SOME FEATURES OF THE BEHAVIOUR OF ENERGY CARRIERS DURING TRANSIENTS IN AN OPEN THERMODYNAMIC SYSTEM

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Abstract. Based on the previously proposed analytical approach for the quantitative analysis of transients in an open thermodynamic system, some possible features of energy transfer mechanisms are considered. The differences in the mechanisms for the two revealed transient modes are emphasized and grounded, as well as their common character for different types of transients. For our expanding Universe, the existence of a three-level effect of distance on the conditions for the realization of the energy transfer mechanisms has been established. Away from the epicentre of the Big Bang, the following sequence of action of the transfer mechanisms is revealed: (i) movement of a collective energy carrier caused by ordered external forces; (ii) combinations of ordered and diffusion-like motion of the carrier; (iii) diffusion-like motion of the carrier caused by the interactions between carriers. The picture of the evolution of the Universe proposed in the paper is in good agreement with the well-known available experimental data and basic physical notions.

Keywords: open thermodynamic systems, energy transfer processes in the expanding Universe, two modes of transient mechanisms, effect of the distance on the distribution of acting transient mechanisms.

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1. INTRODUCTION

As well-known from available observations and commonly accepted theoretical models, practically all natural phenomena and processes in our observable part of the expanding Universe are components of the global transients caused by the Big Bang. In particular, objects that an observer on Earth can consider as stationary ones are in fact moving with our Galaxy, as a part of the general motion of galaxies. However, this fact is not taken into account that restricts our understanding and explanation of the mechanisms underlying some basic natural phenomena. Such a problem becomes more and more relevant in view of the recently obtained results related to the distribution of material objects in the part of space that we observe [1–3].

It has been theoretically found and experimentally observed that most transients in an open thermodynamic system can develop in two modes under appropriate conditions [4–7]: a crystal under a load, a crystalline solid under the temperature gradients etc. It should be noted that the aforementioned and further discussed thermodynamic systems are the systems consisting of a huge amount of conventional material objects of a quantum or classical nature, capable of participating in all kinds of known interactions and energy transfer processes. The detailed theoretical analysis of the transient development in such thermodynamic systems is performed for the particular case of the macroplastic deformation process in crystals [4–5]. The experimental confirmation of the results of the analysis is achieved by comparing the calculated true stress–true strain curves with the experimentally observed ones for several polycrystals [8]. These results are used as a basis to reveal some basic features of the relevant dislocation mechanisms that are consistent with the basic notions of the dislocation theory [9]. More specifically, it was found that one of the modes is realised exclusively under the condition of exceeding a certain critical minimum threshold level of the applied external stress. On the other hand, the other mode can develop under the stresses that do not exceed the analogous maximum critical limit. Based on the results, it is concluded that the last mentioned so-called second deformation mode develops due to the combined action of the applied external stresses and the interaction forces between the dislocations, in contrast to the first mode, the development of which is caused only by the applied external stress. Sumarizing this conclusion in view of the specific case of the performed analysis [4–6], the following dominant mechanisms of the energy carrier movement in the course of the first and second mode of the transient development in an open thermodynamic system can be supposed, respectively: ordered collective movement of the carriers and disordered individual diffusion-like motion of them. The definitions are in agreement with the ones well-known from the theory of phase transformations in crystalline solids, respectively: "military" and "civilian" transformation [10]. A high practical effectiveness of the combination of deformation modes has also been experimentaly found [6].

Aim of the present article is to evaluate the basic features of the mechanisms of possible transients in the observable part of expanding Universe based on the principles and results of the previously developed model for the transient development in an open thermodynamic system.

2. MAIN RESULTS

The analysis described in the article is based on the scheme shown in Fig. 1, where the following space dependencies are schematically shown: (i) the explosive energy density of the Big Bang dE_{expl}/dV, curve 1; (ii) critical energy density $dE_2^*/dV \equiv \widetilde{\sigma_2}$ corresponding to the maximum threshold external stress for the second transient development mode, line 2; (iii) critical energy density corresponding to the minimum threshold external stress for the first transient development mode $dE_1^*/dV \equiv \widetilde{\sigma_1}$, line 3, [4]. It should also be noted that the relation of the energy densities corresponding to the maximum and minimum external threshold stresses $dE_2^*/dV > dE_1^*/dV$ can be used according to [4–6]. The reason for the application of the relation derives from the

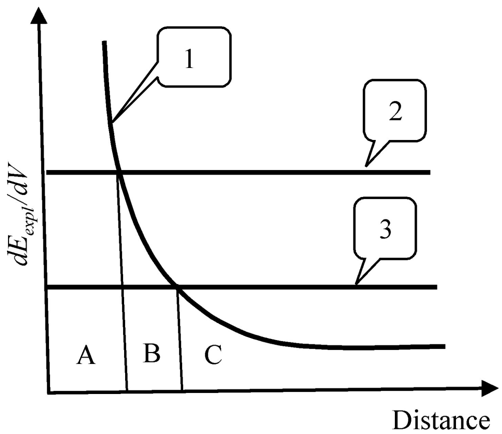

Fig. 1. Schematic representation of the effect of distance on the explosive energy density of the Big Bang dE_{expl}/dV (See text for details)

results of the previously performed analysis, the abandonment of which leads to mathematical inaccuracies of the other relations used.

Taking into account the above mentioned conclusions regarding the mechanisms of the energy carrier motion during the possible transient modes, the following basic results may be obtained.

Initially, it is seen that the full spatial distance from the epicentre of the Big Bang can be divided into three intervals, each of which corresponds to the specific mechanisms of movement of the energy carrier. Namely, the interval A corresponds to the stopping of any transient process that develops at lower stresses than the diffusive-like movement of energy carriers and is a consequence of the interaction of the carriers according to [4–5], where:

$$dE_{expl}/dV > \widetilde{\sigma_2} > \widetilde{\sigma_1}.$$

On the other hand, the condition $dE_{expl}/dV > \widetilde{\sigma_1}$ is also fulfilled within the considered spatial area. It means that the direct effects of the explosive energy are active and lead to the energy transfer through the ordered collective progressive motion of objects, which transfer the energy. However, such energy carriers are unable to interact with each other (due to the accomplishment of the relation $dE_{expl}/dV > \widetilde{\sigma_2}$) and therefore obviously cannot be detected experimentally. So, this earlier stage in the evolution of the Universe and the corresponding spatial area, i.e. the spatial interval A in Fig. 1, where the relation $dE_{expl}/dV > \widetilde{\sigma_2} > \widetilde{\sigma_1}$ is accomplished, should be considered as containing non-interacting each other material objects capable of transferring energy by means of their ordered collective progressive motion caused immediately by the explosion of the Big Bang. Obviously, such material objects and the spatial area they occupy correspond to the known definition of “dark” energy.

The next spatial interval outside the epicentre of the Big Bang explosion is designated as B in the scheme, Fig. 1. As can be seen, at any point of this spatial area the relations are obeyed:

$$\widetilde{\sigma_1} < dE_{expl}/dV < \widetilde{\sigma_2}.$$

As follows from [4–6], the relevant mechanisms of the possible transients under the above conditions are combinations of those attributed to each revealed mode of behaviour of the energy carriers. In other words, material objects being in such part of the expanding Universe can participate in any type of the transients and provide a complete energy transfer. The possible driving forces are caused by both the direct effects of the Big Bang and the interactions of the objects. Based on the results, the direct effect of the Big Bang should be considered here as a reason for the ordered simultaneous collective progressive motion of practically all energy carriers, and the interaction between the carriers (attraction and repulsion) as the factor responsible for the formation of specific spatial quasy-equilibrium configurations of the carriers [4–6]. As a confirmation of the conclusion, the well-known specific case of the formation of dislocation configurations during the plastic deformation can be considered because of the shown typical character of the plastic deformation as the transient [4, 6]. It is primarily about the appearance of a dislocation network due to the repulsive and attractive interactions between dislocations during their movement. Obviously, analogous configurations can be formed by any energy carriers in a thermodynamic system due to analogous interactions of carriers.

The rest of the space, located at a maximum distance from the epicentre of the Big Bang denoted as interval C in Fig. 1, is associated with the energy density under the conditions where:

$$dE_{expl}/dV < \widetilde{\sigma_1}.$$

The relation corresponds to situations where the direct effect of the Big Bang on the material objects capable of carrying energy is negligible according to [4–6]. Meantime, some of the carriers, probably a small amount of them, are able to transfer energy through their motion caused exclusively by their interaction with each other, according to second transient mode, at such low levels of external driving force. It should be noted the very low average speed of the transient corresponding to any energy process of exchange (interaction) between the carriers being within the considered spatial area of the Universe [4].

3. DISCUSSION

So, based on the results obtained from the analysis, the following general picture of the evolution of our expanding Universe can be proposed to improve our understanding of it.

Immediately after the Big Bang, a huge amount of material objects with superhigh energy stocks appeared at its epicentre. The motion of the particles away from the epicentre provides their temporary stay within the spatial area denoted as A in Fig. 1. On the one hand, all such objects cannot participate in the energy transfer of the Big Bang through their diffusion-like motion caused by the interaction of the particles with each other. This notion is based on the inevitable relation $dE_{expl}/dV > \widetilde{\sigma_2} > \widetilde{\sigma_1}$ for this spatial area, which indicates the impossibility of the diffusion-like motion of the energy carriers here. On the other hand, due to the mandatory implementation of the relation $dE_{expl}/dV > \widetilde{\sigma_1}$ in the considered spatial area A, the energy carriers have to transfer the energy of the Big Bang directly through their ordered collective progressive motion. Hence, these carriers, which are all material objects existing in the spatial area, cannot be detected by experiment and therefore should be attributed to the "dark" energy.

On the other hand, far away from the epicentre of the Big Bang the following energy density conditions are obeyed:

$$\widetilde{\sigma_1} < dE_{expl}/dV < \widetilde{\sigma_2},$$

that correspond to the spatial area B, see Fig. 1. According to the definition, there is possibility to develop all types of transients in this spatial area. The admissible mechanisms for the energy transfer from the energy carriers existing there are: the ordered progressive motion; diffusion-like transferring and their combinations that together provide the appearance of all conventionally observed phenomena in our surraunding part of the expanding Universe, including the formation of the corresponding spatial configurations from the energy carriers, which are all existing material objects.

For the larger distances from the epicentre of the Big Bang, outside the spatial area B the energy density condition $dE_{expl}/dV > \widetilde{\sigma_1}$ excludes the ordered progressive movement of the energy carriers due to the insufficient level of external "driving" forces according to [4–6]. Meantime, the internal forces caused by the interaction of the carriers may provide their diffusive-like motion together with the formation of spatial quasy-equilibrium configurations. Taking into account the existence of the known types of energy carriers in such distant place of the expanding Universe, the material objects existing there can be associated with the "dark" matter, as they have large restrictions for the energy exchange between them or for detection by experiment.

Finally, it should be noted that the proposed description is consistent with the generally accepted notions about the possible distribution of different types of energy carriers within a system containing a large number of interacting objects: the kinetic energy of the movement of the components of the system and the potential energy of their interactions. It is obviously that in the case of weak interactions of system components, the fully ordered collective progressive motion of all of them defines the performance of the system and vice versa. As a consequence, properties of the system caused by a complementary part of its full energy can be neglected.

4. CONCLUSION

1. The previously developed model that has been successfuly applied to the quantitative analysis of a transient process in an open thermodynamic system is used to evaluate basic features of transient mechanisms, which provide spatial transfer of the explosive energy from the Big Bang.
2. Taking into account the revealed mandatory development of the transient process by two modes with different energy tranfer mechanisms, schematic spatial distribution of critical energy densities providing development of each possible mechanism is proposed and analysed.
3. It was found the existance of three spatial intervals, in which the following energy transfer mechanisms are successively realised from the epicentre of the Big Bang: (i) ordered collective motion of energy carriers without their interaction with each other; (ii) combined ordered and diffusion-like movement of the carriers; (iii) diffusion-like motion of the carriers without indications of collective motion.
4. Taking into account the features of the explosive energy transfer from the Big Bang in the revealed spatial intervals, it is proposed to consider them as areas, in which the "dark" energy, conventional natural phenomena, and "dark" matter should be successively observed from the Big Bang epicentre.
5. The proposed explanation of the obtained results is in good agreement with the available astrophysical data and the relevant basic physical principles.

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