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Universe's challenges: What is next?

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Abstract

In this paper we consider a quantitative relationship between the probabilistic standard normal distribution and the distribution of matter and energy in the Universe, according to the observations from the Planck cosmic laboratory.

Keywords: dark energy, dark matter

Introduction

In cosmology and astronomy the dark energy and dark matter are hypothetical forms of the analogues of energy and matter, arising from the standard Lambda cold dark matter model, also known as the standard model of cosmology, in order to comment on certain empirical observations.

The main aim of introducing dark energy is to explain the observed, with increasing acceleration, expansion of the Universe. Regarding dark matter, we associate it to problems arising from gravitational effects inducing unobservable mass (i.e. matter which does not emit or absorb any electromagnetic waves) - a well-known example is the anormally high speed of rotation of the outward regions of the galaxies.

The standard model does not say anything about the nature of these unobservable forms but predicts certain measurable effects from their existence -
with these one can describe better, in quantitative manner, these forms of
energy and matter.

Actually, such measurements have already been conducted - their results
are popular not only in science - in fact, they can be found in [3]. Assuming
that the standard model of cosmology is correct, the best current measurements
indicate that dark energy contributes 0.683 of the total mass-energy in the present-day observable universe. The mass-energy part of dark matter and ordinary matter (baryons, described by the Standard Model of particle physics) contribute 0.268 and 0.049, respectively, and other components such as neutrinos and photons contribute a very small amount. The most recently corrected data is mainly due to the Planck cosmic laboratory - the Planck spacecraft, operated by the European Space Agency from 2009 to 2013. Details for these observations are in the report in [1].

Other detailed results for dark energy can be found e.g. at
http://www.darkenergysurvey.org/.

The results and their probability analogues

Firstly we give the values of the distribution of matter and energy in the Universe according to the most recent reliable measurements (After Planck):

contribution of dark energy: 0.683
contribution of dark matter: 0.268
contribution of classical matter: 0.049
contribution of stars from classical matter: 0.004

In a second table we give probabilistic values for a standard normal random variable *X* (i.e. with mean 0, variance 1) to be, in modulus, in several intervals.

For these we can use a software such as Wolfram Mathematica.

$P(|X| < 1) = 0.682689492137086...$
$P(1 \leq |X| < 2) = 0.271810243966556...$
$P(2 \leq |X|) = 0.0455002638963584144 0056...$
$P(2 \leq |X| < 3) = 0.0428004678330982...$

$P\ (3 \leq |X| < 4) = 0.00263645357959395...$

$P\ (4 \leq |X| < 5) = 0.0000627691805224815...$

$P\ (3 \leq |X|) = 0.0026997960632601890533 03...$

Comments

Let us compare the values in the two tables. We see that

- The probability for $|X|$ to be not greater than 1 (0.68268.) is practically equal to the contribution of dark energy in the universe.
- The probability for $|X|$ to be between 1 and 2 (0.271) is quite close to the contribution of dark matter (0.268).
- The probability for $|X|$ to be between 2 and 3 (0.0428) is quite close to the contribution of the intergalactical gas (around 0.04 according to different measurements)
- The probability for $|X|$ to be more than 3 (0.0027) is quite close to the contribution of classical matter (stars, planets, comets, etc.)
- We certainly do not exclude the possibility that future measurements turn out eventually to be more accurate and to give that the stars' contribution is even closer to the probability for $|X|$ to be between 3 and 4. Similarly, the planets' (which are not sources of light on their own) contribution could be the probability for X to be between 4 and 5. The later probabilities might be associated to other forms of matter only on themselves, like asteroids, comets, etc.

So we have a naturally arising question - are these similarities a coincidence (like the Titius-Bode law for the distances between planets and the Sun) or these is a deeper explanation for this relationship?

If there is a reasonable connection, it makes sense that its mathematical part is a consequence of a limit probability law - for example, the Central Limit Theorem (CLT). We recall it in its Lyapunov version:

Theorem. (see [4], p.362) Let X_1, X_2, ... be a sequence of independent random variables, each with finite expected value μ_i and variance σ_i. Denote $s_n^2 = \sum_{i=1}^{n} \sigma_i^2$. If for some $\delta > 0$, Lyapunov's condition

$$\lim_{n\to\infty} \frac{1}{s_n^{2+\delta}} \sum_{i=1}^{n} E\left[|X_i - \mu_i|^{2+\delta}\right]=0$$

is satisfied, then a sum of $\frac{X_i-\mu_i}{s_n}$ converges in distribution to a standard normal random variable , as n goes to infinity:

$$\frac{1}{s_n} \sum_{i=1}^{n} (X_i - \mu_i) \xrightarrow{d} N(0,1).$$

Now we describe a hypothetical reason for the similarities between the above data and CLT.

There exists a field ζ, which we cannot currently observe only by means of today's science, which has random fluctuations on the Planck wavelenght level (1.616229 × 10^{-35} m) and/or Planck time (5.39116 × 10^{-44} sec), which when superposed together give a fluctuation $Y = \sum_{i=1}^{n} X_i$*, with distribution relatively close to the standard normal (this follows from CLT above). On the other hand, the magnitude of this fluctiation Y gives the properties of the corresponding observable object. If* $|Y| \leq 1$ *(possibly in Planck units), the effect is dark energy, if* $1 \leq |Y| \leq 2$ *the effect is dark matter and if* $|Y| \geq 2$ *the effect is classical baryonic matter.*

It is also worth noting that a lot of physical theories of elementary particles predict the existence of such quantum fluctuations. Anyway, the condition of CLT are suffciently general so it does not matter of what kind are these eventual fluctuations. It is enough only that they are independent and satisfy the Lyapunov condition. An eventually crucial moment in the computations would be the magnitudes of the corresponding "standard units" given by the parameters of the limit distribution.

Conclusion

The given hypothesis is of course only one of many possible explanations for the noted similarities between the Standard normal distribution and the distribution of matter and energy in the Universe.

We again note that everything observed in this paper might be just a coincidence.

References

[1] Ade, P. A. R.; Aghanim, N.; Armitage-Caplan, C.; et al. (Planck Collaboration), C.; Arnaud, M.; Ashdown, M.; Atrio-Barandela, F.; Aumont, J.; Aussel, H.; Baccigalupi, C.; Banday, A. J.; Barreiro, R. B.; Barrena, R.; Bartelmann, M.; Bartlett, J. G.; Bartolo, N.; Basak, S.; Battaner, E.; Battye, R.; Benabed, K.; Benoît, A.; Benoit-Lévy, A.; Bernard, J.-P.; Bersanelli, M.; Bertincourt, B.; Bethermin, M.; Bielewicz, P.; Bikmaev, I.; Blanchard, A.; et al. (31 March 2013). "Planck 2013 Results Papers". Astronomy and Astrophysics manuscript no. PlanckMission2013 June 6. % arXiv: 1303. 5062

[2] http://arstechnica.com/science/2013/03/first-planck-results-the-universe-is-still-weird-and-interesting/

[3] https://en.wikipedia.org/wiki/Dark energy

[4] Billingsley, Patrick (1995). Probability and Measure (3rd ed.). John Wiley & Sons