EFFECT OF A CHIRAL IMPULSE ON THE WEAK INTERACTION INDUCED HANDEDNESS IN A PREBIOTIC MEDIUM

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(Received November 1, 1993)

Abstract. Previously we have carried out simulation of the Weak Neutral Current and symmetry breaking transition bifurcation process addressing some of the issues raised by critics of the approach. We now include the effects of a chiral impulse on the transition and show that under certain cases this could greatly alter the transition time. Examples of a chiral impulse could be a nearby Supernova and an impulse of β-emitters. We briefly discuss the possibility of these processes in the early solar system.

1. Introduction

For more than one century there has been evidence for the chiral nature of life forms on earth. Pasteur was among the first to point this out (1848–1880) and the universal nature of chiral symmetry breaking in DNA and RNA is now very well established for all life forms. With the discovery of parity violation in charged current reactions in 1956, and of the Weak Neutral Currents(WNC) in 1973, two universal symmetry breaking processes were uncovered that could have effected the handedness of DNA and RNA (WNC and β decay). The main problem is the extremely small symmetry breaking effects ($\Delta E/k_B T \sim 10^{-17}$). There are plausible non linear mechanisms that could have amplified this small symmetry breaking phase transition up to the full symmetry breaking observed in life forms. However, there is a long standing controversy as to whether these non linear effect are actually large enough to have determined selection of the handedness of life (Kondepudi and Nelson, 1985, Zel'dovich and Mikhailov, 1987, Avetisov *et al.*,1991, Salam, 1991 and Avetisov *et al.*, 1992).

Recently there has been increasing interest in the chiral nature or handedness of biomolecules. In fact there are some who claim that the complex biomolecules structure of life must have arisen from a "Chirally Pure" medium (Avetisov *et al.*, 1991). This concept combined with the likelihood that the period on earth for life to have originated seems to be sometime between 3.8 and 3.5 billion years ago leaves a small window of 300 million years or less for life to have emerged from the prebiotic medium. Some speculate the time could be less than 10 million years. In this paper we discuss the possible effects of a chiral impulse that could have come from the intense pulse of neutrinos interaction from a very nearby Supernova explosion or a sudden release of a large amount of radioactive material near earth to aid in the formation of a chirally pure "prebiotic" medium for the origin of life.

Origins of Life and Evolution of the Biosphere **25:** 201–209, 1995.

2. A Chiral Impulse in the Transition Process

The WNC that interferes with the electromagnetic field and gives rise to weak distortions of virtually all electromagnetic effects, could be one of candidates that causes symmetry breaking in the biosystem. It could make the broken symmetry of the micro-world translate to the macro-world, finally leading protein and both DNA and RNA to display *left-handed* (L) and *right-handed* (R) form, respectively. For organic molecules, however, the difference between the ground state energies of the R- and L-type is about (Hegstrom *et al.*, 1980 and Mason and Tranter, 1985) $\Delta E \sim 10^{-17} k_B T$) of the thermal energy at room temperature. If the WNC interaction is possible to provide an additional energy in such order in an organic biosystem, the handedness of the organic molecules might appear. Such additional energy could be thought as a small bias in this transition process. For simulation this small bias is converted into a non-dimensional parameter $g(\Delta E/k_B T)$ to characterize the relative difference in the time to effect the phase transition. A series of simulations with constant g has been done (Kondepudi and Nelson, 1985 and Cline *et al.*, 1994).

In contrast to the gradual build up of symmetry breaking we propose another mechanism resulting from the effects of a nearby Supernova or an impulse of β-emitters. For example a natural fission reactor where large amount of U^{235} may have accumulated by accident. At first sight this might seem to be an unimportant effect and has been ignored in the past literature on this subject. But with increasing interest currently this issue should be paid more attention. Here we present some results based on our previous work (Cline *et al.*, 1994).

To simulate this intense pulse interaction combined with some reasonable condition, we added a time dependent quasi d-pulse, which gives very large amplitude but not infinite, to the small bias g. Then the first order stochastic equation (Kondepudi and Nelson, 1985 and Cline *et al.*, 1994)

$$d\alpha/dt = -A\alpha^3 + B(\lambda - \lambda c)\alpha + \varepsilon^{1/2} f(t) + Cg \quad (1)$$

becomes

$$d\alpha/dt = -A\alpha^3 + B(\lambda - \lambda c)\alpha + \varepsilon^{1/2} f(t) + Cg + d\delta_{\lambda\lambda'} \quad (2)$$

where α is the amplitude of the symmetry breaking solution, λ the control parameter, g is the interaction or bias *symmetry breaking selector*, λc the symmetry breaking transition point (critical point), $\varepsilon^{1/2}$ is the rms value of fluctuation(noise), f(t) is the normalized fluctuation(noise), d is the amplitude of a quasi δ-pulse, and $\delta_{\lambda\lambda'}$ is the δ-function which $\delta_{\lambda\lambda'} = 1$ when $\lambda = \lambda'$ and $\delta_{\lambda\lambda'} = 0$ when $\lambda \neq \lambda'$.

$$\lambda = \lambda^0 + \gamma t \quad (3)$$

where λ_0 is the initial value of λ, γ the evolution rate, and t the evolution time.

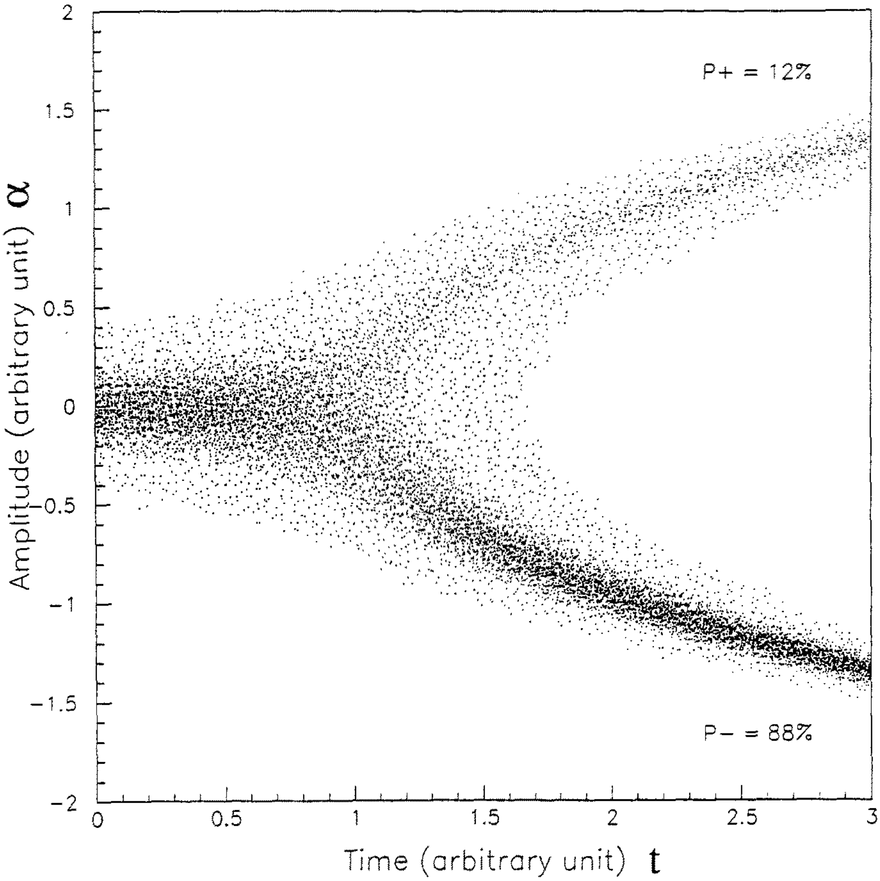

Fig. 1. The results of around 40,000 trials giving a P_{--} = 88% chance for the process favored by g (< 0), where $\epsilon^{1/2}/g = -10$ and d = 0.

3. Simulation Results

In order to examine the effect of the impulse on the time for the phase transition, we made 40,000 trials with constant g (< 0) and $\varepsilon^{1/2}$ which $\varepsilon^{1/2}/g = -10$, and without impulse d (= 0)

To solve the first order stochastic equation numerically we assigned the initial amplitude α to zero at time t = 0, but the f(t) is a random number generated by computer within [−1, 1]. To obtain the trace of the symmetry breaking amplitude α at different time for each trial we just sampled the amplitude α at different time. Finally assembled those data points from about 40,000 trials to produce the Figure 1. It is shown that a P_{--} = 88% chance (Probability) of favored process was selected (Cline *et al.*, 1994). It might make sense that the biomolecular chiral

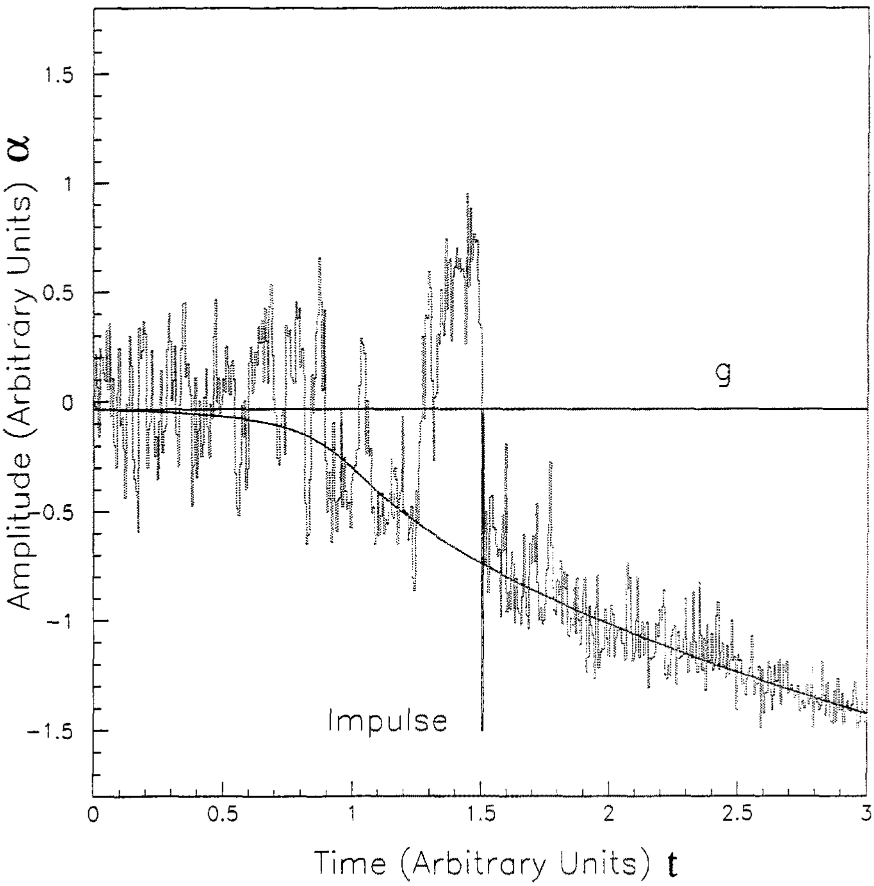

Fig. 2. Single trial with impulse happened at λ = 1.5, where δ = d/g = 100. The impulse strongly affects on the phase transition.

asymmetry could be determined by chiral asymmetric interactions such as WNC, however many still believe that this effect is too small (Avetisov *et al.*,1991).

Based on the calculation of Figure 1 we examined the effects of the impulse by making a series of calculations with a varied d at different periods, but the rest of parameters were unchanged. Three trials with impulse, d/g = 100, are shown in Figures 2, 3, 4. Each figure consists of three curves, one solid curve showed the δ-impulse behavior, other solid curve demonstrated the behavior which there were no noise and δ-impulse in the system, and another showed the system behavior which included both noise and δ-impulse effects for the single trial. One simulation assumes that the impulse takes place near and after the critical point ($\lambda_c = 1.0$), at λ = 1.5. It plays a dominant role to push the process towards a favored state (Figure

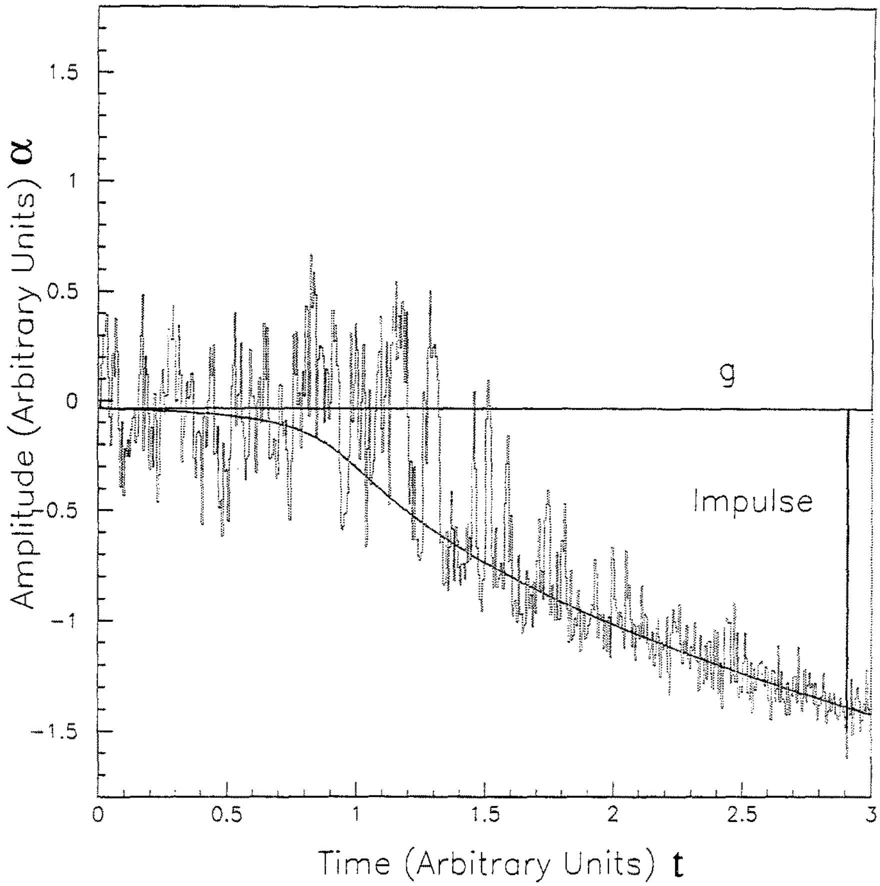

Fig. 3. Single trial with impulse happened at $\lambda = 2.4$, where $\delta = d/g = 100$. The favored state (low branch) is selected. The impulse has no effect on the phase transition.

2); Figures 3, 4 are for an impulse that takes place far beyond the critical point, at $\lambda = 2.4$, where the impulse seems to have little to do with the phase transition. As shown on Figures 2, 3 or 4, a pulse was introduced in the system some time (fixed λ) in the evolution period. The final selectivity (the selected probability of the favored state) as the function of time when an impulse was introduced in the system was recorded (Figure 5). Also the final selectivity is a the function of the amplitude d of the impulse. Three curves correspond to d/g = 50, 100 and 200, respectively. When the impulse was introduced before the critical point, $\lambda < 1.0$, no matter how large the impulse amplitude d (which might correspond to either impulse intensity of particles or amount of the transferred energy from an impulse) and where it was introduced there is no improvement in the phase transition. On

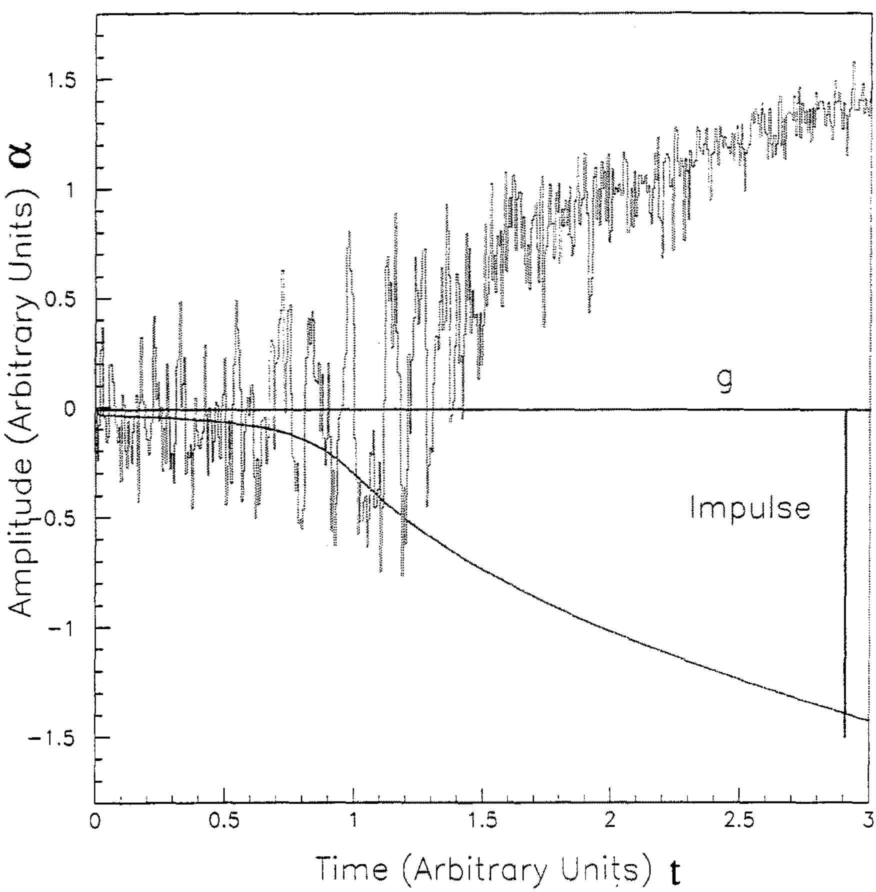

Fig. 4. Single trial with impulse happened at $\lambda = 2.4$, where $\delta = d/g = 100$. The favored state (low branch) is not selected. The impulse has no effect on phase transition.

the other hand when the impulse was introduced far after the critical point the final selectivity showed almost no improvement either if the impulse d was not so large. However, near the critical point we found that the final selectivity was dramatically improved with the impulse d, and there was a maximum of the final selectivity for each system. We noticed that the larger the d, the earlier the transition happened. This phenomenon may coincide with the conjectures we made in (Cline *et al.*, 1994).

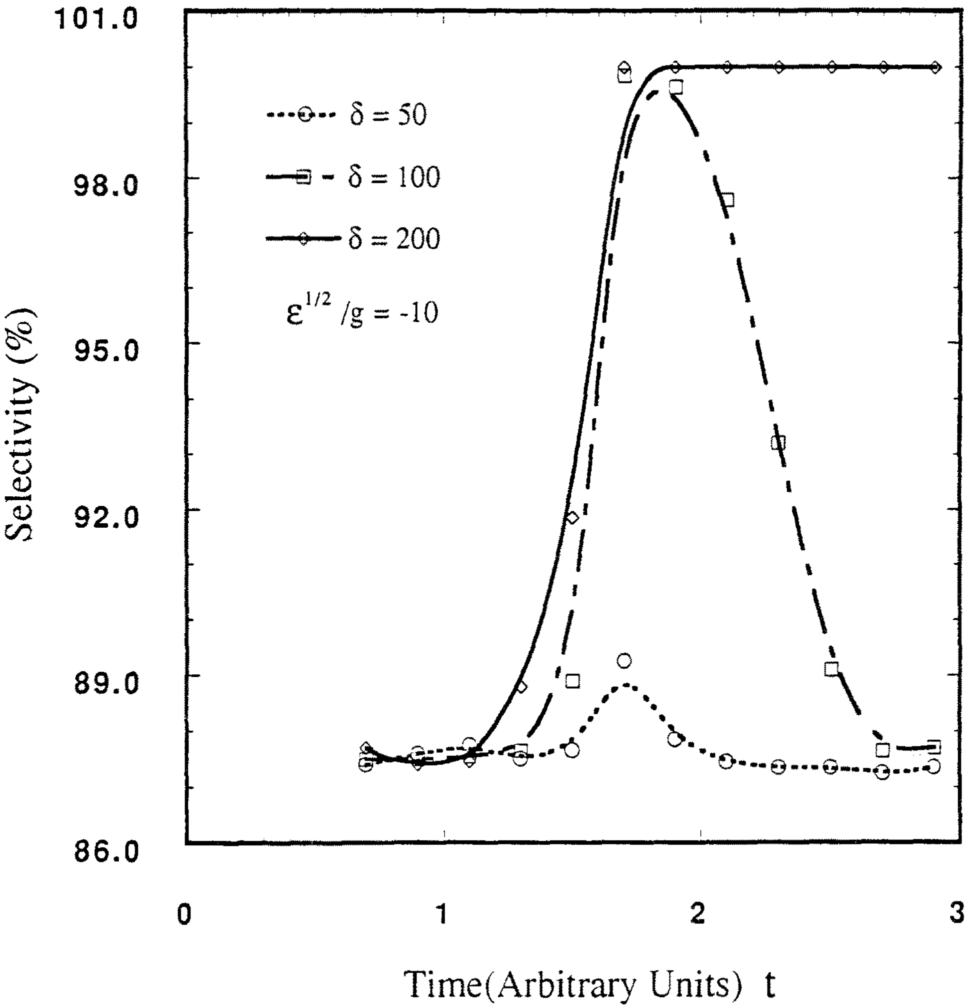

Fig. 5. Single trial with impulse happened at $\lambda = 2.4$, where $\delta = d/g = 100$. The favored state (low branch) is not selected. The impulse has no effect on phase transition.

4. Possible Mechanism for a Chiral Symmetry Breaking Impulse

One possibility is a very nearby Supernova (less than ~ 2 parsec from Earth). We expect about 10^8 Supernova (II) in the galaxy each billion years (possibly more in the early galaxy). The rate could be $\sim 10^{-2}(\text{pc})^{-3}$ during this period and at least one Supernova would be expected within ~ 4 parsecs from Earth. (For the purpose of illustration we assume 1 parsec) We know that the dominant interactions of the neutrinos from the Supernova would be

$$\tilde{V}_e + p \rightarrow e^+ + n \tag{4}$$

and there would be $\sim 10^{23}$ interactions in 10^{16} m^3 of the ocean down to 100 meters depth. In this interaction the positrons will be fully polarized and the subsequent interaction of the positrons on the polarized radiation interacting with the prebiotic molecules can cause a chiral selection effect similar but much stronger than the weak neutral current effects (Kondepudi and Nelson, 1985 and Cline *et al.*, 1994). Effects of β-emitters have been studied by (Hegstrom, 1985 and Hegstrom *et al.*, 1985). Careful modeling will be required to identify the exact mechanism of chiral symmetry breaking – it could either be due to the primary $\tilde{V}_e$ interaction in the prebiotic material on the effects of the e^+ interactions or polarized light emission in slowing down. A nearby Supernova could also provide a large amount of radioactive materials on earth in a relatively short period. Again detailed modeling is needed to estimate the exact effect of this effect. However it seems plausible that such an impulse could have occurred during the formation of the biomolecules on earth. It is also possible that the formation of organic material in the Interstellar medium would be affected by such a chiral impulse. The important point is that the chiral impulse would have the effect of linking all the organic systems so that a single handedness of the biomolecules resulted.

5. Conclusions

We leave it to conjecture where the prebiotic molecules were created, either in the atmosphere, in the oceans or in the Interstellar medium; the simulation results have shown that the impulse does speed up the chiral symmetry breaking transition process. We have shown that in a proper time window, a chiral impulse that could have come from the intense neutrinos interaction from a very nearby Supernova explosion or from a sudden release of a large amount of radioactive material near earth could aid the formation of a chirally pure “prebiotic” medium and therefor the chiral biomolecules of life. For example, as we obtained from a previous simulation, that the slower the process evolves, the higher the selected probability (Kondepudi and Nelson, 1985 and Cline *et al.*, 1994). However, such a system would not only transit to a favored state(with full chirality) but would also be speeded up to reach a higher level selectivity if the evolution sometime passed through a time window combined with an impulse and some reasonable prebiotic conditions (in this simulation, for instance, after the critical point). In sum, a chiral impulse may greatly change the transition time and enhance the chiral symmetry breaking in evolution, but some special conditions would be necessary for this to happen on or nearby Earth.

Acknowledgements

We wish to thank D. Kondepudi for helpful discussions.

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