Belousov-Zhabotinsky reaction, space voids and galaxy clusters.

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Abstract: It is shown that the cause of cosmic voids and galaxy clusters is the chaotic motion of galaxies. According to I. Prigogine, in an open system, near a stationary state, far from equilibrium, fluctuations of parameters are possible. Therefore, in chemical cyclic systems such as the Belousov-Zhabotinsky reaction, the concentration of substances can take on any values, and these values can fluctuate over time. If we assume that the Universe is an open system, which is located near a stationary state (far from equilibrium), then in some regions of the Universe the concentration of galaxies can be any, which inevitably leads to the appearance of clusters of galaxies and space voids.

Keywords: reaction of Belousov-Zhabotinsky, I. Prigogine, Universe, galaxy clusters, space voids, concentration of galaxies.

INTRODUCTION.

The cause of space voids, like galactic clusters, is the chaotic movement of galaxies. Yes, yes, precisely in the chaotic movement of galaxies in our Universe. This becomes obvious and logical when we remember of chemistry. More precisely, the Belousov-Zhabotinsky reaction [1, 2].

The Belousov - Zhabotinsky reaction is a reaction proceeding in an oscillatory, periodic mode. It is especially important that some reaction parameters, such as the concentration of the components, temperature, color, and others, change periodically, thus forming a complex space-time structure of the reaction medium. The Belousov-Zhabotinsky reaction showed that regions of space with different concentrations of substances can form in a homogeneous system. Moreover, A. Zhabotinsky discovered that there are waves of changes in concentration, which are visible to the naked eye in the presence of indicators. Look at these waves appearing in a thin layer in a Petri dish [3].

$t = 0$ s $t = 80$ s $t = 160$ s

Look at the video of the Belousov-Zhabotinsky reaction and the Briggs-Rauscher reaction (also belongs to this type) [4, 5].

Chemist B. Belousov (1893-1970) had a very interesting and difficult life. He personally knew A. Einstein. Belousov attended a full course in chemistry at the University of Zurich, but was unable to redeem a chemistry diploma, since there was no money to buy the diploma. But, despite this, he was a professor of chemistry, and was engaged in the development of antidotes and anti-radiation drugs. His fundamental work on chemical cyclic fluctuations, now a personalized reaction of Belousov-Zhabotinsky, was rejected by scientific journals. And only 8 years later, he published this fundamental, abridged three-page work in a institute collection that did not even have reviewers [1].

RESULTS AND DISCUSSION.

For further consideration, here's a quote [6]:

«During the course of any chemical reaction, an enormous number of reacting molecules take part in it: 1 mol of a substance contains 6.022*10^23 molecules, therefore if at least several moles of chemical substances take part in the reaction, then the number of reacting particles will already be more than 10^24. A more statistically complex system is hard to imagine, but by weight it’s only about 5 to 100 grams of a substance.

So, if we take one substance (a reaction product, or a system of chemical reactions) as a “predator”, then another substance (a reagent, or another system of chemical reactions) will be a typical “prey”.

From this fact, it inevitably follows that during the course of any chemically reversible reaction we must observe cyclic processes (cyclical changes in the concentration of substances, temperature, color and other characteristics), since the reverse reaction reagent can be considered as a kind of “inhibitor” of the direct reaction. But, it is necessary to clarify that such cyclic processes occur in chemical systems that are (still) far from the equilibrium state, and therefore thermodynamics does not impose any restrictions on the change in the concentration of substances, since the concentrations of substances have not yet reached an equilibrium value, and can take In principle, any values, these values can fluctuate in time. Indeed, I. Prigogine in 1955 showed that in an open system, near a stationary state far enough from chemical equilibrium, chemical oscillations are possible [18]».

It is clear from the quote that the molecules of reacting and forming substances, in chemical systems that are far from equilibrium, in fact obey the conservative Lotka-Volterra model [7]. Moreover, thermodynamics does not impose restrictions on the change in the concentration of substances, and therefore, the concentration of substances can take any values (since the equilibrium value of concentrations has not been reached).

That is, if we have a reaction:

$$A + B \leftrightarrow C + D$$

then molecules of substances A and B, we can consider as "prey", and molecules of substances C and D, we can consider as a "predator". The interaction in the "predator-prey" system is the reason for the formation in homogeneous phases of regions of space with different concentrations of molecules, which is the reason for self-oscillations [8].

If we now transfer all this to the visible Universe, then the reason for the formation of voids in space becomes obvious and logical. But, for this, we must take into account the fact that our visible Universe is a cosmological ball. See artist's logarithmic scale conception of the observable universe [9].

Since the speed of light in a vacuum is limited, an observer on Earth is at the center of a cosmological sphere of a certain radius. And this observer sees that the speed of galaxies, with distance from the center, will increase according to the Hubble-Lemaitre law [10, 11]. But, the removal of galaxies is the effect of the observer from the center of the ball, since moving the center to another point will lead to the fact that the speed of a particular galaxy will change for the observer, since the gravitational component will change. This effect is a consequence of gravitational time dilation in accordance with Einstein's STR [12].

Therefore, in the Universe, the usual chaotic movement of galaxies occurs. And this means that if we select a small ball of a certain radius in the observable Universe, then some galaxies will leave it, and some galaxies will enter it (for a certain time). Let's call the galaxies leaving the ball "predator", and the galaxies entering the ball "prey". Then it is obvious that the Lotka - Volterra model can be applied to the observable Universe (cosmological ball). Moreover, the behavior of galaxies will not differ in any way from the behavior of molecules in the Belousov-Zhabotinsky reaction (the same "predator - prey" model). And from this it inevitably follows that a complex space-time structure will be observed in the Universe, which will be completely analogous to the space-time structure of the reaction medium of the Belousov-Zhabotinsky reaction. That is, regions with different concentrations of galaxies will be observed in the Universe, just as regions of space with different concentrations of substances are observed in the Belousov-Zhabotinsky reaction (in a homogeneous medium!). Therefore, we will observe in the Universe both regions with a large concentration of galaxies (a cluster of galaxies), and regions in which there are extremely few galaxies (cosmic voids, Boötes void) [13, 14, 15].

Such fluctuations in the concentrations of galaxies are theoretically justified, since the Universe is a nonequilibrium system. And therefore, thermodynamics does not impose any restrictions on the change in the concentration of galaxies in local regions (they can, in principle, take any values). This inevitably implies the existence of clusters of galaxies and the existence of cosmic voids. Back in 1955, I. Prigogine showed [16] that concentration fluctuations are possible in an open system, near a stationary state far from equilibrium.

CONCLUSION.

Thus, the reason for the existence of cosmic voids and galaxy clusters is the chaotic movement of galaxies in the Universe, which is near a stationary state, which is far from thermodynamic equilibrium. Moreover, if the Universe is infinite, then it is initially a nonequilibrium system, since a thermodynamic system must have its boundaries (separating it from the environment) in order to come to equilibrium. Consequently, the infinity of the Universe leads to the fact that the Universe will always be a nonequilibrium system. And since it is in a stationary state (the state of the system, when the values of quantities remain unchanged in time), this inevitably leads to the structure of the Universe that we observe: fluctuations in the concentration of galaxies, cosmic voids, clusters of galaxies, etc. Still The universe is a big flask of matter! Space chemistry! In my opinion, great.

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