Dimension-Information-Energy Map (DIEM) of the Universe

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Introduction:

Having a map available can be very useful - if we'd like to locate where we are, and chart a path to where we'd like to go. It is a well-known witticism that says: Spaceship Earth does not come with a User Manual. Yet we are lucky to have an excellent map of the Universe that we can use to chart our journey. Knowing the path we would like to take (and the length of the journey) should help us provision Spaceship Earth for the long haul.

The Dimension-Information-Energy Map (DIEM for short), is not our typical earth map with latitude and longitude markings. Along the vertical axis we have dimension, expressed in meters. Thus we could expect to find human beings around the 1 meter range (our approximate size), and atoms around the 10^{-10} meter (0.0000000001 meter) range. The entirety of the Universe, we'd expect to find around the 10^{26} m range. Since each vertical step represents a 10x increase in dimension, this axis has a geometric (or exponential) progression.

Along the horizontal axis we have energy (or its mass equivalent) derived from Einstein's famous equation $E = mc^2$. The unit is electron-Volts (eV), or the energy released by a single electron when it covers an electric potential difference of 1 Volt. This unit is used extensively in particle physics, but can be extended to apply equally to the mass of a human being, or the total energy of the Universe. As with the vertical axis, the horizontal axis also represents exponential progression, and this kind of chart is technically referred to as a log-log chart. Since the scale is so great, each horizontal marking represents a 10,000,000,000 (or 10^{10}) increase in energy. Roughly, this is the scale from a single human to the total population of humanity (rapidly closing in on the 10 Billion mark).

The 'Be' line

Shakespeare's Hamlet famously said: To be or not to be is the question. In this chart, the slanted line coming down from the top left is the 'Be' line. So what does it mean in physical terms? This line represents the energy required for a photon (a quantum of electromagnetic energy) of a specific dimension (wavelength) to exist. Any less energy would cause the photon to lose its continuity in this universe. So this is the minimum energy for anything to exist consistently in this universe, hence the name the 'Be' line.

The curious thing about the Be line is that as dimension (wavelength) increases, the energy required for a single quantum decreases. Hence the most expansive, Universe sized photons have the lowest energy! For a given dimension, this is also the energy required for a single bit of information to exist, so this is a very important existential boundary defined from quantum mechanics.

The 'Belong' line

From the top right corner, slanting down, is the heavyweight counterpart to the Be line – what we will call the 'Belong' line. Objects of a specific dimension that are more massive than the Belong line separate themselves from the rest of the Universe and form a black hole, from which even light cannot

escape. In technical terms this is also called the Holographic Bound. In between these Be and Belong lines, then, is where our normal connected Universe can exist.

Being who we are as humans, Hamlet's parallel 'Belong' monolog is now: To belong or not to belong is the question. As humans, it is far easier for us to mentally isolate ourselves from the rest of the universe. This state of isolation (or individuality) would have us behave as a 'black hole', essentially isolating ourselves while denying the nature of our interconnected existence.

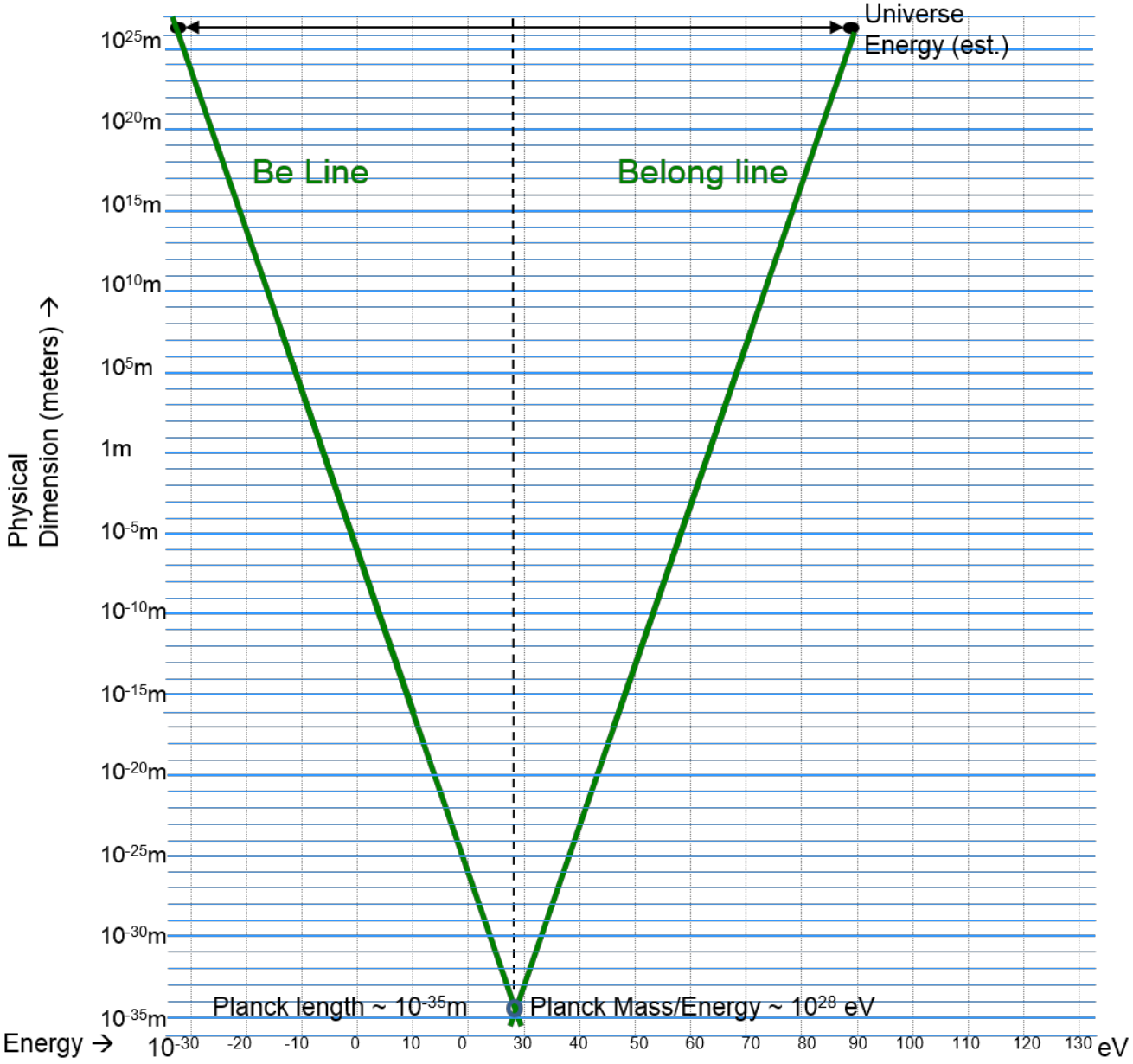


Figure 1: The Be and Belong lines

Planck Length, Planck Energy

We would not expect the Be line and the Belong line to actually meet, but they do. The intersection of the two lines demarcates two important reference quantities for quantum mechanics, the Planck Length

and the Planck Energy. The Planck Length is about 1.62×10^{-35} meters, and Planck Energy is about 1.22 x 10^{28} eV. Plank Energy represents the maximum energy for a single quantum of electromagnetic (EM) energy, also referred to as a Photon.

The Planck Length represents the smallest linear dimension that has significance in this universe. Using a computer screen as a comparison, this can be thought of as the smallest object that can be viewed – usually referred to as a pixel.

At the present state of physics, Quantum Theory governs the interactions at or near the Be line, whereas the Theory of Relativity governs the interaction along the Belong line. Much work remains to connect the two, and such an integration will be necessary before we can fully comprehend the physics around the intersection of the Be and Belong lines.

Butterfly wings

The Be and Belong lines can be visualized as the two wings of the butterfly, connected to the body at the Planck length/energy. Within the symmetry of the two unfolding wings of the butterfly exists our connected Universe. In Figure 2, we place our familiar objects, like protons, atoms, cells and even human beings, on to this map. Incredible as it may sound, the variation of size and mass of atoms, cells and human beings seem to fit well within the tiny ovals representing each object. The differences we view as huge, pale to insignificance when seen in the universal context.

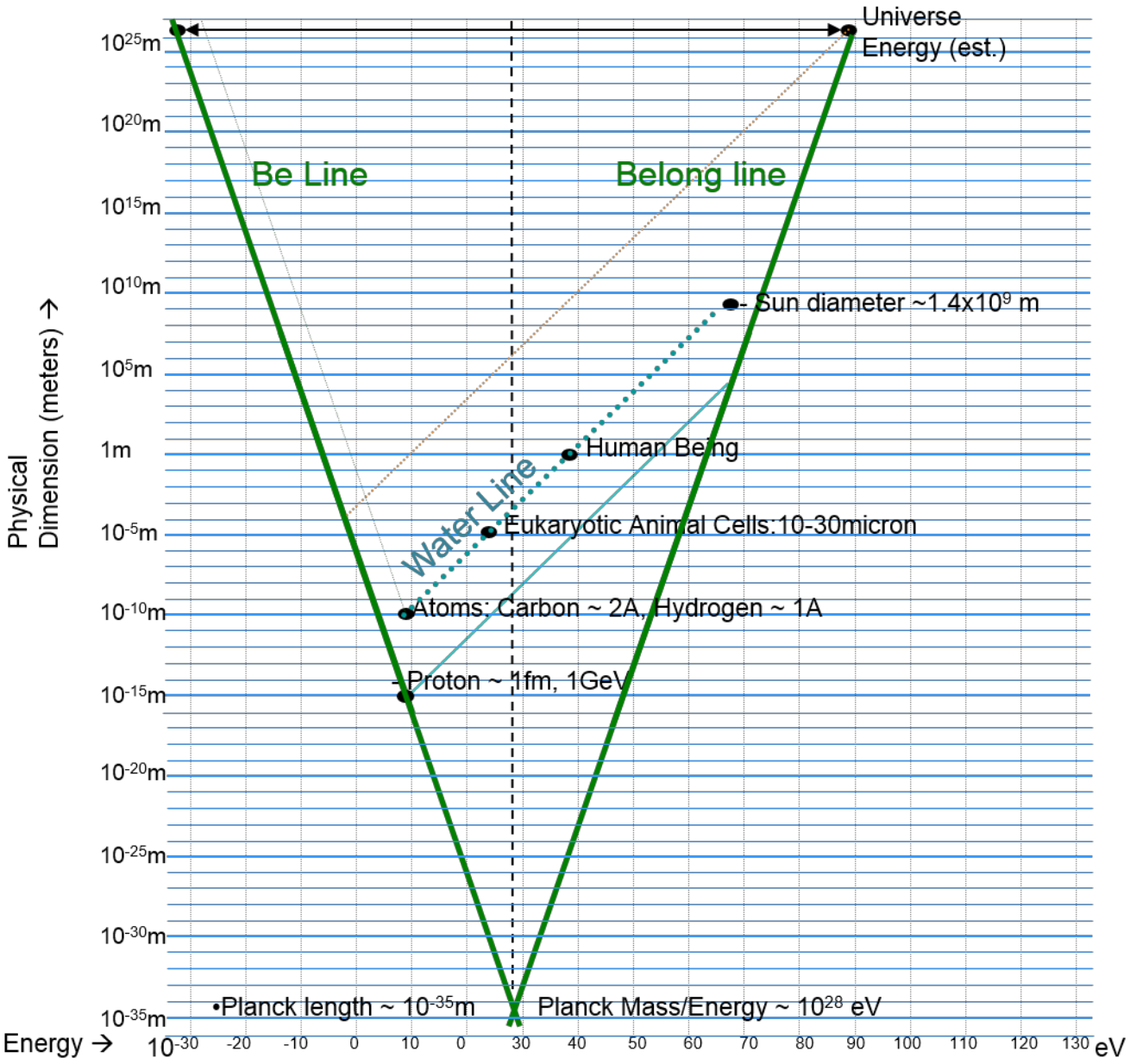


Figure 2: Location of familiar objects on the DIEM Chart

Let us take a moment to discuss how we find the placement for the little oval representing humans. The one meter dimension is relatively straight-forward. For most humans, our height exceeds 1 meter, and our width and depth is somewhat less than 1 meter. Thus, 1 meter is a good approximation of our physical dimension. Next, we take 62 kilograms (about 135 pounds) as the global average mass of adult human beings, and translate it to eV. Since 1 eV ~ 1.78×10^{-36} kg, we end up with a human mass in the $10^{37} – 10^{38}$ eV range, as indicated in the DIEM Chart. All the other points shown above, including the estimated size/mass of the Universe itself, can be plotted in a similar fashion.

Two things become apparent when we plot the length-energy points for atoms, cells and humans. First is that there seems to be a uniform scaling from Atoms → Cells → Humans. The uniform scaling (periodicity) is a very important aspect of how we are internally organized as humans, and we will discuss this further in a later section.

Second, there seems to be a gradient to the line we follow from Atoms → Cells → Human beings. This gradient we will call the 'Water' line, because it reflects the density of our primary ingredient as cells and animals – i.e. water. The gentle upward sloping lines (like the water line) are equal-density lines. Just below the water line there is an equal-density line for nuclear materials like protons and neutrons.

Information Limits

For any object of a given mass/energy and dimension, the maximum theoretical information capacity can now be defined. For a given dimension, the Be line represents the single bit of information, a '1' or a '0', to 'be or not to be'. Moving horizontally from the Be line, the span represents how many bits of information can be contained within a given object. Thus, our body's cells have an information limit of about 10^{25} bits, which exceeds the number of digital bits in computers and servers throughout the world today. The theoretical limit for the human body is about 10^{45} bits, and we do not even come close to utilizing this level of information. By comparison, the Universal Information Baseline is about 10^{122} bits – a number that boggles the mind. This is but a small reflection of how tiny a scope within the Universe we currently represent as humans, and how much room there is to grow.

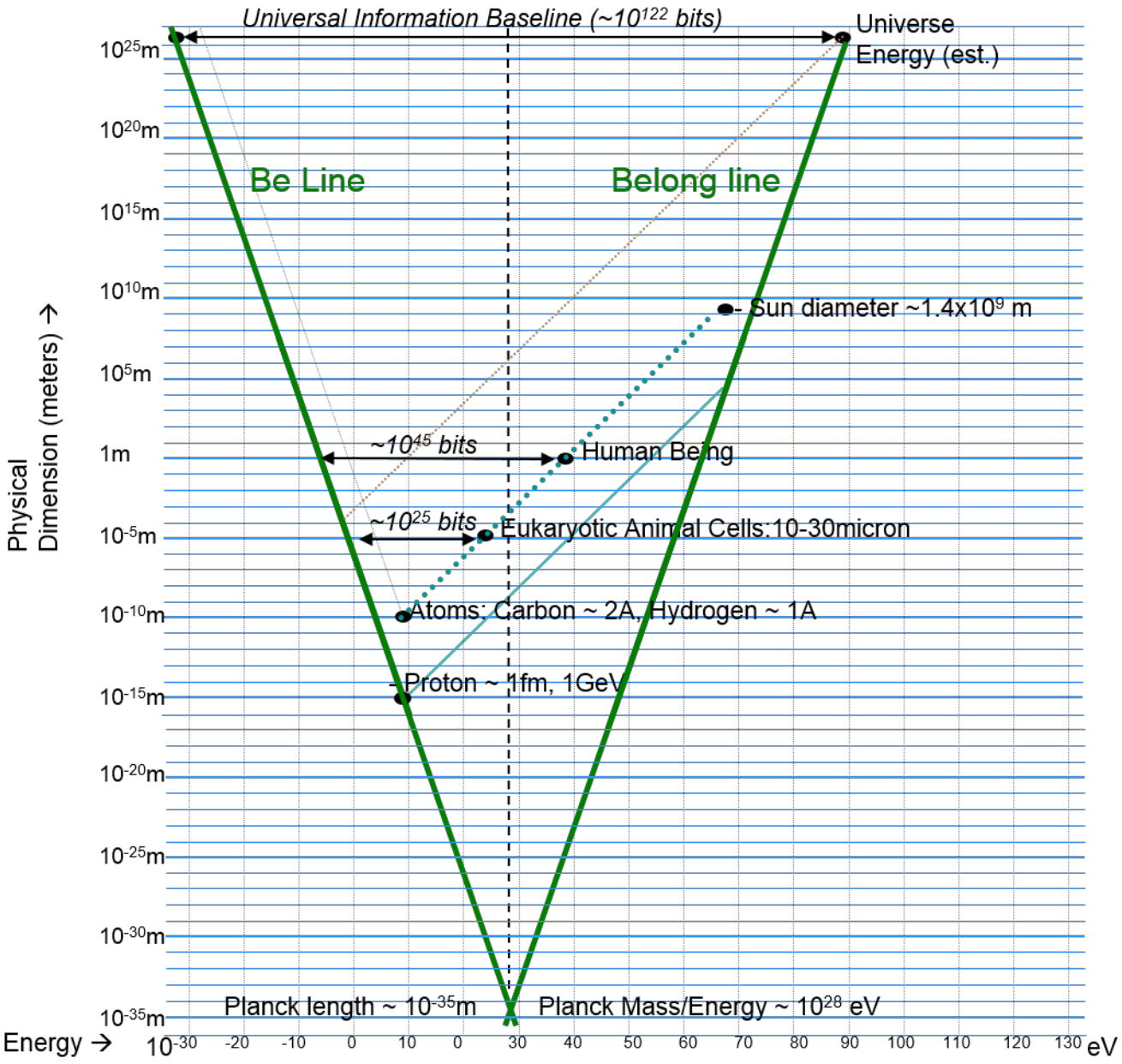


Figure 3: Information limits

Organizational Periodicity

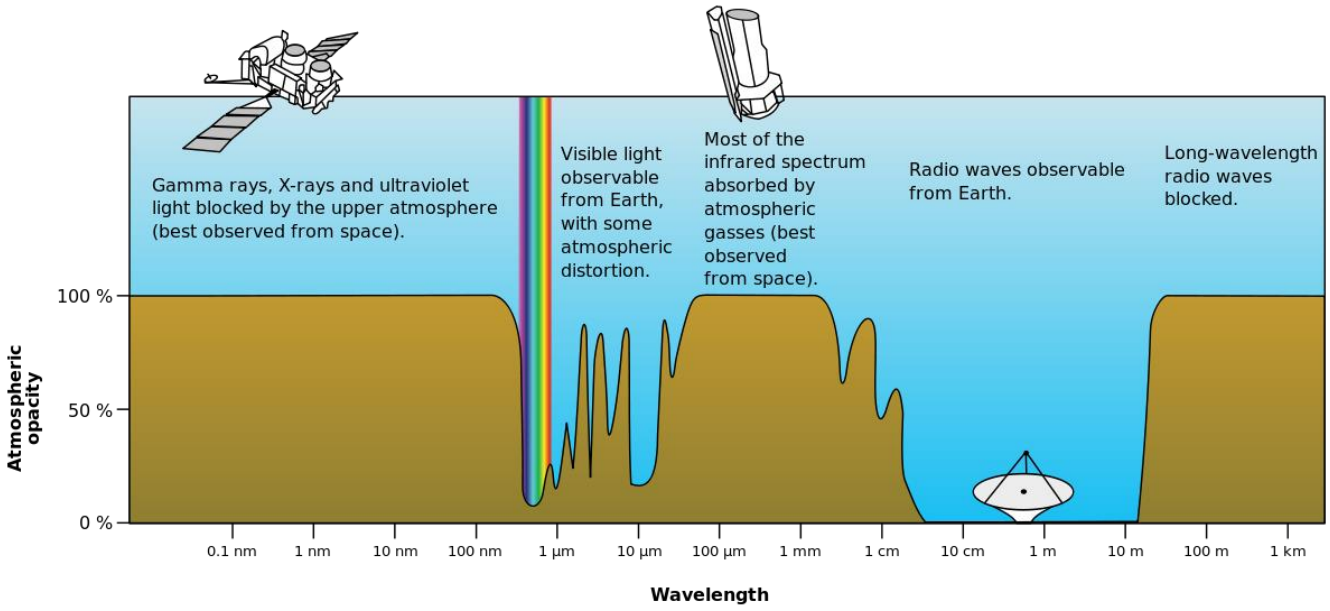
We noted earlier, there seems to be a definite periodicity going from atoms to cells to humans. In each case the linear dimension increases by about 10^5 times and the information potential by about 10^{20}. We also noted that we are climbing the water line to get to the higher levels of organization. Note also that the energy/mass in each step increases by about 10^{15} times, but the information capacity increases about 10^{20} times. This is the beauty of higher levels of organization, the information capacity of the whole is considerably greater than the sum of the parts!

Much work remains for us humans to come to terms with our information capacity. Yet, it appears that there are several more steps of organization (encapsulation) before we can measure to the amazing scale of the Universe.

Let's take another look at the water line, which has brought us to the current state of organization as a water and carbon based organism. How far can this organization be continued? The tiny green dot further up the water line from us represents the entire bio-diversity of planet earth (Fig. 5), if it were consolidated into a single volume. This bio-diversity is like an encapsulating organism to us, we are to it as individual cells are to our body. Personally, some of my strongest feelings of belonging have been when I am surrounded by the biological aspect of nature. Yet there us a bitter-sweet feeling to this shared experience, a feeling of impending separation – almost a birthing process that is about to happen.

Biology following the water line, by itself, does not appear to be a sustainable direction for our continued evolution as a human civilization into a cosmic presence. For biological organisms to flourish, there are many contributing factors from mother earth. First is the atmosphere that protects us from much harmful radiation. Then there is the earth's magnetic field that deflects a lot of the ionizing ration from space. Then there is the plentiful supply of liquid water near the surface, along with plenty of sunshine for photosynthesis.

To see how protected we have been in our earthly habitat, let's note how our atmosphere filters out the radiation in different frequencies of EM radiation. In Figure 4 atmospheric opacity refers to the percent of an incoming (or outgoing) radiation that is intercepted by the earth's atmosphere. An opacity of 100% indicates that none of that energy is passed through, a 0% opacity indicates it is all passed through. Even for visible light, we see that the atmosphere is not quite 0% opaque – i.e. some of the incident energy in these wavelengths is still blocked by the atmosphere.



Source: NASA

Figure 4: Atmospheric opacity and the Electromagnetic Spectrum

There appears to be two areas where the EM radiation mostly gets through, one near the visible / infrared range, and again in the Short / Medium wave radio range. The rainbow colors indicate how narrow the visible spectrum is relative to the range given, yet most of our information about the outside universe comes to us from these very limited wavelengths. To see how narrow our window is on the full spectrum of the Cosmos, let us take Fig 4 and apply it to the vertical axis of the DIEM chart.

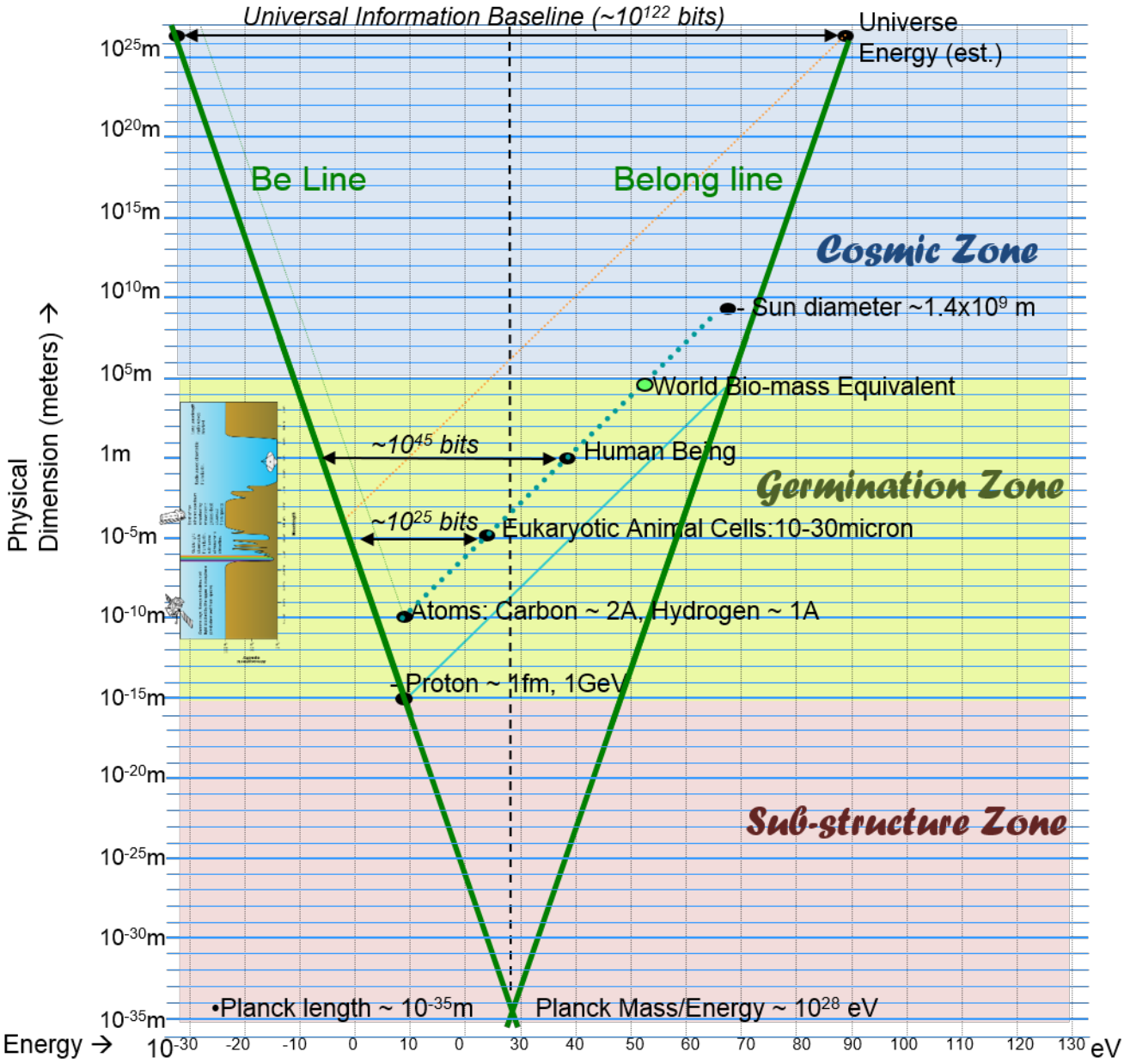


Figure 5: Windows on the Universe – limits of earth based observation

Germination Zone

In Fig 5 it becomes obvious that the two windows of visibility in the EM spectrum roughly correspond to:

1. Our cellular level (0.00001 meter), and
2. The dimensions of our human organism (1 meter)

It is as if the conditions are carefully controlled as to what parts of the EM spectrum we are exposed to, and correspondingly what we can observe of the Universe. With space based observation, this restriction will be less severe. Yet, the observation of large waveforms, whether from the EM spectrum or from gravity waves is still very difficult and expensive.

In Figure 5, a color background has been applied, roughly dividing the vertical Dimension Range into thirds. The bottom, from the Planck length to the proton size, roughly 20 orders of magnitude - is the Sub-structure zone. The next segment, from the proton size to the World bio-diversity equivalent, is the Germination zone. The top third, going up to the Universal baseline is the Cosmic zone.

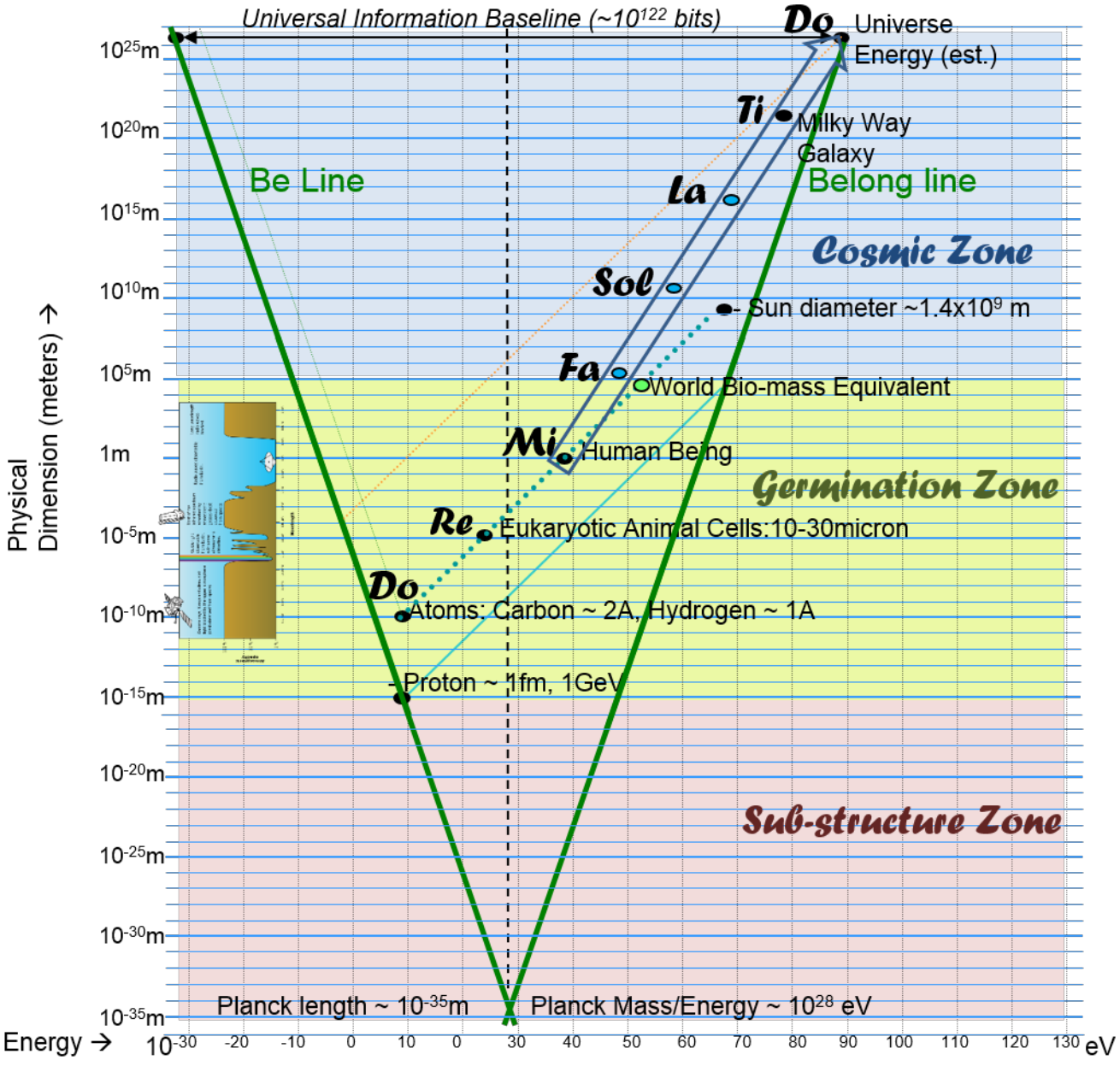


Figure 6: Cosmic Escalator

Cosmic Zone

Extensive as the world's biodiversity is, we cannot expect it to be scale, by itself, to the cosmic totality. It is for this reason that a separate path is proposed by which our human civilization might intercept the Universal Baseline. The blue arrow in Figure 6 shows an alternate path which maintains about the same cadence of scalability of Atoms → Cells → Humans, but scales all the way to the Universe level with four intermediate steps. Let's refer to this upward sequence as the Cosmic escalator. Let's mark the periodic steps with the seven steps of the octave, Do, Re, Mi, Fa, Sol, La, Ti, Do. We find ourselves, as humans, at Mi, at the intersection of the water line and the Cosmic Escalator. Finding our physical self, our 'Me' at the Mi node is not the only coincidence, as we will see later.

Sustainable Trajectory

If our goal is to intercept the Universal Baseline over time, it will be very important for us to maintain the diversity that we find around us. Let's use the Fa point, the first step in the Cosmic Escalator, to illustrate how things would be different from a totally earth bound existence. Residing about two orders of magnitude above the water line, the average density of a Fa existence is closer to that of air than of water. The loss of density is made up with somewhat greater dimensions, to yield about a 10^{16} increase in information capacity from our current human existence. Physically we can think of this as a combined man-machine existence with an approximate aggregated size of 200km, and carrying the information equivalent of earth's biodiversity. The corollary to this approach is that most of earth's biomass is left in its pristine state.

The next step is the Sol point, and it seems hardly a coincidence that it is closest in dimension to our sun (Sol). At this point the average density would be ten times lighter than air. The next La step carries us to a size about 2 light years around the sun, and an even less dense existence. The penultimate Ti point coincides with our Milky Way galaxy, and the ultimate intersection would happen at the second Do point which represents the Universal baseline. Once we are at the second Do point, our average density is the same as the Universe, in the range of one atom of hydrogen per cubic meter.

Fermi Paradox, Revealed?

Let's take a step back from the trajectory discussion and consider the Fermi Paradox – how's it that in a Universe this large we don't see signs of other technologically advanced civilizations? Signatures of technologically advanced civilizations were traditionally believed to exist in the form of radio waves that we could detect through the atmospheric windows visible in Figure 4. The first question would be, could any extra-terrestrial civilization intentionally be trying to reach us?

If we look at our current state of civilization within the Germination Zone, this first answer appears to be 'No.' The Star Trek episodes had their 'Prime Directive' – non-interference with any civilization that hadn't reached the Cosmic Zone. The evolutionary pattern in the Germination Zone would be radically altered under the visible presence of an advanced external entity. Hence, for better or for worse, we must assume that, for now mankind must power its own civilizational trajectory. Hence, any public disclosure of alien activity would need to be purely accidental.

The next question is: what would the Electromagnetic (EM) signature of an advanced civilization in the Cosmic zone really look like? Even for humans, if you look at the most common areas of EM usage – the 50-60 cycle/second (Hertz) used for power lines – we ourselves have a very hard time monitoring

radio activity in that band. Part of the problem has to do with how long an antenna has to be for optimal signal transmission and reception. As the wavelength stretches to thousands of kilometers, large and sophisticated antenna design becomes necessary to effectively transmit or receive these signals wirelessly.

If we think of our human brain waves, ranging from about 1 Hertz – 100 Hertz; this too is a largely un-monitored zone. For civilizations in the Fa range and higher, the operating frequencies will be lower still, and we would have a hard time detecting them from within the earth's atmosphere. For example, a 30 Hertz signal in the EM spectrum would have a wavelength of about 10,000 km, or close to the diameter of the earth.

With a space based existence, these frequencies become easier to monitor. Yet, the path to the Universal baseline is still a long way off. There is much room to grow! It is estimated that an astonishing 73% of the total mass/energy of the Universe is dark energy. We can surmise its existence, but we can't observe it with today's technology. If the Universe already contains intelligence at the Fa, Sol, La and Ti levels, from Fig 6 it we can now infer where their energy signatures might be.

Conclusion:

The Dimensional-Information-Energy Map (DIEM) of the Universe correlates several key aspects of our human existence in this Universe. At one glance we can see the biological evolutionary process powered via the Water Line giving rise to the complexity and level of intelligence we enjoy as humans. We also see the incredible journey we have yet to undertake, if we are truly to meet the potential for growth offered to us in this Universe.

Throughout history, mankind has deluded itself with an anthropocentric model of existence. We now know that we are not the center of the universe. Now, some folks may argue that human beings should never become a Cosmic civilization, that the earthly abode will last us through the end of the Universe. We now estimate that the sun may shine at a steady state for maybe another 5 billion years, and that the Andromeda Galaxy might come crashing through the Milky Way well before that. By comparison, the half-life of a single proton is estimated at about 10^{34} years, or 10 million billion billion billion billion years. A planetary or even solar existence is short-lived in comparison to what the Universe has to offer. I hope this article will leave us with an idea of where we stand individually as humans, collectively as the human civilization, and the incredible journey we have yet to undertake. To properly outfit ourselves for the journey, we must understand what the DIEM chart has to say about our Universe, and the intriguing possibilities (and pitfalls) that lie ahead. Carpe DIEM.