ISSN 1330–0016
CODEN FIZBE7

PROBING FOR COMPOSITENESS, DISCRETE TIME EFFECTS AND MARKOV ENVIROMENTAL INFLUENCES USING SPIN POLARIZATION PRECESSION

CARL WOLF

Department of Physics, North Adams State College, North Adams, MA 01247, U.S.A.

Received 18 May 1995

UDC 538.145

PACS 03.65.-w

By considering a spin-one particle precession in a magnetic field, we demonstrate that if very refined measurements were made of both the precession frequency and the amplitude of spin polarization, these measurements could be used to probe for compositeness of gauge bosons, discrete time effects and possible Markov environmental effects.

1. *Introduction*

Certainly the last twenty years of particle physics have been fruitful in achieving unification of the fundamental interactions in the presence of the standard $SU(3)_C \times SU(2)_L \times U(1)_Y$ model in a certain sense of the word [1]. Despite this unification, there still is room for further speculation regarding the nature of a more predictive and less phenomenological theory. The guest for the origin of the generation structure, the origin of the fermion masses and the quark mixing matrix all suggest that perhaps the standard model is but a clue to the correct theory [2]. Along with these questions, the source of CP violation and the chiral structure of the weak interactions also prod us to look for new physics beyond the standard model [3]. Because the fermion masses are small compared to the electroweak breaking scale, it suggests that perhaps the group $\mathrm{SU}(3)_C \times \mathrm{SU}(2)_L \times \mathrm{U}(1)_Y$ is contained in a GUT group, with perhaps a horizontal symmetry adjoined to the standard model protecting the masses of the quarks and leptons from acquiring large values. Such a candidate generation unification group could be anyone of the orthogonal groups [4]. In addition to this possibility, there also exists the possibility of a unifying technicolour theory [5] as well as a unifying composite theory [6]. Compositeness seems like a most fundamental approach, since all systems (atoms, nuclei and hadrons) have thus far admitted to a composite structure. Two of the most popular schemes are the rishon model [7] and the scalar-fermion scheme of Fritzsch and Mandelbaum [8]. In Ref. 6 there are numerous other composite schemes discussed. Some schemes consider quarks and leptons as composite, while other also consider gauge bosons and Higgs particles as composite [9]. The experimental problem is to probe for compositeness using form factors, anomalous moments and rare decays [10].

Another approach to probing composite structure, that we have discussed in the past, is to consider the fact that at some scale both space and time become grainy and discrete-like [11]. In this regard, we have discussed both the composite structure of leptons [12] and gauge bosons [13] using the discrete nature of time in spin polarization precession measurements. In another study, we have shown how the discrete nature of time can be used to probe for internal hidden quantum numbers within an elementary particle [14]. In a recent paper, we have discussed the spin polarization precession of a spin-1/2 particle using different types of discrete time theories, along with a theory that admits Markov discrete-time jump processes [15]. This study suggests that the Markov process adjoined to the usual quantum theory might generate chaotic fluctuations in the spin-polarization amplitude.

In what follows, we discuss the spin polarization precession of a spin-one particle in a variety of theories. The first is the usual Schrödinger theory which cannot be used to probe for composite structure. The second theory is the Schrödinger theory adjoined to a Markov influence on the underlying preon dynamics. The third theory is a pure spin-1 Schrödinger theory with Markov influences. The distinction between the second and third theory will be found in the different chaotic effects on the spin polarization amplitude. The fourth theory is a discrete time difference theory with a composite structure of the spin-1 gauge boson. This theory can be used to probe for compositness. In theories two and three if Markov influences are present then the second and third theories can be used to distinguish between a pure spin-1 theory and a composite spin-1 theory through a study of the experimental temporal behaviour of the spin polarization amplitude.

2. *Probing for compositness, discrete time effects and Markov influences*

To begin our analysis, we consider a model of w^- (spin-1) gauge boson as consisting of two spin-1/2 preons, each of charge $-e_p = -e/2$ (e = magnitude of electronic charge), held together by a hypercolour spin-spin coupling [16]. For two preons in an external z-component magnetic field B, the hamiltonian reads

$$H = M_0c^2 + \frac{p_1^2}{2m} + \frac{p_2^2}{2m} + \frac{e_p}{m}S_{z1}B + \frac{e_p}{m}S_{z2}B + g\mathbf{S}_1 \cdot \mathbf{S}_2 \qquad (1)$$

where M_0c^2 = rest mass parameter, m = heavy preon mass, $q = -e_p = -e/2$ = charge of each preon, S_{z1}, S_{z2} = z component spin matrices and g = spin-spin coupling constant.

The Schrödinger equation reads

$$H\Psi = \mathrm{i}\hbar\frac{\partial\Psi}{\partial t}, \qquad \Psi = U(x_1, x_2)\alpha\alpha T(t). \qquad (2)$$

Here we first consider the two preons in an $S_z = 1$ state. Equations (1) and (2) give for the eigenstate in Eq. (2)

$$\left(M_0c^2 - \frac{\hbar^2}{2m}\frac{\partial^2}{\partial x_1^2} - \frac{\hbar^2}{2m}\frac{\partial^2}{\partial x_2^2}\right)U(x_1, x_2) = E_1U(x_1, x_2), \qquad (3)$$

$$\left[\frac{e_p}{m}(S_{z_1} + S_{z_2})B + g\mathbf{S}_1 \cdot \mathbf{S}_2\right]\alpha\alpha = E_2\alpha\alpha \qquad (4)$$

$$(E_1 + E_2)T(t) = \mathrm{i}\hbar\frac{\partial T}{\partial t}. \qquad (5)$$

For the spatial equation we consider the infinite square well

$$V = 0 \text{ for } 0 \leq x \leq L \text{ and } V = \infty \text{ for } -\infty < x < 0 \text{ and } L < x < \infty.$$

The antisymmetric spatial function is

$$E_1 = M_0c^2 + \frac{n_1^2h^2}{8mL^2} + \frac{n_2^2h^2}{8mL^2},$$

$$U(x_1, x_2) = \frac{1}{\sqrt{2}}\left(\frac{2}{L}\sin\frac{n_1\pi x_1}{L}\sin\frac{n_2\pi x_2}{L} - \frac{2}{L}\sin\frac{n_1\pi x_2}{L}\sin\frac{n_2\pi x_1}{L}\right). \qquad (6)$$

From Eq. (4), we have

$$\Psi_S = \alpha\alpha,$$

$$E_2 = \frac{e_p}{m}\hbar B + \frac{g\hbar^2}{4}. \qquad (7)$$

The total energy is

$$E_+ = M_0c^2 + \frac{n_1^2h^2}{8mL^2} + \frac{n_2^2h^2}{8mL^2} + \frac{e_p}{m}\hbar B + \frac{g\hbar^2}{4}. \qquad (8)$$

The solution to Eq. (5) is

$$T(t) = \mathrm{e}^{-\mathrm{i}E_+ t/\hbar}.$$

Thus

$$\Psi_+(x_1, x_2, S_{z_1}, S_{z_2}, t) = U(x_1, x_2)\alpha\alpha\mathrm{e}^{-\mathrm{i}E_+ t/\hbar}. \tag{9}$$

Similarly for the $S_z = 0$ and $S_z =$ -1 states

$$\Psi_0 = U(x_1, x_2)\frac{1}{\sqrt{2}}(\alpha\beta + \beta\alpha)\mathrm{e}^{-\mathrm{i}E_0 t/\hbar} \tag{10}$$

with

$$E_0 = M_0 c^2 + \frac{n_1^2 h^2}{8mL^2} + \frac{n_2^2 h^2}{8mL^2} + \frac{g\hbar^2}{4} \tag{11}$$

and

$$\Psi_- = U(x_1, x_2)\beta\beta\mathrm{e}^{-\mathrm{i}E_- t/\hbar} \tag{12}$$

$$E_+ = M_0 c^2 + \frac{n_1^2 h^2}{8mL^2} + \frac{n_2^2 h^2}{8mL^2} - \frac{e_p}{m}\hbar B + \frac{g\hbar^2}{4}. \tag{13}$$

Note that in Eqs. (9), (10) and (12), the spatial function is the same in each case. We now construct a linear combination of Eqs. (9), (10) and (12) so that

$$\langle S_{x_1} + S_{x_2}\rangle_{t=0} = \hbar. \tag{14}$$

This linear combination is

$$\Psi = \left(\frac{1}{2}\alpha\alpha\mathrm{e}^{-\mathrm{i}E_+ t/\hbar} + \frac{1}{2}\beta\beta\mathrm{e}^{-\mathrm{i}E_- t/\hbar} + \frac{1}{\sqrt{2}}\left(\frac{\alpha\beta + \beta\alpha}{\sqrt{2}}\right)\mathrm{e}^{-\mathrm{i}E_0 t/\hbar}\right) U(x_1, x_2). \tag{15}$$

When we evaluate $\langle S_{x_1} + S_{x_2}\rangle_t$ using Eq. (15), we integrate over the spatial coordinates x_1, x_2 from 0 to L; we obtain

$$\int_0^L\int_0^L \Psi^+(S_{x_1} + S_{x_2})\Psi \mathrm{d}x_1\mathrm{d}x_2 = \hbar\cos\frac{e_p B}{m}t. \tag{16}$$

We now let $e_p = e/2$, $m = M_w/2$ (heavy preon mass = 1/2 gauge boson mass) and Eq. (16) gives

$$\langle S_{x_1} + S_{x_2}\rangle_+ = \hbar\cos\frac{eB}{M_w}t. \tag{17}$$

Eq. (17) represents the expected value of the x spin polarization with $\omega = eB/M_w$. Eq. (17) in no way reveals any composite structure of w^-. We next consider the

Markov influence on the individual preondynamics, if each preon has an initial probability of being up and down of 1/2, 1/2, respectively, we have after n steps [17] (n discrete time steps) for the probability of up and down $P(+)_n, P(-)_n$

$$P(+)_n = \frac{p}{p+q} + (1-p-q)^n \left(\frac{1}{2} - \frac{p}{p+q} \right),$$

$$P(+)_n = \frac{q}{p+q} + (1-p-q)^n \left(\frac{1}{2} - \frac{q}{p+q} \right). \tag{18}$$

Here p = probability of a spin-flip down to up in the external B-field and q = probability of a spin-flip up to down in the external B-field

We now modify Eq. (15) to read

$$\Psi = \sqrt{P(+)_n P(+)_n} \alpha\alpha \mathrm{e}^{-\mathrm{i}E_+ t/\hbar} + \sqrt{P(-)_n P(-)_n} \beta\beta \mathrm{e}^{-\mathrm{i}E_- t/\hbar}$$
$$+ \left(\sqrt{P(+)_n P(-)_n} \alpha\beta + \sqrt{P(-)_n P(+)_n} \beta\alpha \right) \mathrm{e}^{-\mathrm{i}E_0 t/\hbar}. \tag{19}$$

Here $P(+)_n, P(-)_n$ are the same for both preons, also since $P_0(+) = P_0(-) = \frac{1}{2}$. Eq. (19) reduces to Eq. (15) at $n = 0$. Evaluating $\langle S_{x_1} + S_{x_2} \rangle$ using Eq. (19), we obtain (again we integrate over the spatial coordinates)

$$\langle S_{x_1} + S_{x_2} \rangle = 2\hbar \cos \frac{e_p B}{m} t \left[\sqrt{P(+)_n^3 P(-)_n} + \sqrt{P(-)_n^3 P(+)_n} \right]. \tag{20}$$

Again, if we set $e_p = e/2$, $m = M_w/2$, Eq. (20) reduces to

$$\langle S_{x_1} + S_{x_2} \rangle = 2\hbar \cos \frac{eB}{M_w} t \left[\sqrt{P(+)_n^3 P(-)_n} + \sqrt{P(-)_n^3 P(+)_n} \right]. \tag{21}$$

Now, Eq. (21) represents the x spin polarization with a chaotic varying amplitude and frequency $\omega = eB/M_w$. Note that p, q can depend on B and thus the amplitude can vary with B. Also, if $p = q$, then for large time Eq. (21) becomes

$$\langle S_{x_1} + S_{x_2} \rangle = \hbar \cos \frac{eB}{M_w} t. \tag{22}$$

The assumption $p = q = 1/2$ for large time suggests a certain statistical equilibrium that is established for an ensamble of spins plus magnetic field. It also suggests that the Markov process might only by operative right after the application of the field. It would suggest that the chaotic fluctuation in Eq. (21) would have to be measured for very small times (low n). If we now assume a pure spin-1 theory for gauge bosons, we have the hamiltonian (no spatial effects)

$$H = M_0 c^2 + \frac{e}{M_w} S_z B. \tag{23}$$

The spin functions for the three states are

$$\Psi_+ = U(+1)\mathrm{e}^{-\mathrm{i}E_+t/\hbar}, E_+ = M_0c^2 + \frac{e}{M_w}\hbar B,$$

$$\Psi_0 = U(0)\mathrm{e}^{-\mathrm{i}E_0t/\hbar}, E_0 = M_0c^2,$$

$$\Psi_- = U(-1)\mathrm{e}^{-\mathrm{i}E_-t/\hbar}, E_- = M_0c^2 - \frac{e}{M_w}\hbar B. \tag{24}$$

Again

$$\Psi = \frac{1}{2}\Psi_+ + \frac{1}{2}\Psi_- + \frac{1}{\sqrt{2}}\Psi_0 \text{ for } \langle S_x\rangle_{t=0} = \hbar. \tag{25}$$

Without Markov's environmental effects, we have

$$\langle S_x\rangle = \Psi^+ S_x \Psi = \hbar \cos \frac{eB}{M_w} t \tag{26}$$

(here we have no internal spatial dynamics). If we include Markov effects, we have a three state system with a 3×3 Markov transition matrix as follows

$$M = \begin{array}{c c} & \begin{array}{ccc} +1 & 0 & -1 \end{array} \\ \begin{array}{c} +1 \\ 0 \\ -1 \end{array} & \left(\begin{array}{ccc} & & \\ & & \\ & & \end{array} \right) \end{array} \tag{27}$$

If we assume p = probability of going from $-1 \to 0, 0 \to 1$, p^2 = probability of going from –1 to 1, q = probability of going from $1 \to 0, 0 \to -1$ and q^2 = probability of going from $1 \to -1$, we have the following transition matrix

$$M = \begin{array}{c c} & \begin{array}{ccc} \quad +1 \quad & \quad 0 \quad & \quad -1 \quad \end{array} \\ \begin{array}{c} +1 \\ 0 \\ -1 \end{array} & \left(\begin{array}{ccc} 1-q-q^2 & q & q^2 \\ p & 1-p-q & q \\ p^2 & p & 1-p-p^2 \end{array} \right) \end{array} \tag{28}$$

If the initial probabilities are

$$P(+) = \frac{1}{4}, P(-) = \frac{1}{4}, P(0) = \frac{1}{2},$$

we have for a n-step Markov process

$$(P(+1)_n, P(0)_n, P(-1)_n) = (1/4, 1/2, 1/4)M^n. \tag{29}$$

If we now include Markov's effects in Eq.(25), we have

$$\Psi = \sqrt{P(+)_n}\Psi_+ + \sqrt{P(-)_n}\Psi_- + \sqrt{P(0)_n}\Psi_0 \tag{30}$$

where $P(+)_n$, $P(-)_n$ and $P(0)_n$ are calculated from Eq. (29). For the expectation value of S_x we have

$$\langle S_x\rangle = \left(\sqrt{P(+)_n}\mathrm{e}^{\mathrm{i}E_+t/\hbar}, \sqrt{P(0)_n}\mathrm{e}^{\mathrm{i}E_0t/\hbar}, \sqrt{P(-)_n}\mathrm{e}^{\mathrm{i}E_-t/\hbar}\right)$$

$$\times\frac{\hbar}{\sqrt{2}}\begin{pmatrix} 0 & 1 & 0 \\ 1 & 0 & 1 \\ 0 & 1 & 0 \end{pmatrix}\begin{pmatrix} \sqrt{P(+)_n}\mathrm{e}^{-\mathrm{i}E_+t/\hbar} \\ \sqrt{P(0)_n}\mathrm{e}^{-\mathrm{i}E_0t/\hbar} \\ \sqrt{P(-)_n}\mathrm{e}^{-\mathrm{i}E_-t/\hbar} \end{pmatrix} \tag{31}$$

$$= \frac{\hbar}{\sqrt{2}}\left(2\sqrt{P(+)_nP(0)_n} + 2\sqrt{P(-)_nP(0)_n}\right)\cos\frac{eB}{M_w}t.$$

Note that $P(+)_n$, $P(-)_n$ and $P(0)_n$ are calculated from the 3×3 transition matrix in Eq. (29) after n steps. Since the dependence on n in Eq. (31) is fundamentally different that in Eq. (21), the comparison of the two results (Eqs. (21) and (31)), with the experimental variation $\langle S_x\rangle_n$ for small n, could be used as evidence for or against composite gauge boson structure. Equation (21) would suggest composite structure while Eq. (31) would not.

Our last theory is that of a discrete time difference theory for spin polarization precession. We also assume a composite gauge boson structure as in Eq. (1). For the discrete time Schrödinger equation we have [11]

$$H\Psi = \mathrm{i}\hbar(\Psi(t+\tau/2) - \Psi(t-\tau/2))/\tau \tag{32}$$

(τ = discrete time interval). For the wave function for $S_z = 1$, we have

$$\Psi = U(x_1, x_2)\alpha\alpha T(t). \tag{33}$$

The solution for $U(x_1, x_2)$ is the same as in Eq. (6) with

$$E_+ = M_0c^2 + \frac{n_1^2h^2}{8mL^2} + \frac{n_2^2h^2}{8mL^2} + \frac{e_p}{m}\hbar B + \frac{g\hbar^2}{4}. \tag{33}$$

The temporal wave function obeys

$$E_+T(t) = \mathrm{i}\hbar\left(T(t+\tau/2) - T(t-\tau/2)\right)/\tau \tag{34}$$

with the solution

$$T = \mathrm{e}^{-\mathrm{i}2t/\tau sin^{-1}(E_+\tau/(2\hbar))}.$$

Thus

$$\Psi_+ = U(x_1, x_2)\alpha\alpha \mathrm{e}^{-\mathrm{i}2t/\tau sin^{-1}(E_+\tau/(2\hbar))}. \tag{35}$$

For the $S_z = 0$, 1 states we have

$$\Psi_0 = U(x_1, x_2)\frac{1}{\sqrt{2}}(\alpha\beta + \beta\alpha)\mathrm{e}^{-\mathrm{i}2t/\tau sin^{-1}(E_0\tau/(2\hbar))},$$

$$E_0 = M_0c^2 + \frac{n_1^2h^2}{8mL^2} + \frac{n_2^2h^2}{8mL^2} + \frac{g\hbar^2}{4}, \tag{36}$$

$$\Psi_- = U(x_1, x_2)\frac{1}{\sqrt{2}}(\alpha\beta + \beta\alpha)\mathrm{e}^{-\mathrm{i}2t/\tau sin^{-1}(E_-\tau/(2\hbar))},$$

$$E_- = M_0c^2 + \frac{n_1^2h^2}{8mL^2} + \frac{n_2^2h^2}{8mL^2} - \frac{e_p}{m}\hbar B + \frac{g\hbar^2}{4}. \tag{37}$$

Again, we construct the linear combination of Eqs. (35), (36) and (37) that gives

$$\langle S_x\rangle_{t=0} = \hbar. \tag{38}$$

The linear combination is

$$\Psi = \frac{1}{2}\Psi_+ + \frac{1}{2}\Psi_- + \frac{1}{\sqrt{2}}\Psi_0. \tag{39}$$

For the x spin polarization we have

$$\langle S_{x_1} + S_{x_2}\rangle_{t=0} = \int_0^L\int_0^L \Psi^+(S_{x_1} + S_{x_2})\Psi \mathrm{d}x_1\mathrm{d}x_2 \tag{40}$$

where

$$S_{x_1} = S_{x_2} = \hbar/2\begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix}.$$

In Ref. 13 we have evaluated the result in Eq. (40). The calculation gives

$$\langle S_x\rangle = \hbar/2\cos(a_1 - a_3)t + \hbar/2\cos(a_3 - a_2)t \tag{41}$$

where

$$a_1 = \frac{2}{\tau}\sin^{-1}\frac{E_+\tau}{2\hbar} \text{ for } S_z = +1,$$

$$a_2 = \frac{2}{\tau}\sin^{-1}\frac{E_-\tau}{2\hbar} \text{ for } S_z = -1,$$

$$a_3 = \frac{2}{\tau} \sin^{-1} \frac{E_0 \tau}{2\hbar} \text{ for } S_z = 0. \tag{42}$$

For small τ, Eq. (41) gives

$$\langle S_x \rangle = \hbar/2 \cos\left(\frac{e_p B}{m} t + \frac{\tau^2}{24\hbar^3}(E_+^3 - E_0^3)t\right)$$

$$+\hbar/2 \cos\left(\frac{e_p B}{m} t + \frac{\tau^2}{24\hbar^3}(E_0^3 - E_-^3)t\right). \tag{43}$$

Eq. (43) would suggest two different sinusoidal functions for the x spin polarization of slightly different frequencies which would generate a slight "Doppler like" effect on the frequencies in the x spin polarization superimposed on the average frequency. If we now allow a Markov influence in Eq. (39) in the form

$$\Psi = \sqrt{P(+)_n P(+)_n} U(x_1, x_2) \alpha\alpha \mathrm{e}^{-\mathrm{i}a_1 t} + \sqrt{P(-)_n P(-)_n} U(x_1, x_2) \beta\beta \mathrm{e}^{-\mathrm{i}a_2 t}$$

$$+ \left(\sqrt{P(+)_n P(-)_n} \alpha\beta + \sqrt{P(-)_n P(+)_n} \beta\alpha\right) U(x_1, x_2) \mathrm{e}^{-\mathrm{i}a_3 t}, \tag{44}$$

and we evaluate $\langle S_{x_1} + S_{x_2} \rangle$, we obtain

$$\langle S_x \rangle = 2\hbar \left[\sqrt{P(+)_n^3 P(-)_n} \cos(a_1 - a_3)t + \sqrt{P(-)_n^3 P(+)_n} \cos(a_2 - a_3)t\right]. \tag{45}$$

Thus, Eq. (45) would signal two different sinusoidal functions for the x spin polarization with slightly different frequencies as well as an amplitude that would vary in a chaotic fashion for small times as given by Eq. (45).

3. *Construction the transition matrix for two and three states in Markov spin transition*

For the two-step Markov process (up and down states), we have the following transition matrix [18]

$$M = \begin{array}{c c} & \begin{array}{cc} + & \ \ - \end{array} \\ \begin{array}{c} + \\ - \end{array} & \begin{pmatrix} 1-q & q \\ p & 1-p \end{pmatrix} \end{array}.$$

Both p and q would depend on the strength of the magnetic field, and we might speculate that they have a power law dependence on B. If measurement of the x spin polarization could be made after n steps, then Eq. (21) could be used to obtain phenomenological values of p and q. Note also that $t = n\tau/2$, where $\tau/2$ would be the discrete time interval between Markov jumps. For the three by three transition matrix in Eq. (28), we have assumed a kind of "random walk" behaviour for Markov jumps, that is p = probability of advancing one step, while p^2 represent probability of advancing two steps, q = probability of decreasing spin by one step, q^2 = probability of decreasing spin by two steps. Again, we might expect that p and q would have a power law dependence on B. With initial probabilities of 1/4, 1/2, 1/4 for the (+ 0 −) state, we may evaluate $P(+)_n, P(0)_n, P(-)_n$ from Eq. (29) and compare Eq. (31) with an experimental curve after n steps to obtain phenomenological values of p and q.

4. *Conclusion*

In the above analysis, we have considered five possibilities for the x spin polarization as a function of n $(t = n\tau/2)$ listed in Table 1.

TABLE 1.
Type of theory and corresponding x spin polarization of spin-one gauge boson after n discrete time steps

Type of theory	$\langle S_x \rangle$
Normal quantum mechanical behavior with no environmental Markov effects	$\langle S_x \rangle = \hbar \cos \frac{eB}{m} t$
Q.M. + Markov environmental effects on 2 preon composite gauge boson	$\langle S_x \rangle = 2\hbar \cos \frac{eB}{M_w} t \left[\sqrt{P(+)_n^3 P(-)_n} + \sqrt{P(-)_n^3 P(+)_n} \right]$
Q.M. + Markov environmental effects on spin-1 gauge boson with no composite structure	$\langle S_x \rangle = \frac{\hbar}{\sqrt{2}} \left(2\sqrt{P(+)_n P(0)_n} + 2\sqrt{P(-)_n P(0)_n} \right) \cos \frac{eB}{M_w} t$
Discrete time difference Q.M. with no Markov environmental effects (2 preon composite structure of gauge boson)	$\langle S_x \rangle = \frac{\hbar}{2} \cos(a_1 - a_3)t + \frac{\hbar}{2} \cos(a_3 - a_2)t$
Discrete time difference Q.M. with Markov environmental effects (2 preon composite structure of gauge boson)	$\langle S_x \rangle = 2\hbar \left[\sqrt{P(+)_n^3 P(-)_n} \cos(a_1 - a_3)t + \sqrt{P(-)_n^3 P(+)_n} \cos(a_3 - a_2)t \right]$

If small chaotic variation for small $t = n\tau/2$ are observed for the x spin polarization, then a comparison of the experimental curve with the above predictions for $\langle S_x \rangle$ could be used to ascertain which model fits the data. Also, if two sinusoidal-superimposed curves were found for $\langle S_x \rangle$, it would signal an underlying discrete time difference theory with a composite gauge boson structure. The experimental problem is to obtain short enough time intervals so that discrete Markov effects would show up. This might be obtained when the spin polarization creates a secondary process whose characteristics are sensitive to small time intervals such as the cross section for $e^+ + e^- \to Z \to$ products. Here the polarization of e^+, e^- and of the products should be studied as a function of discrete time to mimic the spin polarization of the precession particle since the precessing particle induces a definite polarization at each n.

Acknowledgement

I'd like to thank the Physics Departments at Williams College and Harvard University for the use of their facilities.

References

1) I. J. R. Aitchison and A. J. G. Hey, *Gauge Theories in Particle Physics* (Adam Higler, Ltd., Bristol, 1982);
2) J. L. Lopez, D. V. Nanapoulous and A. Zichichi, C.E.R.N.-TH 6934/93, CTP-TAMU-34/93;
3) S. Dimopoulos, preprint CERN-TH 7533/94, Dec. 1994;
4) E. W. Kolb and M. S. Turner, *The Early Universe* (Addison-Wesley Pub. Comp. Reading, MA, 1990), pp. 532;
5) L. Susskind, Phys. Rev. D **20** (1979) 2619 ;
6) L. Lyons, *Prog. in Particle and Nucl. Phys., Vol.* 10, edited by J. P. Wilkinson, (Pergamon Press, NY (1983)) pp. 227;
7) H. Harari, Phys. Lett. B **86** (1979) 83;
8) H. Fritzsch and C. Mandelbaum, Phys. Lett. **102B** (1981) 319;
9) A. Harari, Proc. of XXIII Int. Conf. on High Energy Physics, 16-23 july 1986, Berkeley, CA (World Scientific, Singapore, 1987), pp. 460;
10) I. Bars, Proc. of XXIII Int. Conf. on High Energy Physics, 16-23 july 1986, Berkeley, CA (World Scientific, Singapore, 1987), pp. 443 ;
11) C. Wolf, Phys. Lett. A **123** (1987) 208;
12) C. Wolf, Hadronic Journal **13** (No. 1) (1990) 22;
13) C. Wolf, Annales de la Foundation Louis de Broglie **18** (No. 4) (1993) 403;
14) C. Wolf, Fizika **B3** (1994) 9;
15) D. Grosser, P. Falkensteiner and E. Schoberl, Phys. Lett B **153** (1985) 179;
16) P. G. Hoel, S. C. Port and C. J. Stone, *Introduction to Stochastic Processes* (Houghton Mifflen Comp., Boston 1972), pp. 3;
17) P. G. Hoel, S. C. Port and C. J. Stone, *Introduction to Stochastic Processes* (Houghton Mifflen Comp., Boston 1972), pp. 16.

PROVJERA CJELOVITOSTI, UČINAKA DISKRETNOG VREMENA I MARKOVLJEVIH OKOLNIH UTJECAJA MJERENJEM PRECESIJE SPINSKE POLARIZACIJE

CARL WOLF

Department of Physics, North Adams State College, North Adams, MA 01247, U.S.A.

UDK 538.145

PACS 03.65.-w

Razmatra se precesija čestice spina jedan u magnetskom polju i pokazuje da bi se vrlo precizna mjerenja frekvencije i amplitude polarizacije mogla primijeniti za ispitivanje složenosti baždarnih bozona, učinaka diskretnog vremena i mogućih Markovljevih okolnih učinaka.