

Propagation of Light in a Space Filled with an Electromagnetic Medium

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ABSTRACT

The features of light propagation in outer space filled with an electromagnetic medium, the physical model of which was proposed by A. Rozov (2017), are analyzed. This model made it possible to derive the equations of electrodynamics for moving media within the frame of classical mechanics. Joint analysis of the electromagnetic medium model and electrodynamic equations taking into account known data and astronomical observations of galaxy redshift and cosmic background radiation allowed to make some conclusions both about the internal structure of the electromagnetic medium and on the peculiarities of light propagation in outer space.

Keywords: Electromagnetic Medium, Light Propagation in Space, Redshift, Cosmic Background Radiation

INTRODUCTION

In [1] the physical model of an electromagnetic medium (called Medium further in the paper), allowing derivation of electrodynamic equations for moving media (called Elemm further in the paper) within the frame of classical mechanics, was proposed. The Medium is a fine substance, fills the whole of space and matter, and is a carrier of electromagnetic phenomena. Electromagnetic waves propagate in this Medium independently of the motion of the source of the waves relative to the coordinate system fixed in the Medium at a speed of $c = 1/\sqrt{\varepsilon_0\mu_0}$, where ε_0 and μ_0 are the electric constant or vacuum permittivity and the magnetic constant or vacuum permeability, respectively.

In [2] it was suggested that the Medium, being a material formation, may have gravitational effects and influence the motion of stars in galaxies that is, participate in the processes that we associate with the influence of the so-called dark matter.

In this article, based on a joint analysis of the medium model and Elemm, possible details of the internal structure of the Medium and the features of light propagation in outer space are discussed.

MAIN PART

When light propagates in outer space, its path can pass through various formations (media) that have their own values of characteristics and speeds relative to the Medium [3, 4]. For the general case, Elemm have the form [1]

$$\begin{aligned}\nabla \times \mathbf{E} &= -\frac{\partial \mathbf{B}}{\partial t} - \nabla \times (\alpha \mathbf{B} \times \mathbf{v}) \\ \nabla \cdot \mathbf{D} &= \rho \quad \nabla \cdot \mathbf{B} = 0 \\ \nabla \times \mathbf{H} &= \frac{\partial \mathbf{D}}{\partial t} + \mathbf{j} + \rho \mathbf{v} + \nabla \times (\alpha \mathbf{D} \times \mathbf{v}) \\ \alpha &= \frac{\mu \varepsilon - \mu_0 \varepsilon_0}{\mu \varepsilon},\end{aligned}\tag{1}$$

where $\mathbf{E}$, $\mathbf{H}$, $\mathbf{B}$ and $\mathbf{D}$ are the vectors of electric and magnetic field strengths, magnetic and electric induction, respectively, ε is the electric permittivity of a medium, and μ is the magnetic permeability of a medium, $\mathbf{j}$ is the conduction current density vector, ρ is the density of free-moving charges, $\mathbf{v}$ is the medium velocity vector, t – time.

This article does not deal with the passage of light through space environments (media) having ε and μ , other than ε_0 and μ_0 . It considers the propagation of a light wave in outer space filled only with the Medium. Since for the Medium we have: $\varepsilon = \varepsilon_0$, $\mu = \mu_0$, $\mathbf{v} = 0$, $\mathbf{j} = 0$, $\rho = 0$, to describe the propagating light wave in this case we get from (1)

$$\nabla \times \mathbf{E} = \mu_0 \frac{\partial \mathbf{H}}{\partial t}, \tag{2}$$

$$\nabla \times \mathbf{H} = \varepsilon_0 \frac{\partial \mathbf{E}}{\partial t}. \tag{3}$$

Let's analyze the system (2) - (3). The right side (3) contains the displacement current. It follows from the equations that this is a necessary element for the possibility of light wave propagation in the space (in the Medium).

One knows, that the displacement current is formed by the displacement of the associated elementary electrical charges. We come to the necessity of existence in the Medium elementary electric charges in the connected state. Thus, there are reasons to consider the Medium as a dielectric.

It is known about the existence of vacuum capacitors in which vacuum (more precisely the Medium) plays the role of dielectric. Therefore, it can be assumed that there is a certain structure of the Medium. In this case, the light wave propagating in the Medium must inevitably interact with this structure, resulting in a loss of energy.

The obvious consequence of this loss of energy is a decrease in frequency and an increase in wavelength, which leads to a redshift of the spectral lines of light-emitting objects.

Therefore, it can be assumed that Edwin Hubble, who discovered the redshift [5], probably found the effect of reducing the frequency of light as it propagated through space due to the loss of energy resulting from interaction with the Medium in accordance with the relation:

$$\nu = \frac{E}{h}, \quad (4)$$

where E and ν are the energy and frequency of the wave, respectively, h - the Planck constant. The Hubble's law can be interpreted as an empirical law linking the redshift of galaxies and their distance from the Earth in a linear way

$$z = \frac{H_0}{c} r, \quad (5)$$

where z is the galaxy's redshift, r is the distance to it, H_0 is the proportionality factor called the Hubble constant, c is the speed of light.

The redshift calculated by (5) correlates satisfactorily with the observational data up to $z \leq 0.6$ - 0.7 , and sometimes even higher (see, e.g. [3 (Fig. 26.11), 4 (Figs 7.3, 9.6), 6 (Fig. 6), 7 (Figs 3-4), 8 (Fig. 2), 9 (Fig. 3)]). Measuring the magnitude of redshift for large values of z is difficult due to the complexity of the measurement of galaxy distances and their luminosity, especially of distant galaxies. Dependence of these measurements on a number of factors was found (see, e.g. [8-10]).

For the convenience of analysis, by summing (4) and (5), we obtain

$$\nabla E = h\nu_0 \frac{H_0}{c} r, \quad (6)$$

$$\nabla \nu = \frac{\nabla E}{h} = \nu_0 \frac{H_0}{c} r, \quad (7)$$

where ∇E and $\nabla \nu$ are the loss of energy and frequency of a light wave, as it travels a distance r , respectively, ν_0 is frequency of a light wave emitted by object.

It follows from equations (6) and (7) that when a light wave propagates in space, it loses energy proportionally to the distance traveled and, accordingly, proportionally decreases the frequency of the wave.

DISCUSSION

So, there are reasons to believe that redshift is the observable result of the loss of energy by a light wave as it propagates in outer space (in the Medium). The question remains what happens next with this energy.

Apparently, this energy should constantly, more or less evenly, heat the material structure of the Medium, which should lead to thermal radiation that evenly fills the Universe.

Such radiation has been discovered - this is the cosmic background radiation, uniformly filling the Universe with a high degree of isotropy (see, e.g. [3, 4]). This radiation is often associated with the consequences of the processes of the “hot stage” of the Universe shortly after the “Big Bang” (see, e.g. [3, 4]). Such an interpretation of the origin of this radiation and the high degree of its observed isotropy led to the need to place the site of observation (Earth) at the center of the Big Bang. Such an approach, as a scientific concept, could be a serious scientific contribution to the biblical interpretation of creation, but it is required to explain why this radiation has not moved during the existence of the Universe (according to the Big Bang theory) to distant spaces from the center.

SUMMARY

The Medium, in which light propagates, is a dielectric and has a certain structure.

Light during propagation in outer space loses energy as a result of interaction with the structure of the Medium and, accordingly, the frequency of the light wave decreases.

This process leads to a redshift of the spectral lines of light-emitting objects and is described by the Hubble's law.

The loss of energy by a light wave as it propagates through the medium results in thermal radiation that evenly fills the Universe and is known as cosmic background radiation.

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