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EDITORIAL

What does the Universe consist of?

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Since the very beginning of the human history, we are striving for knowledge about the world we are living in. We don't get this knowledge intuitively, but rather use scientific method to acquire it. When we face certain feature of the world that we don't understand, we start building models of it and testing them.

So, at this state we are living in the world of models, doomed to endlessly come closer and closer to the true nature of things. Another possibility could be asking the Creator of the Universe, which is simply a one-step way, but modern science, based on the scientific method, cannot afford it.

It needs to be mentioned that some models become so habitual, that we take it for natural laws and use it in everyday life, ignorant of its incorrectness. Newton laws of motion are good examples. The first law states the existence of an inertial frame of reference (IFR), and the second law as we know it is stated to be valid in any IFR. As we do not know of any free body in our Universe, IFR can also not be constructed in it so the second law is not applicable and yet we use it in our everyday life! Why? Simply because in most of the cases the uncertainties we get due to using this wrong model are quite negligible and we need to think of more complicated models only when we deal with more accurate matters. Within this paradigm we can say that we've been through several revolutions in understanding of what does the Universe consist of, and it seems like another one is at hand!

Now we understand that any atom consists of a nucleus, containing massive protons and neutrons, and almost 2000 times less massive electrons orbiting the nucleus. Protons and neutrons are baryons, so we can say that all we see around is baryonic matter. And some might think that the whole Universe is like this - it consists of baryonic matter. How true is this?

It has been thought to be like this for a long time. We can say that all we see including planets, stars, interstellar and intergalactic gas - everything that is produced or is capable of interacting with electro-magnetic radiation and so be observed does indeed consist of baryonic matter. To describe various elements that constitute this matter we use Mendeleev's periodic table and due to modern developments in astrophysics and other fundamental sciences we now know quite well where and how did these elements come from. Soon after the Big Bang (several seconds) expansion of the Universe led to its cooling to a state when stable particles like protons, neutrons and electrons could exist and primary nucleosynthesis had occurred, but only 379,000 years later during the primary recombination epoch these could come together and form H atoms, much less of He atoms and a bit of Li atoms. Some 300 million years later these formed primordial stars, where thermonuclear reactions used these bricks to produce heavier elements up to Fe. After burning all the H fuel in thermonuclear reactions heavier stars went into supernova and even heavier elements were born in their explosions. This way simple H, He and Li multiplied into the whole periodic table. As far as we understand at the moment 88.6% of all baryonic matter atoms in the Universe are H – it is mostly intergalactic and interstellar gas, and a minor part is in stars and other massive astronomical objects. H is a main fuel for main sequence stars, so we can say that our fuel tank is almost three quarters full and we still have a long way to go as a Universe. Another piece of the baryonic pie is He – these atoms occupy 11.3% of it by number (23% mass wise) and are also present both in the interstellar medium and in stars and other bodies. All the rest of heavier atoms are within 0.1% of the pie by their numbers, which might be a surprise to a non-physicist as almost all we see around on the Earth and the Earth itself are made of these heavier atoms – a minority in our Universe!

Later in 1982 Jim Peebles assumed that existence of a substantial amount of dark matter may account for a discrepancy between the lack of essential baryonic matter density variations at the primary recombination era and the modern large-scale structure of the Universe, which could not have been able to develop in such a short

time. At the same time the theory of inflation that appeared in 1980s could explain the Cosmic Microwave Background (CMB) radiation isotropy under assumption of critical density of the Universe, which could only be reached with the existence of very significant amount of dark matter, for baryonic matter would only account for a minor part of it.

Up until now the existence of dark matter has been needed to explain not only the galactic rotation curves, dynamics and morphology of satellite galaxies and globular clusters and behavior of multi-galaxy systems. X-ray observations of hot gas in giant elliptic galaxies and clusters witness of its temperatures that are too high to be balanced only due to the visible baryonic matter gravity. Gravitational lensing allows us to see the lack of visible matter in massive galaxy clusters. Finally, some observed merging clusters witness of different plasma and main mass distributions in it. These are all hard to explain unless we assume existence of dark matter - a new type of particles, that participate in gravitational interactions, but have no connection to electromagnetism, so we cannot see it with our electromagnetic devices. We need it to be there to explain what we see, but we do not see it and do not understand what it is, therefore we call it "Dark Matter".

If only baryonic and dark matter are taken into account, equations predict a slowing down expansion, which is obvious and can be easily explained by its gravity. So it became a big surprise, when in late 1990s observations of type Ia supernova led to the opposite conclusion – the Universe seemed to be expanding with positive acceleration. It was accepted (now this issue is a point of argue) that type Ia supernova are standard candles, in other words, they should have the same luminosity wherever they appear. So, if observations show that such an object is deemer, it just means it is further and this is a good needed second prosedure for measuring distance to galaxies in addition to red shift. In this research supernova were deemer than if being situated at distances predicted by the Hubble law, meaning they were further and Universe expansion is accelerated. This result was also confirmed by measurements of CMB and gravitational lensing.

The Big Bang nucleosynthesis theory gives a good explanation to formation of such light elements as De, He and Li in the young Universe. Universe large scale theory discribes well forming of stars, quasars, galaxies and galaxy clusters. Both the theories assume that baryonic and dark matter density is around 30% of the critical value. At the same time recent CMB mesurments with WMAP sattelite show that global space-time curviture of the Universe is indeed close to zero, corresponding to a flat Universe and implying overall density to be around critical. But than where do the rest 70% come from?

These discripancies inspired an introduction of a new entity with negative linar coefficient in cosmological equation of state, which not only accounted for lacking energy density in the Universe, but also could be responsible for its accelerated expansion. Different observational facts agrue this entity should exist, but we do not know what it is and we do not see it directly with our electromagnetic equipment, so, as usual, let's call it Dark something! Dark Mater is taken, so let it be Dark Energy - yet another part of the Universe we cannot explain.

Since the end of inflation stage radiation played a dominant role in the evolution of the Universe. About 70,000 years from the Big Bang matter came to rule and it effected the Universe expansion. According to modern astrophysical data interpretation about 4 billion years ago the nature of expansion changed again - it started to accelerate again and we are seeing it now. Unlike Dark Matter, Dark Energy does not participate in gravitational attraction and so crowding - it is distributed homogeneously. Density of matter decreases with expansion of the Universe, but density of Dark Energy remains the same, so 4 billion years ago matter density fell below the Dark Energy density and the latter is now ruling the Universe's behavior.

So, what does the Universe consist of? Almost 70% of energy density is determined by Dark Energy, around 25% are due to Dark Matter and only 5% consist of baryonic matter. Within these 5% almost 4% represent free H and He in intergalactic and interstellar medium, 0.5% is in stars, 0.3% in neutrinos, 0.03% in heavier chemical elements and 0.01% in radiation. In other words, we know almost nothing about 95% of our home Universe and know a bit about the rest 5%.

And there is another part of our world that science will yet have to explain someday. Throughout the whole human history, the vast majority of us were believers. There are numerous reports of so-called spiritual phenomena in different parts of the world experienced through millennia of our existence. Some efforts were made to find scientific explanations of such phenomena, but they all failed. Some scientists would say that the case is closed and there is nothing to research, but other, including myself, never give up on the path of resolving worlds wonders. Imagine, if we would say: "What we see is all there is", and would not develop observational techniques

such as telescopes, optical at first, but then radio, infrared, ultraviolet, X-ray, gamma-ray, gravitational observatories – we would never know the Universe is so huge and various and consists of much more than just several thousand stars one can see in the night sky. Development of science allows us to go deeper in the nature of things in micro world as well as on the Universe-size scales. New ideas, based on deeper understanding of the physical Universe, and state of art accuracy in experiments we have achieved by today may shed a light on this terra incognita. Understanding of spiritual phenomena, based on the clear and scientific description of the spiritual world, will have to become one of the crucial goals for science in this millennium.

This is the reality of today's science and this hints us that we are living in an era on the edge of huge discoveries, when the Standard Model will have to expand to cover 5, 6 or, may be, even 7 interactions, or there may appear another model theory, describing all we know now as a whole in a completely different prospective. One thing is clear: as long as there are unresolved questions, there will always be an indestructible endeavor of human spirit to resolve it and shed the light to the unknown.