

On the Effect of Lengthening Circadian Rhythm by Heavy Water

Takhir R. Akhmedov

333 S. Webster Ave, Suite 4, Norman, OK 73069. E-mail: TakhirAkhmedov@yandex.com

The problem of time sensor of biological clock (BC) attracts interest of many scientists, and a great number of experiments are being conducted to study the influence of various physical and chemical factors on functioning of BC. Special attention is drawn to studying the influence of heavy water (D₂O) on functioning of BC that always leads to lengthening of circadian rhythms (CR). This work presents theoretical consideration of lengthening of CR, when hydrogen (H₂) in water is replaced by deuterium (D₂), that is based on spacial difference of energy levels with similar principle quantum numbers.

The problem of the mechanism of time sensor (TS) of biological clock (BC), or biorhythms of periods close to periods of geophysical factors, attracts attention of scientists for a long time. The most thoroughly experimentally studied are circadian rhythms (CR) i.e. rhythms with a period close to 24 hours. And in a range of data about physical and chemical factors influence on CR there is a special case for the effects of D₂O on the rhythms. In [3, 4] it is noticed “that at present D₂O is the only matter, which always leads to lengthening of endogenous rhythms”, and it is underlined, that theoretical interpretation of “the effect of heavy water” is based on the theory of reactions’ absolute speeds, neglecting mass effects. However, the principle difference of H₂O and D₂O is the difference of masses of hydrogen and deuterium nuclei.

Consideration of the mass difference permits qualitative explanation of the lengthening of CR in biological objects, where H₂O is partially or completely replaced by D₂O.

Let’s consider spacial distribution of energy levels of the same principle quantum number in atoms of hydrogen and deuterium. Taking into account the masses of the nuclei energy levels are separated by the distance.

$$r_{nH} = \frac{\alpha}{4\pi} \times \frac{1}{R_H} \times n^2 \quad \text{in a hydrogen atom, and}$$

$$r_{nD} = \frac{\alpha}{4\pi} \times \frac{1}{R_D} \times n^2 \quad \text{in a deuterium atom}$$

where α is fine structure constant, R_H and R_D are Rydberg constants for hydrogen and deuterium, respectively, n – the main quantum number [4].

In comparison with the similar levels of hydrogen atom in an atom of deuterium energy levels of the same principle quantum number are spatially shifted towards the nucleus by the value of

$$\Delta r = n^2 \times \frac{\alpha}{4\pi} \times \left(\frac{1}{R_H} - \frac{1}{R_D} \right)$$

Accepting that $\alpha = 7.397535 \times 10^{-3}$, $R_H = 109677.576 \text{ cm}^{-1}$ and $R_D = 109707.419 \text{ cm}^{-1}$, for $n = 1$, we have $r_1 = 1.3937 \times 10^{-12} \text{ cm}$. For example for $n = 10$, $r_{10} = 1.3937 \times 10^{-10} \text{ cm}$.

It is natural to assume, that the lower the energy threshold through which biochemical processes run in bio-objects

the higher the sensitivity of the objects to the spatial shift of energy levels caused by the replacement of H₂ by D₂.

Thus, from above mentioned it follows that lengthening of CR by adding D₂O is caused by decreasing the possibility of biochemical processes running through the appropriate energy levels in deuterium atoms, which, being caused by mass difference, are spatially shifted towards the nucleus in comparison with analogous levels in hydrogen.

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