about the detailed properties of this effect such as the number of Higgs particles needed to obtain an effect, or whether luminosity or beam energy matters the most for the  $S_I$ ?

It is the purpose of the present article to raise and discuss these questions of how to arrange a card-drawing game experiment to obtain maximum information and benefit and minimal loss and obtain statistically minimal restrictions.

In section 2, we formulate some of the goals one would have to consider in planning a card-drawing game or random number experiment on restricting the LHC. In section 3 we give a simplified description of the optimal organization of the



game and propose that the probability distribution in the game should be assigned on the basis of the maximum allowed size of some quantity consisting of luminosity, beam energy and number of Higgs particles etc..

In section 4 we develop the theory of our imaginary action so as to obtain a method of estimating the mathematical form expected for the probability of obtaining a “miraculous” closedown of the LHC.

In section 5 we discuss possible rules for the card-drawing game and random quantum generator. However, we still think that more discussion and calculation may be needed to develop the proposed example before actually drawing the cards.

Section 6 is devoted to further discussion and a conclusion.

## 2 The goals, or what to optimize

It is clear that the most important goal concerning the LHC is for it to operate in a way that delivers as many valuable and interesting results as possible while searching for one or more Higgs particles, strange bound states and supersymmetric partners. In contrast, our model is extremely unlikely to be true, and thus, the investigation of our model should only be allowed to disturb the other investigations very marginally. The problem is that although the probability of disturbance by the investigation of our theory has been statistically evaluated to be very tiny, there is a risk that the selection of a very unlucky card could impose a significant restriction on the LHC, and thereby cause a very major disturbance.

### 2.1 What to expect

Before estimating the optimal strategy with respect to the card-drawing game and its rules, we wish to obtain a crude statistical impression of what to expect.

The most likely event is that our model is simply wrong, and thus it is very unlikely that anything should happen to the LHC unless it is caused by our card-drawing experiments. If, however, our model is correct in principle, we must accept the unlucky fate of the SSC [17] as experimental evidence and conclude that the amount of superhigh-energy physics at SSC, measured in some way by a combination of the luminosity and beam energy, seemingly sufficient to change the fate of the universe on a macroscopic scale. We do not at present know the parameters of our

model, and even if we make order-of-magnitude guesses, there are several difficulties in estimating even order-of-magnitude suppression mechanisms. For instance, there may be competition between the arrangements of the events in our time to give a low  $S_I$  with a similar arrangement for other times. Thus, even guessing the order-of-magnitude of fundamental couplings will still not give a safe estimate for the order-of-magnitude of the strength in practice. We are therefore left with a crude method of prior estimation by taking the probability of different “amounts of superhigh-energy collisions” (say some combination of beam energy and luminosity) needed to macroscopically change the fate of the universe to be of constant density in the logarithm of this measure of superhigh-energy collisions.

For simplicity, we consider that  $\chi$  is, for example, the integrated luminosity for collisions with sufficiently high energy to produce Higgs particles, or take it simply to be the number of Higgs particles produced. Whether they are observed or not does not matter; it is the physically produced Higgs particles and the time they exist that matters.

We know in the case that our theory was correct, an upper limit for this amount of superhigh-energy collisions is needed to obtain an effect. Namely, we know that the SSC was canceled and that its potential amount of superhigh-energy collisions must have been above the amount needed. On the other hand, we also know that the Tevatron seemingly operates as expected so that its amount of superhigh-energy collisions must be below the amount needed to cause fatal macroscopic changes.

In our prior estimation, we should thus calculate the probability for the amount  $\chi$ . This is needed to cause fatal effects in a machine, where  $\chi$  is in the interval  $[\chi - \frac{1}{2}d\chi, \chi + \frac{1}{2}d\chi]$ , as

$$\text{Probability} \left( \left[ \chi - \frac{1}{2}d\chi, \chi + \frac{1}{2}d\chi \right] \right) = p(\chi)d\chi, \quad (3)$$

and we assume

$$p(\chi) = \frac{1}{\chi} - \frac{1}{\log \chi_{\text{SSC}} - \log \chi_{\text{Tevatron}}} \quad (4)$$

for  $\chi_{\text{SSC}} \geq \chi \geq \chi_{\text{Tevatron}}$  and that  $p(\chi) = 0$  outside this range.

Here we have respectively denoted the amounts of superhigh-energy collisions, say, the numbers of Higgs particles, produced as integrated luminosity in the SSC and the Tevatron by  $\chi_{\text{SSC}}$  and  $\chi_{\text{Tevatron}}$ .

The SSC should have achieved a luminosity of  $10^{33} \text{ cm}^{-2}\text{s}^{-1}$  and a beam energy 20 TeV in each beam, while the Tevatron has achieved values of  $\sim 10^{32} \text{ cm}^{-2}\text{s}^{-1}$  and 1 TeV.

The LHC should achieve a luminosity of  $10^{34} \text{ cm}^{-2}\text{s}^{-1}$  and a beam energy of 7 TeV in each beam.

	Beam Energy	Luminosity
Tevatron	1 TeV	$10^{32} \text{ cm}^{-2}\text{s}^{-1}$
LHC	7 TeV	$10^{34} \text{ cm}^{-2}\text{s}^{-1}$
SSC	20 TeV	$10^{33} \text{ cm}^{-2}\text{s}^{-1}$

With respect to luminosity, the LHC is expected to be even stronger than the SSC; thus, if we apply our criterion, one would expect the LHC to be prone to even greater bad luck than the SSC.

Let us, however, illustrate the idea by using for the beam energy for  $\chi$ . Then

$$\begin{aligned} \log \chi_{\text{SSC}} &= \log(20 \text{ TeV}), \\ \log \chi_{\text{Tevatron}} &= \log(1 \text{ TeV}) \end{aligned} \tag{5}$$

and

$$\log \frac{\chi_{\text{SSC}}}{\chi_{\text{Tevatron}}} = \log 20 \simeq 3. \tag{6}$$

Hence,

$$p(\chi) = \frac{1}{\chi} \cdot \frac{1}{3} \quad \text{for } \chi_{\text{Tevatron}} \leq \chi \leq \chi_{\text{SSC}}. \tag{7}$$

Now  $\chi_{\text{LHC}} = \log(7 \text{ TeV}) \simeq 2 + \log \text{TeV}$ . Thus, the probability that the critical  $\chi$  for closure is smaller than  $\chi_{\text{LHC}}$  is  $P(\chi < \chi_{\text{LHC}}) = \frac{2}{3}$ . This means that if our theory was correct and the beam energy was the relevant quantity, then the LHC would be stopped somehow with a probability of  $\simeq \frac{2}{3} \simeq 66\%$ .

## 2.2 What would we like to know about our model, if it is correct?

There are several information one would like to get concerning our model:

- 1) One would like to obtain an estimate of how strong the effect is, i.e., one would like to estimate at least the order-of-magnitude of the value of  $\chi$  needed to disturb the fate of the universe macroscopically.

- 2) One would like to determine whether it is the beam energy or the luminosity that is most important for causing closing.
- 3) One would also like to determine which type of random numbers, quantum random numbers or more classically constructed ones, allow our  $S_I$ -effect to more easily manipulate the past. One could even speculate whether one could construct a mathematically random number that should make it almost impossible to manipulate such a physical effect (from the future).

In addition to all these wishes, to get questions answered random number experiment that causes minimal harm to the optimal use of the LHC machine.

### 2.3 How to evaluate cost?

Let us now discuss the above questions about our model.

To obtain a convincing answer to question 1), of whether there is indeed an effect, as proposed, the probability of selecting a random number – a card for instance – that leads to restrictions should be so small that one could practically ignore the possibility that a restriction occurs simply by chance. This suggests that one should let the a priori probability of a restriction, i.e., the number of card combinations corresponding to a restriction relative to the total number of combinations, be sufficiently small to correspond to getting by accident an experimental measurement five standard deviations away from the mean. That is to say, a crude number for the suggested probability of any restriction at all is  $e^{-\frac{5^2}{2}} \simeq e^{-12.5} \simeq 10^{-\frac{12.5}{2.3}} \simeq 10^{-5.4} \simeq 4 \times 10^{-6}$ .

To obtain a good answer to question 2) on the order-of-magnitude of the strength of the effect we must let the a priori probability of a drawing card giving a certain degree of restriction vary with the degree of restriction. Thus, a milder restriction is made, a priori, to be much more likely than a more severe restriction. We can basically assume that *we will not draw a restriction* (card combination) appreciably stronger than that required to demonstrate our effect. Thus, we can assume that the restriction drawn will be of the order of the magnitude of the strength of the operating machine,  $\chi$ , which is the maximum allowed before our effect stops it. Thus if we arrange the probabilities in this way, we may claim that the restriction resulting from the drawn random number represent the strength of the effect. Mathematically, such an arrangement means that we choose the a priori probability for the restriction

value of  $\chi$ ,  $\chi_{\text{restriction}}$ , to be a power law:

$$P_{\text{a priori}} \left( \left[ \chi_{\text{restriction}} - \frac{1}{2}d\chi_{\text{restriction}}, \chi_{\text{restriction}} + \frac{1}{2}d\chi_{\text{restriction}} \right] \right) = p(\chi_{\text{restriction}}) d\chi_{\text{restriction}} , \quad (8)$$

where

$$p(\chi_{\text{restriction}}) = K\chi_{\text{restriction}}^\alpha , \quad (9)$$

and  $K$  is a normalization constant. Here a larger value of  $\alpha > 0$  should be chosen for a sharper measurement of the strength of the effect. If we only require a crude order of magnitude, we can simply take  $\alpha \simeq 1$ .

Note that having a large  $\alpha$  means that very severe restrictions become relatively very unlikely. Thus, a large  $\alpha$  is optimal for ensuring minimal harm to the operation of the machine.

We shall also assume that since the Tevatron seems not to be disturbed we do not have to include more severe restrictions on the LHC than those that would force it to operate as a Tevatron.

Concerning question 3) as to which features of the operation, e.g., luminosity and center-of-mass beam energy, are the most important for our effect, we answer this question by letting different random numbers – the drawings – result in different *types of restrictions*. That is to say, the different drawings represent different combinations of restrictions on the beam energy and luminosity. Presumably it would be wise to make as many variations in the restriction patterns as possible, because the more combinations of various parameters, the more information about our effect one can obtain. If one draws a combination of cards that causes a restriction, then one has immediately verified our type of model or the existence of an effect from the future. In this case, any detail of the specific restriction combination obtained from the drawing is no longer random but is an expression of the mysterious new effect just established by the same drawing. The more details one can thus arrange to be readable from the card combination drawn, the more information one will obtain about the  $S_I$ -effect in the case of restrictions that actually show up in spite of having been a priori arranged to do so with a probability of the order of 5 standard deviations from the mean. Thus, to obtain as much profitable information as possible, there should be as many drawing combinations with as many different detailed

restrictions as possible. One could easily make restrictions only for a limited number of years or one could restrict the number of Higgs particles produced according to some specific Monte Carlo program using, at that time, the best estimate for the mass of a Higgs particle. If one allows some irrelevant details to also result from the drawing, it is not a serious problem, since one will simply obtain a random answer concerning the irrelevant parameter. It would be much worse if our theory was correct and one missed the chance of extracting an important parameter, that could have been extracted from the drawing.

One should therefore also be careful when adjusting the relative a priori probabilities of the values for parameters one hopes to extract, so that one really extracts interesting information relative to theoretical expectations and does not simply obtain a certain result because one has adjusted the priori probability too much.

Concerning question 4), to determine the type of random number that can be most easily manipulated by our  $S_I$ -effect, we should extract information – but unfortunately very little information we suspect – to answer the question, by using several, or at least two, competing types of random numbers. One could, for instance, have one quantum mechanical random number generator and one card-drawing game. One could easily reduce the probability of a restriction in each of them by a factor of 2 so as to keep the total probability of obtaining a restriction at the initially prescribed level of 5 standard deviations. Then one should have two (or more) sources of random numbers, e.g., a genuine card-drawing game and a quantum random number generator, each with a very high probability that there will be no restrictions on the running of the LHC (for that type of random number) and only a tiny probability of some restriction (as already discussed with as many different ways of imposing a restriction as one can invent) of less than 5 standard deviations divided by the number of different types of random number, 2 in our example.

After having drawn a restriction from one of the types of random numbers, one would at least know that this type of random number was accessible for manipulation by our  $S_I$ -effect. Such information could be of theoretical value because one can potentially imagine that various detailed models based on our type of effect from a future model may give various predictions as to through which type of random number the  $S_I$ -effect can express itself. If, say, a model only allowed the  $S_I$ -effect through classical effects of the initial state of the universe but quantum experiments

gave fundamentally random or “fortuitous” [18] results that not even  $S_I$  could influence, then such a model would be falsified if  $S_I$ -effect produced the quantum number led to restrictions on the LHC.

One could also imagine that more detailed calculations would determine whether the effect from the future had to manifest itself not too far back in time. In that case one could perhaps invent a type of card game with cards that had been shuffled many years in advance, and one only used the first six cards in such stack of cards.

If it was the type of random number that came from stack shuffled years in advance that allowed the  $S_I$ -effect, then any type of detailed theory in which the effects of the future go only a short time interval back in time could be falsified.

## 2.4 Statistical cost estimate of experiment so far discussed

Let us now, as a first overview as to how risky it would be to perform a random number experiment, consider the simple proposal above:

The highest probability in the experiment is that no restrictions are imposed because we only propose restrictions with a probability of the order of  $10^{-6}$ . Even in the case of drawing a restriction, one then considers the distribution of, say, the beam energy restriction to be the  $\alpha$ th power of the beam energy. Here we think of  $\alpha$  being 1 or 2. This leads to the average allowed beam energy being reduced by  $\chi_{\text{LHC}} \cdot \langle(1 - X)\rangle$ , where  $X$  denotes the fraction of allowed beam relative to the maximum beam. In other words we call the highest allowed beam according to the card-drawing game  $X\chi_{\text{LHC}}$ . Then the average reduction in the case with  $10^{-6}$  probability that we get a reduction relative to the maximum beam  $\chi_{\text{LHC}}$  becomes

$$\begin{aligned}
 \langle 1 - X \rangle &= \frac{\int_{\text{Tevatron}}^{\text{LHC max}} X^{+\alpha}(1 - X)dX}{\int_{\text{Tevatron}}^{\text{LHC max}} X^{+\alpha}dX} \\
 &= \frac{\left(\frac{1}{-\alpha-1} - \frac{1}{-\alpha-2}\right) \chi_{\text{LHC}}}{\chi_{\text{LHC}} \frac{1}{-\alpha-1}} \\
 &= \frac{-\alpha - 2 - (-\alpha - 1)}{-\alpha - 2} \\
 &= \frac{1}{\alpha + 2}.
 \end{aligned} \tag{10}$$

For  $\alpha = 2$  we lose  $\frac{1}{4}$  of the maximum beam due to the restriction.

With the cost of the LHC machine estimated at 2 to 3 billion Swiss francs, the probability of a restriction  $r$  being  $10^{-6}$ , and the expected loss of the beam being  $\frac{1}{4}$ , the average cost of the card game experiment is of the order of 100 Swiss francs. However, of course there is, a priori, a risk. One shall, however, not mind if the “bad luck of drawing a restriction card” occurs, because in reality it is fantastically good luck because one would have discovered a fantastic and at first unbelievable effect from the future!

## 2.5 Attempts to further reduce the harm

One can, of course, seek to further bias the rules of the game so as to assign the highest probabilities to the restrictions causing least harm. For instance, one could allow a relatively high probability for restrictions of the type in which one is only allowed to operate the machine for a short time at its highest energy.

## 3 Competition determining the fate between different times

To determine how our effect from the future functions let us consider our imaginary Lagrangian model from a more theoretical viewpoint.

In the classical approximation of our model, we consider a first approximation such that

- 1) the classical solution is determined alone by extremizing the *real* part of the action  $S_R[path]$ , i.e.,

$$\delta S_R[path\ cl.sol.] = 0 . \tag{11}$$

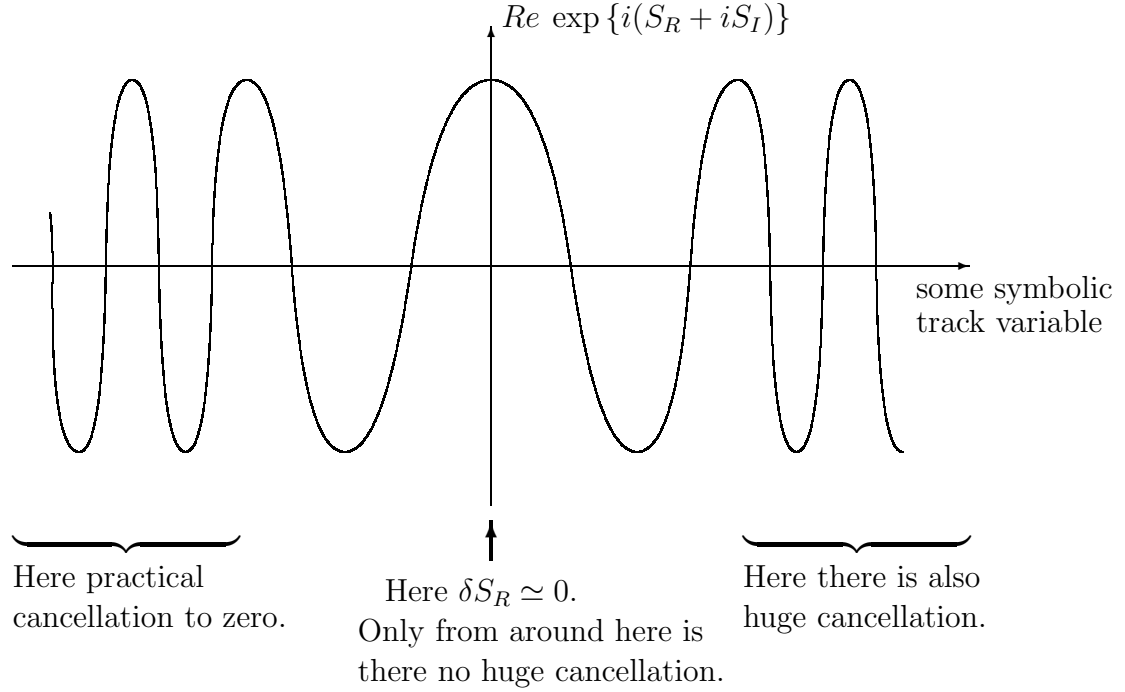
The reason for this is very simple. The real part  $S_R$  determines the phase variation of the integral in the Feynman pathway

$$\exp \{i (S_R + iS_I)\} , \tag{12}$$

and thus, it is only when  $S_R$  varies slowly, i.e., when  $\delta S_R \simeq 0$ , that we do not have huge cancellation because the rapid sign variation (phase rotation) cancels the contribution out.



We may illustrate this by the following drawing.



$S_I$  only results in a factor in the magnitude and leaves the phase of the integrand undisturbed.

- 2) The effect of  $S_I$  has a total weight of  $e^{-S_I[cl.sol.]}$  on the amplitude or Feynman path integral contribution, upon which one then inserts the solution to the classical equations of motion (i.e., to  $\delta S_R = 0$ ) for the path in the symbol  $S_I[path]$ . This means then that the probability that the classical solution “*cl.sol.*” exists is proportional to  $e^{-2S_I[cl.sol.]}$ . We have to square the amplitude to obtain the probability.

The probability density of  $e^{-2S_I[cl.sol.]}$  was referred to as  $P[cl.sol.]$  in our early works in the present series and, unless one adds special assumptions about  $S_I$ , it behaves as a function of the path, i.e., there is only notational difference between  $P[cl.sol.]$  in the early works and  $e^{-2S_I[cl.sol.]}$ , i.e.,

$$P[cl.sol.] = e^{-2S_I[cl.sol.]}. \quad (13)$$

### 3.1 The importance of competition between times on determining the fate of all times

Here we want to stress a very important effect that reduces the strength of the observable effect from the future in our model. We call this effect the competition between the different eras upon what shall happen in the universe. We have noted that the probability of a certain classical solution to the equations of motion  $\delta S_R = 0$  – the true track – is given by  $e^{-2S_I[cl.sol.]}$ , where the imaginary action  $S_I$  is *an integral over time*

$$S_I = \int L_I dt. \quad (14)$$

The important point here is that selecting a certain solution to the equations of motion in one period of time via the equations of motion in principle determines the solution at all times, both earlier and later. This is basically “determinism”; simply knowing the position and velocities of all the dynamical configurations of variables at one moment of time allows one, in principle, to integrate the equations of motion so as to obtain the solution at all times. This determinism may only be true in a principal or in an ideal way, since we know that, depending on the Lyapunov exponents, very small deviations between two solutions at one time can become huge at a later time. Also, extrapolation backward in time may also have the same effect. Furthermore, it is known that this determinism is challenged by the measurement postulates of randomness in quantum mechanics.

Nevertheless, there is certainly a strong restriction as to what can be obtained from a solution at one moment of time if it has already been used to make a small  $L_I$  at another time. The different regions in time are, so to speak, competing in the selection of the solution that gives the minimal contribution to  $\int_{\text{a time region}} L_I dt$  in the different time regions. Here, we simply draw attention to the “competitional” problem that the contribution to  $S_I$  from  $\int_{\text{Big Bang time}} L_I dt$  in Big Bang time does not usually make  $\int_{\text{our times}} L_I dt$  the minimal value. Thus, a compromise must occur between the different time eras so as to minimize

$$S_I = \int_{\text{all times}} L_I dt. \quad (15)$$

This means that even if one estimates a large effect of  $L_I$  in one era, it may not be easy to use this effect to determine the minimal  $L_I$  in our times or  $\int_{\text{our times}} L_I dt$ ,

because the enormously long time spans outside our own times will typically almost completely determine which solution to  $\delta S_R = 0$  will be selected that results in minimal  $S_I$ . Our own human lifetime only makes up an extremely small part of the  $10^{10}$  years in which the universe has already existed. Thus, much stronger  $S_I$ -contributions are needed to have any effect than would be required with a universe existing only for human-scale time.

In other words, practically everything about the solution obtained by minimizing  $S_I$  is determined by contributions from time intervals very far from the interval in which we know some history and have some memory of its significances. This means that we should observe extremely little effect from the future in practice. We would not be able to recognize much of any effect because most of the future as well as most of the past is so remote that we know exceedingly little about it.

We might recognize an effect from the future if some accelerator that is already planned is then stopped by Congress. However, if the accelerator is to be built in  $10^{10}$  years, we would most likely not know about the plans and be unable to recognize the effect from the future that causes its closure in  $10^{10}$  years from now.

We would only see such prearrangements as purely random and not as prearrangements. We can conclude that prearrangement is difficult to recognize unless you have knowledge of the plans that shall be accepted or rejected.

## 3.2 The rough mathematical picture

To get an idea of the significance of the competition between various time intervals on determining what is selected to be true solution of the classical equations of motion, we give a very rough description of the mathematics involved in minimizing  $S_I$  and in searching for a likely type of solution when we have the probability density  $e^{-2S_I}$  over phase space. One should bear in mind that the set of all classical solutions are in one-to-one correspondence with phase space points when a solution is given by integrating up -backward and forward- from a certain standard moment  $t_0$ .

We should take  $S_I$  to be an integral or a sum over a large number of small time intervals  $\sum_i \int_{I_i} L_I dt$ . Each of these small contributions  $\int_{I_i} L_I dt$  may be taken as a random function written as a Fourier series over phase space in the very rough approximation for the first orientation. We even assume for the first orientation that we have a random form of  $L_I(t_i)$  or, approximately equivalently,  $\int_{I_i} L_I dt$  remains

of the same form with the same probability of having different values after being transformed to the standard moment  $t_0$  by using the canonical transformations associated with the Hamiltonian derived from the real part of the action  $S_R$ . That is to say, in the phase space variables  $(\vec{q}_0, \vec{p}_0)$  at time  $t_0$ , each of the contributions  $\int_{I_i} L_I dt$  is a stochastic variable function over phase space that can be expressed as

$$\int_{I_i} L_I dt = \sum c(\vec{k}^{(q)}, \vec{k}^{(p)}) \cdot e^{i\vec{k}^{(q)} \cdot \vec{q} + i\vec{k}^{(p)} \cdot \vec{p}}, \quad (16)$$

where we require

$$c(-\vec{k}^{(q)}, -\vec{k}^{(p)})^* = c(\vec{k}^{(q)}, \vec{k}^{(p)}). \quad (17)$$

We take the real and imaginary parts of the  $c(\vec{k}^{(q)}, \vec{k}^{(p)})$  to have a Gaussian distribution with the spread

$$\begin{aligned} \langle \left\{ \text{Re } c(\vec{k}^{(q)}, \vec{k}^{(p)}) \right\}^2 \rangle &= \sigma_r(\vec{k}^{(q)}, \vec{k}^{(p)}), \\ \langle \left\{ \text{Im } c(\vec{k}^{(q)}, \vec{k}^{(p)}) \right\}^2 \rangle &= \sigma_i(\vec{k}^{(q)}, \vec{k}^{(p)}). \end{aligned} \quad (18)$$

Since it is a rough model, we shall not go into details of how to choose  $\sigma_r$  and  $\sigma_i$ , but imagine that we have a cutoff that effectively separates large  $\vec{k}^{(p)}$  and  $\vec{k}^{(q)}$  regions. Also we would like to roughly take each  $\int_{I_i} L_I dt$  to be periodic in the phase space variables  $\vec{q}$  and  $\vec{p}$  so that we effectively use a Fourier series. The period is a cutoff in phase space  $\Lambda_{phs}$ , and the cutoff in  $\vec{k}^{(q)}$  and  $\vec{k}^{(p)}$ , say  $\Lambda_k$ , separates the rapid variations of  $\int_{I_i} L_I dt$  over the phase space. There is, thus, effectively a number of independent phase space points  $(\Lambda_k/\Lambda_{phs})^N$  in which  $\int_{I_i} L_I dt$  can take its values. Here  $N$  is the number of degrees of freedom. The statistical distribution for one of the  $\int_{I_i} L_I dt$  in one of these effective phase space points is assumed to be Gaussian with a mean square deviation of

$$\sigma_r = \sum_{\vec{k}^{(p)}, \vec{k}^{(q)}} \sigma_r(\vec{k}^{(q)}, \vec{k}^{(p)}) \simeq \left( \frac{\Lambda_k}{\Lambda_{phs}} \right)^N \cdot \sigma_r, \quad (19)$$

where  $\sigma_r$  is a typical value for  $\sigma_r(\vec{k}^{(q)}, \vec{k}^{(p)})$ . The contribution from the imaginary part is of the same order, and we ignore a factor of 2 here.

When we search for  $S_I = \sum_i^{n_{step}} \int_{I_i} L_I dt$ , we again have a Gaussian distribution since each  $L_{I_i}$  has, by assumption, independent Gaussians. But if there are  $n_{step}$

time steps of type  $I_i$  then the distribution of  $S_I$  becomes broader than that of  $\int_{I_i} L_I dt$  by a factor of  $\sqrt{n_{step}}$ . That is to say,  $S_I$  is of the order  $\sqrt{n_{step}} \cdot \sigma_r$ .

The mathematical picture, we have constructed is summarized by the following two points:

- 1) There are  $(\Lambda_k/\Lambda_{phs})^N$  classical path solutions, or equivalently  $(\Lambda_k/\Lambda_{phs})^N$  possible ways that the universe could have started and subsequently developed.
- 2)  $S_I$  for each of these developments has a Gaussian distribution with a mean square deviation of  $n_{step}\sigma_r$ .

Our model postulates that the probability of the realization of a classical solution is weighted by  $P = e^{-2S_I}$ .

This extra effect of our model converts the distribution of what from a Gaussian of the form

$$\exp\left(-\frac{S_I^2}{2n_{step} \cdot \sigma_r}\right) \quad (20)$$

into a distribution of the form

$$\exp\left(-\frac{S_I^2}{2n_{step} \cdot \sigma_r} - 2S_I\right). \quad (21)$$

Equation (21) implies that the realistic or most likely  $S_I$ -value for the chosen development of the universe should be realized by maximizing the exponent

$$-\frac{S_I^2}{2n_{step} \cdot \sigma_r} - 2S_I \quad (22)$$

in this probability distribution.

The maximum occurs when

$$S_I \simeq n_{step}\sigma. \quad (23)$$

The actual development of the universe will not have exactly this value  $n_{step}\sigma$  for  $S_I$ , but a value typically deviating by the order  $\sqrt{n_{step}\sigma}$ .

Now let us imagine that in our time, say, in one of the intervals  $I_i$ , we look for a special occurrence that may give an extra contribution  $\Delta S_{I \text{ extra}}$  to  $S_I$ . It is easy to see that compared with the probability without this contribution, the probability with the  $\Delta S_{I \text{ extra}}$  contribution should be  $e^{-2\Delta S_{I \text{ extra}}}$  times high. However, the question is whether we would realistically notice this effect.

To detect our  $S_I$ -effect we might carry out a card-drawing experiment by turning a card, which if black we let the experiment giving  $\Delta S_{I \text{ extra}}$  be performed, and if red we do not perform it. We first imagine, for the sake of argument, that the extra  $L_I$  contribution is switched off by not there at all. Then, for symmetry reasons, the probabilities of red and black should both be  $\frac{1}{2}$ .

Thus, it would appear that the result of black or red would be dominantly determined from what happens in other time intervals rather than in “our time”, in the sense that the contribution to the fluctuation in  $S_I$  from times other than ours would be

$$\Delta S_{I \text{ fluctuation}} \Big|_{\text{from other times}} = \sqrt{(n_{\text{step}} - 1)\sigma}. \quad (24)$$

This effect of the contributions from these other times, which we cannot treat scientifically or understand or know anything significant about, will give an  $S_I$ -contribution of the order  $\sqrt{(n_{\text{step}} - 1)\sigma} \sim \sqrt{n_{\text{step}}\sigma}$ , to which the extra contribution  $\Delta S_{I \text{ extra}}$  has to be compared when it is switched on.

Let us first estimate what we would be an ordinary value of  $\Delta S_{I \text{ extra}}$  relative to  $\sqrt{\sigma}$ . Since we not only live in a short accessible time but also in a small accessible spatial region, we should take an ordinary order of magnitude for  $\Delta S_{I \text{ extra}}$  of  $\sqrt{\sigma \cdot \frac{V_{\text{acc}}}{V_{\text{univ}}}}$ , where  $V_{\text{acc}}$  is the part of the universe controllable by our card game and  $V_{\text{univ}}$  is the total effective volume of the universe.

Thus, the “ordinary” value for  $\Delta S_{I \text{ extra}}$  is

$$\Delta S_{I \text{ extra}} \Big|_{\text{ordinary}} \sim \sqrt{\sigma \cdot \frac{V_{\text{acc}}}{V_{\text{univ}}}}, \quad (25)$$

which is to be compared with

$$\Delta S_{I \text{ fluctuation}} \sim \sqrt{n_{\text{step}}\sigma}. \quad (26)$$

This gives

$$\frac{\Delta S_{I \text{ extra}} \Big|_{\text{ordinary}}}{\Delta S_{I \text{ fluctuation}}} \simeq \sqrt{\frac{V_{\text{acc}}}{n_{\text{step}}V_{\text{univ}}}}, \quad (27)$$

which means the square root of the universe accessible by the card game part of space time relative to the full space time of the universe.

If we use a weak scale to give us the region in space time in which a Higgs particle contributes  $l_W \sim \frac{1}{100 \text{ GeV}} \sim 2 \times 10^{-3} \text{ fm} \sim 10^{-26} \text{ s}$  while the extension of the reachable universe and its lifetime is taken to be  $10^{17} \text{ s}$  then

$$\frac{V_{acc}}{n_{step} V_{univ}} \sim \left( \frac{10^{-26} \text{ s}}{10^{17} \text{ s}} \right)^4 = 10^{-172}. \quad (28)$$

This would give us  $10^{-86}$  as the quantity that must be compensated by having an extraordinary size of  $L_I$  to obtain any recognizable effect. Now if, as is quite likely, the hierarchy-problem-related fine tuning of the square of the Higgs mass should only be for the real part  $m_{HR}^2$  of the square of the mass, while the imaginary part  $m_{HI}^2$  of the  $|\phi_H|^2$ -coefficient is of the Planck scale order of magnitude,  $m_{HI}^2 \sim (10^{19} \text{ GeV})^2$ , then the ratio of  $\Delta S_{I_{extra}}$  relative to  $\Delta S_{I_{ordinary}}$  from the  $m_{HI}^2$ -term would be expected to be of the order of

$$\frac{m_{HI}^2}{m_{HR}^2} \sim 10^{34} \quad (29)$$

times bigger than “ordinary”  $S_I$ -contribution. This would not be enough to compensate the  $10^{-172}$ , but the latter might be very many orders of magnitude wrong for several reasons, as we shall now discuss in the next subsection.

### 3.3 What value to take for an effective $\frac{V_{acc}}{n_{step} V_{univ}}$ ?

One could say:

- 1) The card game result is mainly connected with the earth as far as its development and dependence is concerned. Thus we should reduce the effective universe size  $V_{univ}$  to be that of the earth, i.e., a length scale of  $10^7 \text{ m} \sim 3 \times 10^{-2} \text{ s}$  rather than the  $10^{17} \text{ s}$  in the above estimation.
- 2) If we compare the situation on earth events only really occur in the atoms, and if something happens at a weak scale when Higgs particles are present it may seem reasonable that each Higgs particle has as many degrees of freedom as an atom and should be assigned in our estimate space having an as atomic size, i.e.,  $\sim 10^{-10} \text{ m} \sim \frac{1}{3} \times 10^{-18} \text{ s}$ .

From only these two corrections we would obtain

$$\left. \frac{V_{acc}}{V_{univ}} \right|_{\text{eff}} \sim \left( \frac{\frac{1}{3} \times 10^{-18} \text{ s}}{3 \times 10^{-2} \text{ s}} \right)^3 \simeq 10^{-45}. \quad (30)$$

3) We might also have to count the lifetime of the Higgs particle as closer to  $\frac{1}{\text{MeV}}$  than  $\frac{1}{100 \text{ GeV}}$  meaning that  $n_{step}$  would decrease from  $n_{step} \sim \frac{10^{17} \text{ s}}{10^{-26} \text{ s}} \simeq 10^{43}$  to  $n_{step} \sim \frac{10^{17} \text{ s}}{10^{-21} \text{ s}} \simeq 10^{38}$ . This would increase the square root to  $\sqrt{\frac{V_{acc}}{n_{step} V_{univ}}} \simeq \sqrt{\frac{10^{-45}}{10^{38}}} \simeq \sqrt{10^{-83}} \simeq 10^{-41.5}$ . Then we would only lack a factor of  $\frac{10^{41.5}}{10^{34}} = 10^{7.5}$ , which may be able to compete in producing a significant value of  $\Delta S_{I \text{ extra}}$  due to the existence of many Higgs particles.

4) If, for instance, we could replace the whole lifetime of the universe by some inverse Lyapunov exponent for political activities, i.e., the time in which exceedingly small effects develop into politically important decisions, say a few years, then we could effectively reduce  $n_{step}$  by a factor  $10^9$  and we would need  $10^{4.5}$  times less compensation.

This would mean that we might only need to produce  $10^3$  Higgs particles in an accelerator for it to be enough that the SSC would be canceled by our model.

In the light of the huge uncertainties even in the logarithm of these estimates and the closeness to the achievements of the LHC of our relevant scale, it is clear that a much better estimation to the extent that such an estimate is possible is called for.

### 3.4 Baryon destruction

Let us bring attention here to an effect in our model that will potentially be much more important than the Higgs particle production in the SSC: baryon destruction. Since the quarks in the baryons couple to the Higgs particle field, which decreases it numerically to close to that of the quark or baryon, they function as a tiny negative number of Higgs particles. However, in contrast to the Higgs particle itself, the baryon effectively lives eternally. Thus, if one produces an accelerator that has sufficiently high energy that it can violate the baryon number, then it may affect the Higgs field more than genuine Higgs particles. Indeed, the  $|\phi_H|^2$ -charge by  $d$  quark may typically be of the order of  $|g_d|^2$  times that of a genuine Higgs charge. However, since the baryon lives eternally, we gain a lifetime factor of  $\frac{10^7 \text{ s}}{10^{-21} \text{ s}} = 10^{38}$ , which hugely overcompensates for  $|g_d|^2 \sim (10^{-5})^2 = 10^{-10}$ . Thus, the destruction of a single baryon should be about as  $S_I$ -significant as  $10^{28}$  Higgs



particles. This estimate would result in the borderline significance of the Higgs particle being converted into an absolute necessity for the SSC to be canceled.

Now we might even ask whether our first estimate

$$\sqrt{\frac{V_{acc}}{n_{step}V_{univ}}}\Bigg|_{\text{first}} \simeq 10^{-86} \quad (31)$$

would allow there to be  $S_I$ -effects resulting from baryon destruction. Because of the extremely long baryon lifetime compared with the Higgs particle, the effect of  $\Delta S_{I\text{ extra}}$  increased by a factor of  $10^{28}$  upon the destruction of a baryon. This would convert  $m_{HI}^2/m_{HR}^2 \sim 10^{34}$  into a factor greater than the “ordinary” one,  $10^{34+28} = 10^{62}$ . Even that would not be sufficient to compensate for  $10^{-86}$ .

However, even one of the above corrections results in a change from the weak size to the atomic size, thereby increasing  $V_{acc}$  by a factor of  $(10^7)^3$ , and thus increasing  $\sqrt{\frac{V_{acc}}{n_{step}V_{univ}}}$  by a factor of  $10^{10.5}$  or perhaps more correctly, using the distance between the atoms in the universe, resulting in yet another increase by a similar factor  $\sqrt{(10^8)^3} = 10^{12}$ . Indeed, we would then have  $\sqrt{\frac{V_{acc}}{n_{step}V_{univ}}} \sim 10^{-65}$ , so that the  $10^{62}$  could cope if the the SSC had destroyed only  $10^3$  baryons. However, if the baryon destruction resulted in the cancellation of the SSC, then the LHC is not in danger because there will presumably be no baryon destruction at the LHC. Presumably there would not even have been in the SSC.

## 4 Conclusion

We first reviewed our model with an imaginary action to be inserted into the Feynman pathway integral. It seems a bit artificial to assume that the action  $S$  in the integrand  $e^{\frac{i}{\hbar}S}$  should be wholly real when the integrand itself is clearly complex. We claim that such an imaginary part  $S_I[path]$  in the action  $S = S_R + iS_I$  does not influence the classical equations of motion  $\delta S_R = 0$ , but rather manifests itself by determining the initial conditions for the development of the universe. Indeed, the various classical solutions that contribute to the Feynman pathway integral are weighted by an extra factor  $e^{-S_I[path]}$ , which leads to a probability weight of  $P = e^{-2S_I[path]}$ .

The main discussion in the present article was on the development of an earlier proposal [1] for how to search for the effects on the determination of initial conditions

of such an imaginary action term  $S_I[path]$ . From this viewpoint, the most remarkable fact is that this imaginary part  $S_I$ , in analogy with the real part  $S_R$ , is given as an integral

$$S_I = \int L_I dt \quad (32)$$

over all times and thus depends on the fields or dynamical variables not only in the past but at all times. Thereby, the discussion became focused on searching for effects from the initial conditions, which have been adjusted so as to take into account what should happen or should not happen at a much later time.

Because of the very high probability that, in contrast to the real part  $m_{HR}^2$  of the coefficient  $m_H^2 = m_{HR}^2 + im_{HI}^2$  of the expression  $|\phi_H|^2$  in the Higgs field  $\phi_H(x)$  part of the Lagrangian density  $\mathcal{L}(x) = \mathcal{L}_R(x) + i\mathcal{L}_I(x)$ , the imaginary part  $m_{HI}^2$  was not fine tuned to be exceedingly small compared with the fundamental scale. It was suggested that  $m_{HI}^2$  is likely to be huge compared with  $m_{HR}^2$ . We refer here to the problem behind the so-called hierarchy problem associated with the fact that the weak-energy scale given by  $m_{HR}^2$  is very small compared with, say, the Planck scale. Since the reason for this fine tuning of  $m_{HR}^2$  to a small value is still unknown, it may be equally likely that the mechanism for this fine tuning would also tune  $m_{HI}^2$  to a small value or leave it at the Planck scale. It is therefore very likely that there is an imaginary action for which the ratio between the corresponding coefficients in the imaginary part  $S_I$  and the real part  $S_R$  would be unusually large in the case of the Higgs mass square say

$$\frac{m_{HI}^2}{m_{HR}^2} \sim 10^{34}. \quad (33)$$

This possibility makes it likely that particularly large effects of  $S_I$  can be found, and thus, cases of the future influencing even the initial conditions, and thus the past may occur when the Higgs mass square term is involved. In almost all investigations of the Standard Model so far, the Higgs mass square term  $(m_{HR}^2 + im_{HI}^2)|\phi_H|^2$  is only involved via the Higgs field vacuum expectation value  $\langle\phi_H\rangle$ , which is determined only from the real part  $m_{HR}^2$ . Thus, we may have to wait for genuine Higgs-particle-producing machines to search for the effects of the huge expected imaginary part  $m_{HI}^2$  of the Higgs mass square. Alternatively, we would have to search for the effects of previously observed particles, such as quarks or leptons, on the Higgs field, by a back reaction which give a contribution proportional to  $m_{HI}^2$  to  $S_I$ .

One such effect could be caused by an accelerator able to violate the conservation of the baryon number [19] and presumably destroy more baryons than it creates. Then, the width  $|g_d|^2$  – the quark Yukawa coupling squared – which is proportional to the suppression of the Higgs field around the baryon or the quark would be lost for the rest of the existence of the universe. This effect of having a baryon being destroyed forever while a Higgs particle has only a short lifetime overcompensates for the Yukawa coupling suppression so that the effect of a baryon being destroyed on  $S_I$  is presumably much bigger – by say  $10^{28}$  – than that of the creation of a genuine Higgs particle. Nevertheless, our estimates of these effects are at the moment so approximate that it is uncertain whether the  $S_I$ -effect would be sufficient for preventing Higgs production; thus, we predict possibly that the initial state would have been organized somehow so that a large Higgs-particle-producing machine such as the LHC should somehow be prearranged so as not to come into existence.

Such an effect would, of course, be even stronger for the the terminated SSC machine in Texas since it would not only have produced more Higgs particles but also perhaps have destroyed some baryons.

From the LHC-threatening perspective, the main point of the present article is that the LHC should really not be allowed to operate at full intensity or beam energy by these effects on the initial state due to  $S_I$ . In order to obtain as much knowledge and as little loss as possible out of this otherwise problematic event. We then propose our card or random number experiment.

Our main proposal was to perform a quantum random number or card-drawing experiment, with both “old” and “new” random numbers, meaning that the random numbers are created at longer or shorter times before the LHC is switched on, and then let the value of this random number determine the restrictions on the running of the LHC.

It should be stressed that this whole process of closing random numbers to decide the fate of the LHC should be arranged so that it is by far the most likely that no restrictions are imposed at all. Only if there is some mysterious effect such as the  $S_I$ -effect in our model, which might have prearranged the initial state so as to prevent the LHC from operating, should there be any significant chance of obtaining anything apart from “everything is allowed for the LHC”. In this way, if any restriction was indeed drawn by the card or by the quantum random number generator

then this would, a priori, be so unlikely that such a drawing would immediately justify our type of model. Such a result would be so miraculous that it would require a new set of physical laws.

Thus, we stress that if such a restriction is drawn, we should arrange matters so that the exact value of the drawing tells us as much as possible about the details of the theory on the effect from the future, which is justified merely by the selection of a restriction-requiring card.

This extraction of extra information from the drawing should have three features:

- 1) One should use different types of random numbers such as a) cards shuffled recently, b) cards shuffled long ago, c) quantum random numbers made immediately before the decision, and d) quantum random numbers made in advance. Then one can determine which type of random number – old/recent, card-drawing game/quantum – is the easiest for the  $S_I$ -effect to manipulate so as to carry out the desired task of stopping or restricting the LHC.
- 2) One would like to know which parameters of the machine are important in terms of the  $S_I$ -effect. We should arrange the experiment so that, for all the different types of random numbers, there are appreciably higher a priori probabilities (i.e., higher numbers of card combinations) of mild restrictions than of strong restrictions. By designing the game in this way, we can learn from the result which restriction is really needed for causing any effect backward in time. The trial is of course also economical in the sense that we would thereby only obtain a result giving the minimal restriction needed to verify our theory; for example, this may be that only high luminosity combined with the highest energy in the beams would be forbidden by the card, but many of other combinations of operational parameters would be allowed. This would then cause minimum disruption to the program at the LHC.
- 3) The most important result from the card-drawing experiment or random number selection if our model turned out to be correct may be that we would obtain a controllable estimate of its reliability. Of course, one would become convinced of a model of our type in which Higgs particles or baryon destruction affect the past if something happened so that the LHC was prevented from operating. However, if this was not due to a controlled card-drawing or

random number game, one could always claim that the cooling system was defective, or that the failure was due to the political circumstances of some physicists or because of a war or an earthquake. However, the  $S_I$ -effect would always have to use some natural effect to cause the effective restriction. Thus, there will always be alternative reasons that may account for the failure of the plant. The main point, of course, is that if our model is not true then by the far the most likely outcome is that the LHC will simply start operating next year. Thus, if something happens to prevent the LHC from operation, then we should believe our theory, but to obtain a more easily estimable basis for the degree of belief if a failure or restriction occurred, we should carry out a fully controlled experiment involving random numbers, and if we had assigned an extremely low probability to the restriction that occurred, we would obtain valuable information about the  $S_I$ -effect.

Of course, there is the “danger” that by making the probability of an experimental restriction extremely low, it becomes more likely that if our theory was correct that, in spite of the selection, something else (the cooling system not working, an earthquake, etc.) would stop the machine.

In the present article we have also derived a very rough estimation of the amount of extra  $S_I$ , called  $\Delta S_{I \text{ extra}}$ , that is needed to be significant enough to produce observable effects. So far, these estimates are so approximate that we cannot say that, even if our model was in principle correct, it would have sufficiently strong effects associated with the Higgs particle that it would actually lead to a closure or restriction of the LHC. We concluded from the approximation that the effect of the destruction of baryons, which has been speculated [19] would have occurred at the SSC, would be much stronger than the effect of Higgs particles. However, in our first estimate, uncertainties were so high that we cannot even claim that if our theory was in principle correct, an accelerator causing baryon destruction would definitely have to be closed (by some sort of “miraculous” effect).

We think that we may be able to produce a somewhat better estimate, but Lyapunov exponents in the real world, which includes political decisions, may be difficult to estimate. Of course, the real uncertainty is whether our model is true, even in principle. To establish the truth of such models, successful

cosmological predictions are hoped for. We are on the way to obtaining some predictions concerning the neutron lifetime by considering the order of the capture time in Big Bang nuclear synthesis, and the ratio of dark energy density to full energy density, which is estimated to be around  $2/3$  to  $3/4$ . In fact, predictions are being made for essentially the whole process of cosmological development except for the first inflation itself.

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