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How Solar Activity Influences Earth's Molecular Processes

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Abstract: The paper presents a solution to the two-century old problem of how solar activity influences biological objects on Earth. It gives a description of the modern state of the kT-problem, which for a long time has been the most difficult obstacle in the way of explaining solar activity effects. Based on recent advances in spin chemistry, magnetoplasticity physics, and physics of critical conditions, it is shown that a "molecular target" sensitive to weak electromagnetic fields and corresponding radio emissions of the Sun has spin dynamics in non-equilibrium and is near the lower critical point of dividing into layers. A way is proposed as to how solar activity can have an influence on Earth's molecular, including biological, processes through a "transparency window" of the Earth's atmosphere at the 80Mhz frequency.

Keywords: Solar-terrestrial, spin dynamics, singlet-triplet conversion, lower critical point of dividing into layers, biological effects of solar activity.

INTRODUCTION

Study of solar-terrestrial links has a long history, since the famous English astronomer William Herschel found a correlation between the market prices of grain and solar spot numbers [1], and it is still a challenging problem for natural sciences [2]. For a long time, the most difficult obstacle in the way of solving this was the so-called kT-problem. Physical theory considered that weak influences with much less energy than thermal fluctuations could not change the state of molecular systems, which should be thermalised. This dogma dominated researchers' thinking and so they looked for a mechanism able to intensify the weak influences by 10^4-10^5 times [3, 4] but failed.

The physics of crystal magnetoplasticity was faced with the same problem [5, 6]. Alshits *et al.* [7] reported that a magnetic field with an induction of 0.3 T stimulated dislocation mobility at room temperature. It seemed to be impossible from the view-point of equilibrium thermodynamics because it required 10^2-10^3 T. In 1991, Alshits proposed a solution of this puzzle outside equilibrium thermodynamics [8, 9]. Dislocation nuclei, being paramagnetic in the triplet state, have been found not to prevent dislocation removal to a neighbouring Peierls's valley in contrast with the singlet state. It occurs when two factors take place: first, the magnetic field stimulates the singlet-triplet conversion of a radical pair formed in the singlet state by thermal decomposition of a chemical bond and, second, a duration of an elementary act of the crystal plastic deformation must be less than the spin-relaxation time. In this case, thermal fluctuations have no time for mixing spin states and consequently the plastic deformation process in such a crystal becomes spin-selective.

Spin chemistry theory is developed enough today to provide a firm means for solving tasks related to spin dynamics of the molecular system [10, 11]. The first biochemical reaction of phosphorylation in mitochondria, recently revealed by Buchachenko's research group [12, 13], is strong evidence supporting the main proposition of this paper.

The present paper proposes another way of getting over the kT-problem. It is related to the phenomenon of dividing into layers at the lower critical point (LCP).

SPIN DYNAMICS IN LCP

Chemical evolution of the molecular system strongly depends on its spin configuration. One can see it at the simplest in an example of a radical pair (RP):

A↑ + B↓ = A-B chemical bond is formed (1)

A↑ + B↑ ≠ A-B bond formation is banned by the law of angular momentum conservation (2)

In the situation 1, a chemical bond is formed but in situation 2, triplet state, the bond formation is prohibited by the law of quantity of movement momentum conservation. Hence we see that changing the spin orientation of one electron only in a multielectronic system leads to a cardinal difference in the chemical destiny of this system. At room temperatures, spin states, usually with 10^5-10^7 times less energy than thermal fluctuations, are mixed by thermalisation and so no spin-selectivity in chemical reactions is. The situation becomes different in principle when thermalisation is limited. A situation arises where spin-lattice relaxation occurs with insufficient time for mixing spin states during an early act of a chemical reaction and consequently the system evolves farther in a way directed by this early act. Here the spin plays a role of a switchman, who directs a train onto one or another track. It is clear that spin-selectivity may be expressed only in non-equilibrial conditions. Those are all biological organisms. They are recognised [14] as states of "sustainable non-equilibrium" that is a principal feature of living matter. It is because, in specific conditions where thermalisation is limited, spin-selective biochemical reactions under internal and external magnetic (influencing

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Zeeman's gap between spin states) and electromagnetic (causing resonant skips between spin states) fields change their rates, i.e. a biochemical balance, which should lead to an observable biological effect. Such conditions are in the vicinity of critical points.

In critical conditions, as is already known, the correlation radius aspires to an infinite value, reaching the temperature equilibrium is slowed, as is diffusion [15, 16]. Because molecular motion in LCP becomes co-operative, so spin states are less influenced by environmental thermalisation and consequently chemical reactions become spin-selective. It is easy to assess as following: the spin-state saturation under an appropriate radio-wave emission can be written as

$$\ddot{\Delta}n = \ddot{\Delta}n_0 \cdot e^{-2\Delta\nu \cdot t} \qquad (3)$$

where Δn is population difference n_α - n_β, Δn_0 is start population difference at the moment t = 0, $\Delta\nu$ is a split of the spin-states. Hence

$$\lim_{t \to \infty} \ddot{\Delta}n = 0 \qquad (4)$$

When thermalisation is "switched on", a population difference appears

$$n_\alpha = \frac{1}{2} n \left(1 + \frac{g\mu_0 H}{2kT} \right), \qquad (5)$$

$$n_\beta = \frac{1}{2} n \left(1 - \frac{g\mu_0 H}{2kT} \right), \qquad (6)$$

$$\Delta n = n \frac{g\mu_0 H}{2kT}, \qquad (7)$$

where n_α and n_β are populations of the lower and upper levels, n is spin number in total, g is Lande factor, μ_0 is Bohr magneton, H is magnetic field, k is Boltzmann constant, and T is ambient temperature. At room temperatures, $kT >> g\mu_0 H$ by 5-6 orders, therefore population differences are very small, a few thousandths or 10^{-4} %. In the vicinity of LCP, thermalisation is almost stopped, which automatically means that the population of the lower n_α level is close to 100% and that the n_β population is near to empty. But this distribution is while radio-waves are calm. Radio EMF, corresponding to the spin-state gap, mixes spin states to zero (see eq. 4 and 5). Such a contrasting change in the spin populations is impossible under thermal control but LCP conditions allow plant, animals, and other living organisms to feel the Sun's "mood".

So, are there the critical phenomena present in biological objects? We must answer yes because there are known phenomena related to rebuilding the water-shell structures between clathrate-like and typical for liquid water and ice [17]. These phase-transitions occur at appropriate values of temperature and pressure. As well many biologically active compounds, such as poisons, anaesthetics, narcotics, hallu-

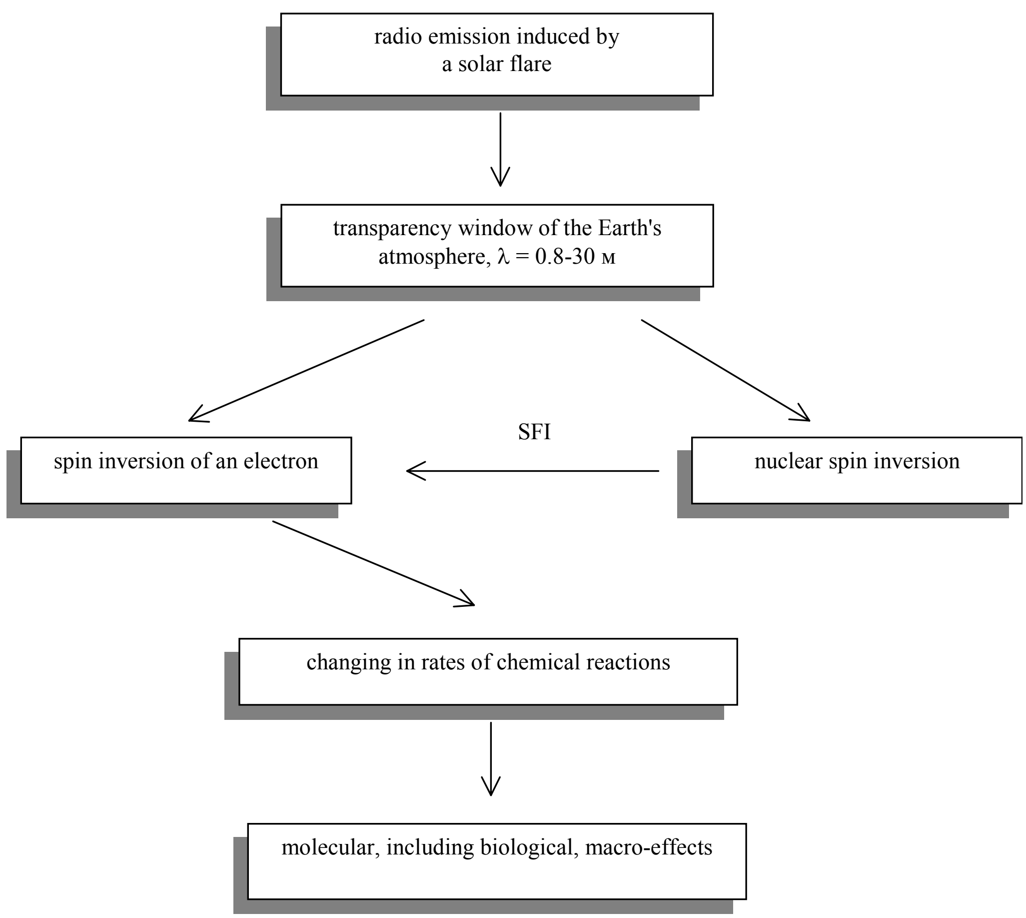

Fig. (1). A way of providing solar activity influence on Earth's molecular, including biological, processes.

cinogens, neurotransmitters, etc. influence them that leads to division of the liquid cell-medium into layers.

RADIO-FREQUENT CHANNEL OF THE SOLAR ACTIVITY INFLUENCE ON BIOLOGICAL OBJECTS

Hence, let us consider the following scheme, how does solar activity influence biological objects on Earth. As is well known, solar flares induce intense radiation in the X-ray and radio-frequent ranges of the Sun's spectrum [18-20]. In the far radio-wave range, the intensity increases up to 10^5 times in comparison with the intensity of the calm Sun. The Earth's atmosphere absorbs most of cosmic radio radiation but there is a "transparency window" 0.8-30m wide (375 to 10 Mhz in the frequency scale), through which radio waves reach the Earth's surface.

In biological objects, hydrate shells wrapping bio-molecules are near their LCPs of dividing into layers [17]. Electromagnetic emission of an appropriate frequency causes a spin-inversion of some RP in a biochemical reaction and consequently changes its rate that, in turn, results in a macrobiological effect. That first reaction was found in 2004 [12, 13]. The phosphorylation reaction in the mitochondria has been found to accelerate by 2-2.5 times under radio emission of 80 Mhz (non-paired electron spin-state splitting on the nucleus ^{31}P) and 1800 Mhz (correspondingly on ^{25}Mg). Splitting gaps are easy calculated from the super-fine interaction (SFI) constants a_p = 80 Mhz on ^{31}P and a_{Mg} = 600 Mhz on ^{25}Mg using the Breit-Rabi equation:

$$E = -\frac{a}{4} \pm \frac{a}{2}(I + \frac{1}{2}), \qquad (8)$$

where E is spin-state splitting energy, a is SFI constant, I is nucleus spin. The first of the frequencies (wavelength equal to 3.75 m) is situated within this "transparency window" and thus the 3.75m solar emission reaches the Earth's biosphere and accelerates the mitochondrial phosphorylation reaction in biological organisms. This is a way in which solar flares influence biological processes on Earth (Fig. **1**).

Of course, it is very like that there are other biochemical reactions sensitive to the solar radio emission reaching the Earth surface through the "transparency window". Experiments [21-24] showed that growth rates of the fruit fly *Drosophila melanogaster* were increased immediately after solar flares. This fact make it clear that an active factor of the Sun radiation is its EMF-radiation not corpuscular emission (solar wind) reaching the Earth orbit in 2-3 days while light needs 8 minutes only to run the same distance.

CONCLUSION

Thus, the radio-frequent channel of solar flare influence on Earth's biological processes should take place in special conditions when thermalisation is limited. These conditions are realised at critical points, namely the lower critical point of dividing into layers that has been found in biological systems. In the vicinity of the critical point, some chemical reactions become sensitive to spin-inversions that lead to their sensitivity to radio emission of appropriate frequencies. This is, in principle, a way in which solar activity affects the Earth.

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NOTE

This research is a private research of the author and not a part of the scientific programmes of the institutes he currently works and worked before.

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