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COSMIC MICROWAVE BACKGROUND AS THERMAL RADIATION OF INTERGALACTIC DUST?

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Abstract: This paper is an interview about an alternative theory of evolution of the Universe with dr. Václav Vavryčuk from the Institute of Geophysics of the Czech Academy of Sciences.

Keywords: Olbers' paradox, adiabatic expansion, Big Bang nucleosynthesis, thermal radiation

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Cosmic microwave background (CMB) is a strong and uniform radiation coming from the Universe from all directions and is assumed to be relic radiation arising shortly after the Big Bang. It is the most important source of knowledge about the early Universe and is intensively studied by astrophysicists. Arno Penzias and Robert Wilson (see Figure 1) received the Nobel Prize in 1978 for the CMB discovery and George Smoot and John Mather received the Nobel Prize in 2006 for a discovery of the CMB anisotropy. In this interview, we talk with dr. Václav Vavryčuk from the Institute of Geophysics of the Czech Academy of Sciences about another possible origin of the CMB, and we debate how this alternative theory could affect the currently accepted cosmological model.

Jana Žďárská: Most astrophysicists and cosmologists consider the cosmic microwave background (CMB) as relic radiation originating in the epoch shortly after the Big Bang. However, you propose to explain the CMB as thermal radiation of intergalactic dust. Why?

Václav Vavryčuk: This alternative explanation of the CMB is closely related to the so-called Olbers' paradox, which addresses an apparent discrepancy between observed amount of light coming from the universe and predictions for a model of

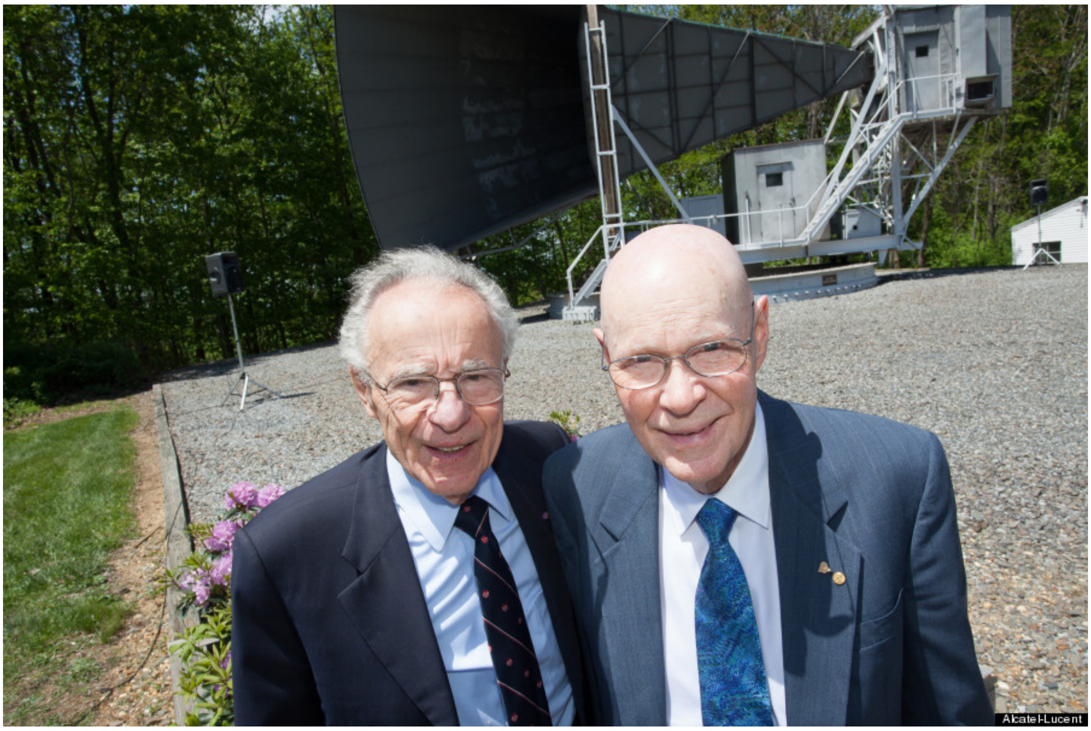

Figure 1: The Nobel Prize laureates Arno Penzias (left) and Robert Wilson (right) for the discovery of the Cosmic Microwave Background.

stationary infinite universe. The model predicts the intensity of light in the night almost 13 orders higher than that actually observed. In 1823, Olbers explained this paradox by light attenuation when photons travel through the universe. However, the Olbers' solution was rejected and the paradox is now explained by an idea of the universe with a finite age, where the finite age prevents accumulating too many photons in the universe. In my theory, I adopt the idea of Olbers and explain the low intensity of light in cosmic space by attenuation of photons by intergalactic dust. Dust grains are present in interstellar and intergalactic matter, they are rich in carbon and they have a complex fluffy shape with size of μm. The dust grains well absorb light in a broad range of wavelengths.

J.Ž.: You mean that the energy of photons absorbed by dust causes that dust is heated up and emits thermal radiation into the cosmic space?

V.V.: Exactly. Dust is present in galaxies but also in intergalactic space. Galaxies produce light and electromagnetic waves at other wavelengths, and dust is warmed up due light absorption. Subsequently, dust emits thermal radiation according to the Planck's law. Light of stars in galaxies can heat up galactic dust grains up to 10–40 K, and in the galaxy centres even to 80 K. However, light intensity in intergalactic space is much lower and the temperature of intergalactic dust is below 5 K.

J.Ž.: Is it possible to calculate the temperature of intergalactic dust more accurately?

V.V.: Yes, we can do that. If we take into account the amount of galactic and intergalactic dust and the amount of light in intergalactic space, it is possible to show that intergalactic dust should have temperature of 2.7 K that is the observed temperature of the CMB (see Figure 2). Hence, my theory suggests that the CMB is not relic radiation originating in the Big Bang but thermal radiation of intergalactic dust.

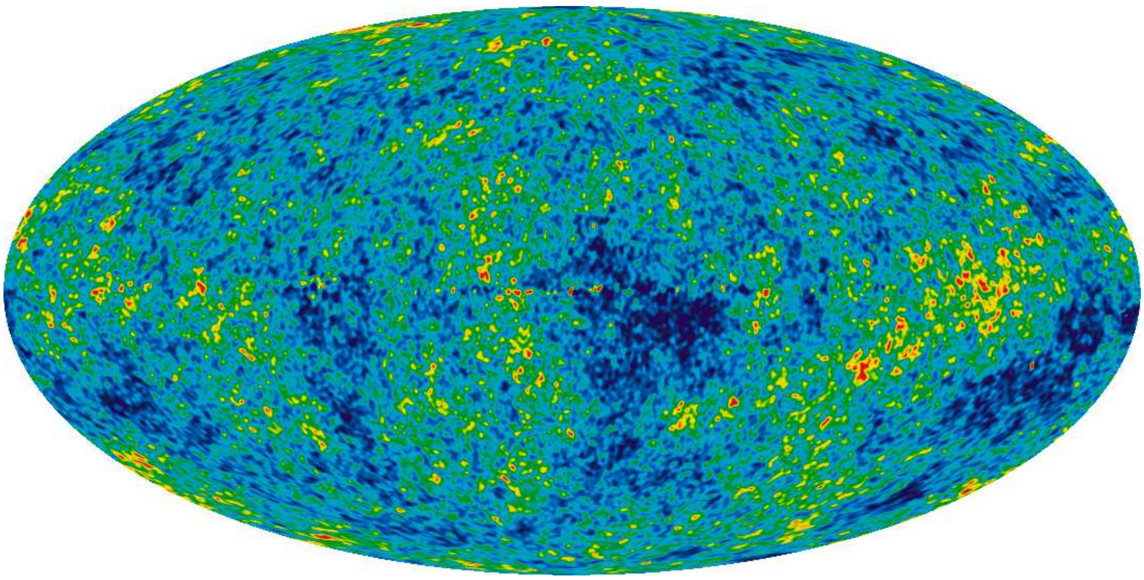

Figure 2: Map of temperature anisotropies of the Cosmic Microwave Background with temperature 2.725 K obtained by the WMAP spacecraft. The colour scale has a range $\pm 70 \mu$K. Source: `http://wmap.gsfc.nasa.gov/media/101080`

J.Ž.: But why the temperature is not continuously increasing by persistent absorption of star light?

V.V.: This is an important question. Intergalactic dust absorbs light from galaxies and is heated up. However, it also emits thermal radiation. Hence, it loses energy and this energy is absorbed back by galaxies. Both energies – absorbed by dust and emitted by dust — are equal and dust is in energy balance. Nevertheless, it does not mean that the temperature of dust was 2.7 K also in the past epochs of the universe. When the universe occupied a smaller volume, galaxies were closer each to the other and the intensity of light was higher in intergalactic space. Consequently, also the dust temperature was higher.

J.Ž.: Does it mean that intergalactic dust is cooling due to the expansion of the universe?

V.V.: Yes, you are right. The process of dust cooling is caused by an adiabatic expansion of the universe. The same property is attributed also to relic radiation of the Big Bang. Light with the temperature of $\sim 3000\,\mathrm{K}$ decoupled from the matter in the early universe with the redshift of ~ 1100, and then it was cooling due to the universe expansion down to the temperature of $2.7\,\mathrm{K}$. However, this theory is not capable to explain, why light was not dimmed and why its spectrum was not disturbed by absorption by galactic and intergalactic dust over the whole history of the universe.

J.Ž.: Your theory provokes many questions and has many important consequences. Can you mention some of them?

V.V.: There are many open questions, which must be explained consistently, the proposed theory to be accepted. For example, why do we observe small temperature fluctuations in the CMB called the CMB anisotropies, and why are they associated with polarization anomalies? In recent years, these anomalies are mapped very accurately by the Planck spacecraft (see Figure 3) and their properties are intensively studied. Interestingly, the origin of the CMB anisotropies is very easy to understand. The thermal radiation of dust depends on the density of galaxies in the universe; hence, it is warmed up to a higher or lower temperature according to the local density of galaxies. Inside galaxy clusters and superclusters, the dust temperature is high, near voids and supervoids with the absence of galaxies, the dust temperature is low. Consequently, we observe a slightly different CMB properties from different directions of the universe. The polarization anomalies can also be explained easily. They just map magnetic fields around galaxy clusters in the universe. The carbon present in dust grains is in the form of graphite and it is conductive. Hence, the dust grains are aligned according to the magnetic field of galaxy clusters and emit polarized light.

J.Ž.: Have you already published your theory?

V.V.: Yes, the theory has been published in several papers [1]–[4]. However, it was not easy, because the idea of the CMB as thermal radiation of intergalactic dust is not new, and it was rejected by the astronomical community many years ago. I had to persuade the editor and reviewers that rejecting this idea was unjustified.

J.Ž.: Your theory can cause a revolution in the modern cosmology. Are there any reactions to your papers?

V.V.: So far, I have noticed just a few reactions to my results. Indeed, my theory is in an essential contradiction with the currently accepted universe model. It refutes fundamentals of the modern cosmology. Obviously, it invokes doubts and suspicions.

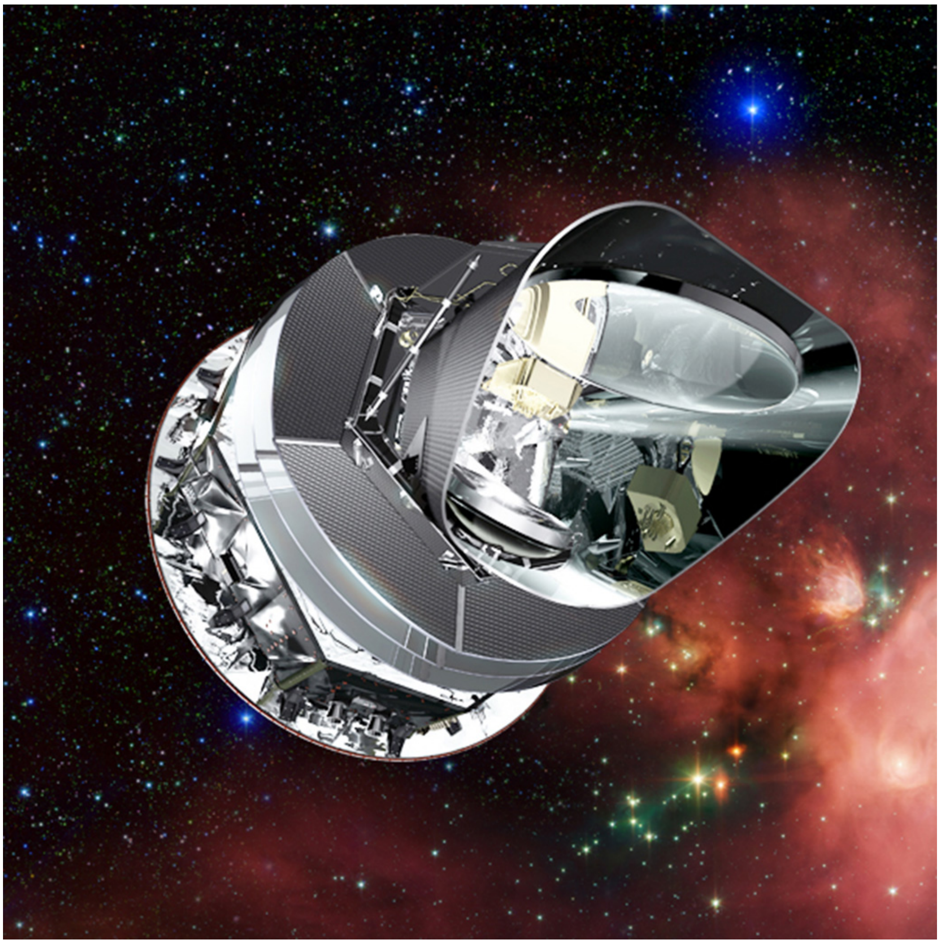

Figure 3: Planck is a space laboratory of the European Space Agency that maps the early universe on wavelengths 0.3–11.1 mm, which corresponds to the Cosmic Microwave Background. Source: `https://www.nasa.gov/mission_pages/planck`

The review process was difficult and reviewers pointed to a negligible chance that my theory could be correct and disprove the accepted cosmological model. They asked for clear and persuasive arguments and calculations supporting my theory and urged me to find weak points of the Big Bang theory and discuss the impact of my results to it.

J.Ž.: You believe that there was no Big Bang. What are your arguments against the Big Bang theory?

V.V.: The main pillar supported the Big Bang theory is the existence of relic radiation. If we question the idea of the CMB as relic radiation of the Big Bang, only few arguments for the Big Bang remain. Moreover, they are rather indirect and not very persuasive.

J.Ž.: One of these arguments is the so-called Big Bang nucleosynthesis. Can you clarify it a little bit and discuss its validity?

V.V.: The Big Bang nucleosynthesis (BBN) predicts a composition of the universe just after the Big Bang. It is believed that the universe was formed by 75% of hydrogen (H) and almost of 25% of helium (^{4}He). Other elements in the early universe were present by less than 1%. For example, the BBN predicts very accurately relative abundances of helium (^{4}He) and lithium (^{7}Li) with respect to the hydrogen. As regards the helium, the first observations did not confirm the prediction, and a satisfactory fit with observations was achieved after two decades of efforts when a large number of random and systematic corrections had to be applied to observations. As regards the lithium, the prediction and observations are completely different with no possibility to remove this discrepancy.

J.Ž.: Is it possible to calculate a ratio between matter and light in the universe?

V.V.: Yes, based on the abundance of deuterium, the nucleosynthesis predicts a ratio between amounts of matter and light in the universe, specifically, the ratio between photons and other particles, such as protons and neutrons. We know well, how many photons are in the cosmic space, and thus we can calculate, how much matter should be there. However, the BBN predicts ten times less number of particles than expected from other observations (e.g., the observed curvature of the universe). Therefore, a new and exotic physical substance called 'dark matter' was introduced to remove this evident discrepancy. It is assumed that the dark matter is formed by unknown particles, which do not interact electromagnetically with the standard matter. Obviously, introducing such an unphysical quantity undermines the credibility of the Big Bang theory.

J.Ž.: You propose a cyclic model of the universe, which periodically expands and contracts with time. How did you come to this idea?

V.V.: A cyclic expansion-contraction of the universe is one of possible alternatives. In contrast to the standard model, I assume that the universe does not contract to a singularity, but just to a volume, which is about 5×10^3 times smaller than at present. Large-scale structures in the universe as galaxies would exist irrespective of the universe expansion history. The cyclic variation of the universe volume could be an analogy to Earth's tides. Of course, there must be forces controlling this cosmic dynamics.

J.Ž.: According to your theory, the universe exists infinitely long time. Do you think that stars could continually arise during such a long period?

V.V.: In my model, the global stellar mass density and the overall dust masses within galaxies and in intergalactic space are essentially constant with cosmic time. Consequently, the cosmic star formation rate should be balanced by the stellar mass-loss rate due to, for example, core-collapse supernova explosions (see Figure 4) and

Figure 4: Image of the remnant of the Type Ia supernova N103B located in the Large Magellanic Cloud taken by the Hubble Space Telescope.
Source: `http://www.sci-news.com/astronomy/type-ia-supernova-remnant-large-magellanic-cloud-04746.html`

stellar winds or superwinds. Hence, formations/destructions of stars and galaxies and complex recycling processes in galaxies and in the intergalactic medium play a central role in this model. Note that the production of heavy elements in stars due to the nuclear fusion can possibly be balanced by their destruction back to hydrogen by a strong radiation of quasars.

J.Ž.: Which highest redshift do we observe and why the current models of the universe are based on the idea of the universe expansion from a singularity?

V.V.: The universe expansion is documented on observations of redshifts measured for nearby and distant galaxies. The most distant known galaxies have redshift of about 11–12. We have no observational evidence about the expansion for earlier cosmic epochs. Hypothetical behaviour of the universe at redshifts higher than 12 is highly speculative and based on very simplistic Friedmann equations, which might be wrong. This includes a hypothesis of the initial singularity as the origin of the universe.

J.Ž.: How about concepts of dark matter and dark energy? Do you consider them in your theory?

V.V.: Dark matter and dark energy are notions contradicting physics and they are missing in my theory. At the present epoch, almost 95% of energy in the universe is attributed to dark matter and dark energy, which violate all known physical laws. In my opinion, these 95% of 'darkness' evidences our substantial ignorance of the universe evolution, and it rather measures how tiny fraction of processes in the universe can be rationally explained by the standard cosmological model.

J.Ž.: As far as I know, the dark energy was introduced in order to explain an unexpected dimming of the luminosity of supernovae, and Saul Perlmutter, Adam Riess and Brian Schmidt received the Nobel Prize in 2011 for this discovery. Can you explain details about this interesting phenomenon?

V.V.: You are right, the supernovae are a hot topic in the current astronomy. Namely, the so-called Type Ia supernovae (SNe Ia) are very useful for cosmology, because they explode with a roughly constant luminosity. Hence, the observed luminosity of these supernovae depends just on their distance. Based on measurements of their luminosity and redshift, we can trace the current velocity expansion and the expansion history of the universe. Surprisingly, the measurements revealed that the luminosity of the supernovae is dimming with distance faster than that predicted by the universe with decelerating expansion. In order to comply the model with the observed dimming, the idea of the expansion decelerating due to the gravity forces acting against the expansion was abandon and substituted by an idea of the accelerating expansion due to the outward repulsive forces associated with dark energy. However, the unexpected luminosity dimming of supernovae with distance is also possible to explain by absorption of light by intergalactic dust without any necessity to introduce dark energy as shown in my recent paper [5].

J.Ž.: Let's go back to your cyclic model of the universe with the absence of the Big Bang. How do you explain the dynamic contraction and expansion of the universe?

V.V.: The dynamic contraction is caused by gravity. The primary question is, however, which forces balance the gravity and give rise to the universe expansion. In my concept, I assume that the universe works similarly as stars. Also stars are objects with gravity, but still they do not collapse. This is caused by their radiation of light and other electromagnetic waves. The repulsive radiation pressure in stars is so strong that it maintains stars in a balance with gravity and avoids their collapse. The stars collapse only when they are run out of fuel and are not able to radiate photons anymore.

J.Ž.: OK, but how this concept works for the universe with galaxies?

V.V.: In fact, the mechanism is simple. Galaxies are formed by stars, gas and galactic dust, and they emit light into the intergalactic space. This light produces pressure on galaxies and repels the galaxies each from the other similarly as wind acting on sail moves a sailing boat. The process is described by the standard physics and the radiation pressure acting on galaxies can easily be calculated. At present, the radiation pressure is negligible compared to gravity forces and the universe expansion must decelerate. After some time, the expansion will cease due to its deceleration and the universe contraction will begin. With decreasing the volume of the universe, the galaxies will be closer each to the other, and the intensity of light in the intergalactic space will rapidly increase and the contraction will be decelerating. I calculated that the contraction will stop for the universe volume corresponding to redshifts of about 15–20. At such redshifts, the radiation pressure will be so high that the universe will again start to expand. In this concept, the universe has no origin and is infinite in time. The number of galaxies would be roughly the same: the dying galaxies would be substituted by new born galaxies.

J.Ž.: Is there any experiment, which could confirm your theory?

V.V.: The progress in astronomy is based on gradually improving observations. A big step forward was the installation of the Hubble Space Telescope launched into low Earth orbit in 1990, which is capable to detect galaxies with redshifts up to 11–12. Surprisingly, we observe mature galaxies even at such very early universe. This observation belongs to many other puzzles in the Big Bang theory.

J.Ž.: Nevertheless, we need observations even from earlier epochs of the universe using a telescope of higher resolution ...

V.V.: With some delay, a new telescope called the James Webb Telescope (see Figure 5) will be launched in 2021. This telescope should be of about 100 times more sensitive than the Hubble Telescope and should be able to explore very early universe epochs. I expect that it brings many surprising discoveries and it will confirm that the number of galaxies in the universe is roughly constant with time. Now, we observe only the biggest and most luminous galaxies in the early universe, because the luminosity rapidly decreases with distance. With a more sensitive telescope we could observe galaxies in epochs, when no galaxies should exist according to the Big Bang theory. If such galaxies are detected, my cosmological model will be strongly supported.

Figure 5: James Webb Telescope prepared by the cosmic space agency NASA should be launched in 2021. Its sensitivity will be 100× higher than for the Hubble Telescope. Source: `https://bigthink.com/jazzy-quick/the-james-webb-space-telescope-will-bring-us-closer-to-a-galaxy-far-far-away`

J.Ž.: How about the discovery of gravitational waves in the universe, for which Rainer Weiss, Barry Barish and Kip Thorn received the Nobel Prize in 2017*? Can observations of gravitational waves contribute to verification of your theory?*

V.V.: Partially yes. Gravitational waves excited by mergers of neutron star-neutron star or of the black hole-neutron star can serve for measuring the speed of the universe expansion similarly as the luminosity measurements of supernovae. Observations of gravitational waves would be better than those of supernovae, because they are not affected by the presence of intergalactic dust. Hence, they can uniquely confirm or disprove, whether the universe expansion is accelerating according to the Big Bang theory or decelerating according to my cosmological model. However, we need a very sensitive detector of gravity waves, as the planned Einstein Telescope, a third generation detector proposed by a consortium of European institutions, the installation of which is scheduled to 2025.

J.Ž.: Recently, you presented your theory at an international astronomical workshop in Bonn, Germany. How were your ideas received?

V.V.: It was a workshop organized by prof. Pavel Kroupa and his collaborators from the University of Bonn, and devoted to gravity, specifically to difficulties and controversies in the galaxy dynamics produced by the presence of hypothetical dark matter. My talk was received with interest and invoked a long and eager discussion. However, persuading a broad astronomical community that my cosmological model is correct or at least a reasonable alternative to the Big Bang theory will not be easy and will take time.

J.Ž.: In your opinion, how long time does it take the current cosmological model to be abandon?

V.V.: It is difficult to estimate when the Big Bang idea will definitely be rejected. The most of astronomers and cosmologists accepted this theory, even though it is full of many discrepancies, contradictions and puzzles. Instead of developing new alternative theories, they used to live with these puzzles and became resistant to a critique of the Big Bang. For example, a very old star (denoted as HD 140283) with age of 14.5 billion years was discovered at distance of 60 pc from the Sun. Paradoxically, the age of the universe predicted by the Big Bang theory is estimated to be 13.8 billion years only. Even after this revolutionary discovery, the mainstream opinion on the Big Bang did not change.

J.Ž.: Does it mean that even such evident discrepancy between theory and observations did not wake up astronomers from their lethargy?

V.V.: Yes. This is partly caused by firmly rooted preconceived opinions of astronomers, and by reluctance of scientists, who developed the Big Bang theory, to admit their mistakes. However, the critique of and the unsatisfaction with the current cosmological model are continuously increasing, and a deep crisis in cosmology is coming near. I expect that enough evidence against the Big Bang will be accumulated in the horizon of 5–10 years. It will very much depend on observations of the future James Web Space Telescope, and possibly on the Einstein Telescope for detection of gravitational waves.

J.Ž.: What do you find most fascinating in the universe?

V.V.: I guess, the universe fascinates everybody. As a student of the grammar school, I often visited observatory and admired a variety of stars and galaxies and the immense space among them. In particular, I was excited by the fact that the universe is a subject to simple physical laws. Understanding the universe evolution is a big challenge for us, and I recommend to all scientists, who like solving demanding and ambitious problems, to work in astrophysics and cosmology.

J.Ž.: Thank you very much for the interesting interview and I wish you success with your novel cosmological ideas.

Acknowledgements

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References

[1] Vavryčuk V.: Impact of galactic and intergalactic dust on the stellar EBL. Astrophys. Space Sci. **361** (6) (2016), art. no. 198.

[2] Vavryčuk V.: Universe opacity and EBL. Mon. Not. R. Astron. Soc. **465** (2) (2016) 1532–1542.

[3] Vavryčuk V.: Missing dust signature in the cosmic microwave background. Mon. Not. R. Astron. Soc. **470** (1), (2017) L44–L48.

[4] Vavryčuk V.: Universe opacity and CMB. Mon. Not. R. Astron. Soc. **478** (1), (2018) 283–301.

[5] Vavryčuk V.: Universe opacity and Type Ia supernova dimming. Mon. Not. R. Astron. Soc. **489** (1) (2019), L63–L68.