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An Extension of the General Theory of Relativity Through Asymmetric Time

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Abstract

In order to solve some current problems of cosmology, the theory of relativity is extended by asymmetric time, whose flow velocity is variable. Asymmetric time is based on Einstein's recommendation: the principle of the constancy of the speed of vacuum light can be used to complete the definition of time. It is a logical consequence of the earlier standard model of cosmology, the Einstein-de Sitter universe. The following explanations show how this is done.

Keywords: Cosmology, Theory of Relativity, Dark Matter, Dark energy, Inflation Theory.

The Asymmetric Time Hypothesis (ATH)

The Einstein-de Sitter universe was long regarded as the standard model of cosmology. It was later abandoned when it was concluded from measurements of type la supernovae that the universe is expanding at an accelerated rate. Another observation was that the stars rotate faster around the centre of their galaxy than Newton's theory allows. Instead of trying to reconcile the empirical findings with the Einstein-de Sitter model, the more convenient route was taken and two new terms were introduced without further ado - dark matter and dark energy - mysterious substances that are ultimately nothing more than placeholders for unknown physics. Today, they are an essential component of the current standard cosmological model, the ΛCDM model (Λ = cosmological constant, (CDM = Cold Dark Matter). Einstein had already pointed out the right way. For the Einstein-de Sitter universe (Λ = 0, k = 0), he formulated the equation[1] $\varkappa\varrho/3 - h^2 = 0$

By transforming this equation (see appendix for the meaning of the symbols), we obtain

$$2\, GM/Rc^2 = 1 \qquad (1)$$

This is no longer compatible with the original Einstein-de Sitter model because G, M, c = constant and $R \sim t^{2/3}$. From Eq. (1) follows

$$c \sim t^{-1/3} \sim \dot{R} \qquad (2)$$

i.e. a time-dependent speed of light proportional to the expansion speed of the flat universe. With Einstein's coupling constant $\varkappa = 8\pi G/c^2$ = constant, this further results in

$$G \sim t^{-2/3} \qquad (3)$$

and from the law of conservation of energy $E = Mc^2$ = constant finally follows

$$M \sim R \sim t^{2/3} \qquad (4)$$

Note: Decades ago, Dirac and Jordan developed a theory based on GRT in which the gravitational constant G should decrease over time[2].'This would result in a steady increase in the total mass of the world. This theory has so far failed to provide a plausible explanation for the formation of new matter.'

But it is precisely this constant creation of matter that relationship (4) requires. It is not a question of new formation, but of the transformation of energy into matter. According to observations, this conversion rate (star formation rate) decreases over time, which is also required by the ATH ($dM/dt \sim t^{-1/3}$).

Equations (2) to (4) are compatible with equation (1), but they all contradict the current state of knowledge. Equation (2) is the most provocative, because it directly violates Einstein's axiom <The speed of light is a universal constant of nature> The statement c = constant means that the measured numerical value of c must always be the same at any place and at any time. The problem now is to harmonise this requirement with the relationship (2). This can be achieved by following Einstein's recommendation and introducing a time τ in which the speed of light is always measured as a constant quantity.

For the Einstein-de Sitter universe we then obtain

$$\tau \sim R \sim t^{2/3} \qquad (5)$$

and the relationship corresponding to (2)

$$d\tau/dt \approx \Delta\tau/\Delta t \sim t^{-1/3} \sim \dot{R} \sim c \quad (6)$$

In fact, pendulum clocks and atomic clocks display exactly the asymmetric time τ if they tick according to the laws of the ATH[3]. Measured with such clocks, the speed of light is then a constant quantity

$$c(\tau) \sim dR/d\tau = \text{constant} \quad (7)$$

The time cycle would therefore not only depend on the relative velocity (SRT) and the gravitational potential (GRT), but also on time itself (ATH). Figure 1 shows a comparison of these dependencies. As can be seen from this, asymmetric time measures the speed at which cosmic evolution changes. ($\Delta\tau/\Delta t = (t/t_1)^{-1/3} = c/c_1$). In relation to the here-now time cycle Δt, the Big Bang disappears into the infinite past.

Stephen Hawking can also agree with this[4]: According to the strong version of cosmic censorship, in a realistic solution the singularities are always entirely in the future (like the singularities of gravitational collapse) or entirely in the past (like the Big Bang).

Note: In order to be able to compare and interpret events that took place at different times, the physical quantities must be related to the same point in time. For the AZH, this is the here-now time t.

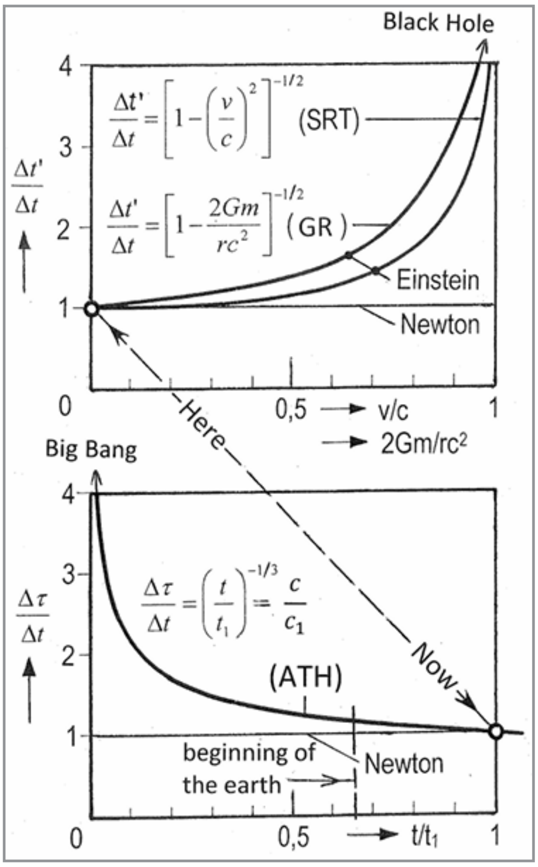

Figure 1: Time measures of SRT, GRT and ATH (tl = today)

The Spacetime of the Universe

In the theory of relativity, space and time were summarised in the four-dimensional space-time continuum.

$$dx_1^2 + dx_2^2 + dx_3^2 + dx_4^2 = 0 \quad (8)$$

(x_1, x_2, x_3 = space coordinates, x_4 = ict = imaginary time coordinate)

Transferred to the flat expanding universe ($R \sim t^{2/3}$, $dR/dt \sim t^{-1/3}$, $r \sim R$), $dx_1^2 + dx_2^2 + dx_3^2 = dr^2$ results in the relationship

$$dr^2 = (cdt)^2 \quad (9)$$

or $$c \sim dr/dt \sim t^{-1/3} \sim d\tau/dt \quad (10)$$

This result is identical to the relationship (6) and also answers the question of R.A.Muller:[5] 'If we imagine the universe as a 4-dimensional space-time, why should it only expand spatially and not also temporally?' According to the ATH, space (R), time (τ) and matter (M) develop according to identical laws ($R \sim \tau \sim M \sim t^{2/3}$).

Old Problems of the Big Bang Theory

Problem of the Horizon

It consists in the fact that it was not possible to explain why the cosmic background radiation (CMB) is so uniform, as satellite measurements show.

The theory of inflation was developed to solve this problem. It states that shortly (10^{-35} seconds) after the Big Bang, the universe suddenly expanded by a factor of 10^{50} and became isotropic on a large scale.

The ATH offers a much more plausible explanation. According to this, the light signals in the early universe were fast enough ($c \sim t^{1/3}$) to enable the high isotropy of the CMB. This renders the inflation theory obsolete.

The Problem of Flatness

This problem was also attempted to be solved by means of the theory of inflation. Due to the extreme inflation, the universe is said to have become almost exactly flat. However, inflation theory does not provide an answer to the question of how the unstable state of flat space could be maintained to this day. J. Magueijo[6] : In fact, it seems that the universe has been walking this delicate tightrope for 15 billion years - a process that is highly improbable, if not simply impossible. This is why we talk about the flatness problem, the second of the Big Bang puzzles.

The ATH explains why flatness is maintained in the long term as follows: If the universe expands faster than Eq. (1) predicts, the gravitational constant G also increases, which delays the expansion. If it expands more slowly, G decreases and the expansion is accelerated. The ATH is therefore not only more elegant than the theory of inflation, but also more meaningful.

The Problem of Galaxy Formation and the Formation of Supermassive Black Holes in the Early Universe

The problem is that, according to the Big Bang theory, there was not enough time to form the concentrations of matter (stars, galaxies, black holes, galaxy clusters) that can be observed today. However, the ATH also offers an explanation for this. It states that the 'event speed' in the early universe was many times higher than today ($c \sim t^{-1/3}$). In addition, the gravitational constant was also much greater than it is now ($G \sim t^{-2/3}$). This could not only explain the images from the James Webb Space Telescope, but also answer the question of why supermassive black holes with several billion solar masses already existed in the early universe and why they are all the larger the further back in time we look.

Problem of the World Age

Because the ATH universe has no beginning in time ($\Delta\tau/\Delta t \sim t^{-1/3}$), this problem does not exist. Note: The following explanations of astronomical observations all refer to the here-now time t and a world age of $13{,}8 \cdot 10^9$ years.

Cosmic Energy Balance

Many cosmologists assume that the total energy in the universe is exactly zero. They postulate a negative binding energy that exactly balances the positive energy (matter and radiation). However, it is difficult to understand why the gravitational binding energy should be negative. After all, the further apart two masses are, the greater it becomes. If they attract each other gravitationally and the smaller one, like a planet around a central star, is forced into a circular orbit by the larger one, the former gravitational energy has been converted into kinetic energy of the same magnitude, albeit with higher entropy, as can be demonstrated in the Sun - Earth or Earth - Moon system.3 The original gravitational energy must therefore have been positive. In the decelerated expansion of the universe, the opposite takes place. The space of the universe with the material objects in it expands more and more slowly as time progresses ($R \sim t^{2/3}$, $\dot{R} \sim t^{-1/3}$), i.e. the kinetic energy (Ekin) decreases over time and the potential space energy (E_{pot}) increases accordingly ($E = E_{kin} + E_{pot}$= constant = first law of thermodynamics).

Incidentally, Einstein also dealt with the term 'negative energy' after he removed the cosmological constant Λ, which he himself had originally introduced and which can be understood as a synonym for negative energy or negative pressure, from his field equations.

Dark Energy and the Cosmological Constant

Measurements of supernovae Ia (SN Ia) require - if they are interpreted using established theories - that the universe today is expanding at an accelerated rate, caused by a 'negative' dark energy. The interpretation of the measurement data by the ATH leads to completely different results. According to this, the universe is also expanding at a decelerated rate today, as required by the Einstein de Sitter universe.

A brief explanation: The measured z-values were analysed with c= constant. According to the ATH ($c \sim t^{-1/3}$), however, the same z-value results in higher escape velocities v. In relation to c = constant, this would correspond to a larger z-value. Figure 2 shows the measurement data analysed according to the ATH in comparison to conventional analyses. An accelerated expansion of the universe is no longer recognisable, which also invalidates the main argument

for the introduction of dark energy. The SNIa measurement results are therefore no surprise, but are to be expected according to ATH.

Dark energy is also not needed to explain why the universe is flat ($\Omega = 1$). This is because if, as explained in[3], vacuum energy is regarded as positive energy, which is contained in the energy-momentum tensor of Einstein's field equations, then the sum of all (positive) energies is sufficient for a flat universe ($\Omega = 1$) despite $\Lambda = 0$.

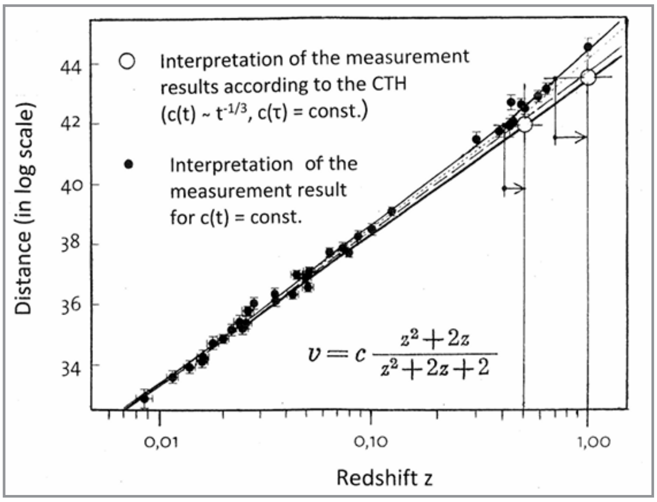

Figure 2: Hubble relationship according to measurement data from SNIa[3]

The Mystery of the Cosmological Constant Λ

It remains unsolved to this day and is perhaps the most profound unsolved fundamental problem in physics today ‘[7]. It consists in the fact that the value of the vacuum energy density calculated using quantum field theory (QFT) is approximately 122 powers of ten (10^{122}) greater than it should be based on observations. According to the ATH, the vacuum energy density is [3] $\mathcal{E}_v = 0.75 \cdot \mathcal{E} \sim t^{-2}$ ($\mathcal{E}$ = total energy density of the universe). H. Goenner[8] explains how to calculate the vacuum energy density using QFT: In the existing quantum field theories, the vacuum energy density usually diverges (ultraviolet divergence), i.e. the integral over the wave numbers k diverges. To avoid infinitely large values, the k-space is cut off at an energy scale Ex ≈ 10^{19} GeV, i.e. at the Planck scale (*tp* ≈ 10^{-43}*s*). For the vacuum energy density at Planck time (tp = $5.4 \cdot 10^{-44}$s) - quantum field theory cuts off the divergent integral series at this point - this results in a ratio of[3] compared to today ($t_1 \approx 4.3 \cdot 10^{17}$s)

$$\mathcal{E}_{vp}/\mathcal{E}_{v1} = (4.3 \cdot 10^{17}/5.4 \cdot 10^{-44})^2 = 0.64 \cdot 10^{122} \quad (11)$$

This result is compatible with observation.

The ATH thus requires a completely new interpretation of the concept of vacuum energy:

1. the vacuum energy density is positive and time-dependent ($\mathcal{E}_v \sim t^{-2}$) not negative and constant, which is the assumption of today's doctrine.
2. the cosmological constant does not exist in reality (Λ = 0), therefore there is no dark energy ($\Omega_\Lambda = 0$).
3. the vacuum energy is part of the total energy of the universe and is contained in the energy-momentum tensor (T_{ik}) of Einstein's field equations.

Does Dark Matter Exist?

Astronomical measurements have shown that the rotational speed of stars around their galaxy centre is greater than Newton's law of gravity allows. From this and from the gravitational lensing observations, it was concluded that there must be more matter than can be seen, i.e. additional dark matter. However, some scientists are now considering whether these observations could also have other causes, e.g. that the law of gravity must be slightly modified for large distances[9]. ‘ ... so that under certain circumstances the gravitational forces are a little stronger than expected. This alternative to standard cosmology is conceptually even simpler than the dark matter hypothesis, which speaks in its favour for reasons of scientific theory. And even the standard model of particle physics would not have to be supplemented by the particles of dark matter and would continue to be valid. Mass would no longer be ‘missing’ in galaxies; instead, the visible, barionic matter would cause slightly stronger forces. An order of magnitude of 10^{-10} m/s² was derived for this threshold from rotation curves of galaxies. (For comparison: on the Earth's surface, we experience an acceleration that is 100 billion times stronger due to the Earth's mass).’ As we always look back a little into the past when we look at galactic objects, we see them in the state in which they were in when we first observed them.

According to the ATH, gravity used to be stronger than it is today ($G \sim t^{-2/3}$). Close objects should therefore, as measurements also show, hardly give any indication of dark matter. However, the greater the distance, the greater the deviation from Newton's law of gravity (G = constant) should be. Whether this is the case should be recognisable from various gravitational lensing observations at different distances. If this were true, there would be no dark matter at all.

The Dynamics of Local Structures

Matter in a local gravitational field attracts each other until a stable state of equilibrium is reached. Example: planets orbiting a central star. Matter in the universe often forms local structures which, according to current theories, should become increasingly denser over time in accordance with the law of gravity. However, this is refuted by observation[11]. ‘It is precisely absurd that Hubble's law is observed in very small groups of galaxies (as for the entire universe) even with the same value Ho! This very irritating anomaly defies any accepted description of structure formation.’ The ATH provides an explanation for this anomaly using the example of planets orbiting the sun in a stable orbit. As the gravitational constant decreases with time according to the KZH ($G \sim t^{-2/3}$), the radius r of the planetary orbits does not remain constant, but must slowly increase in order to maintain the state of equilibrium between centrifugal force and gravitational force. Figure 3 explains the law according to which the orbit enlargement takes place. The result:

$$r \sim t^{2/3} \quad (12)$$

The ATH therefore requires that Hubble's law also applies to small groups of galaxies and even to planetary orbits and the orbit of the moon. According to the ATH, the moon should move away from the earth by 2.7 cm/year. The measurement was 3.8 cm/year. The difference is probably due to braking forces caused by the tides.

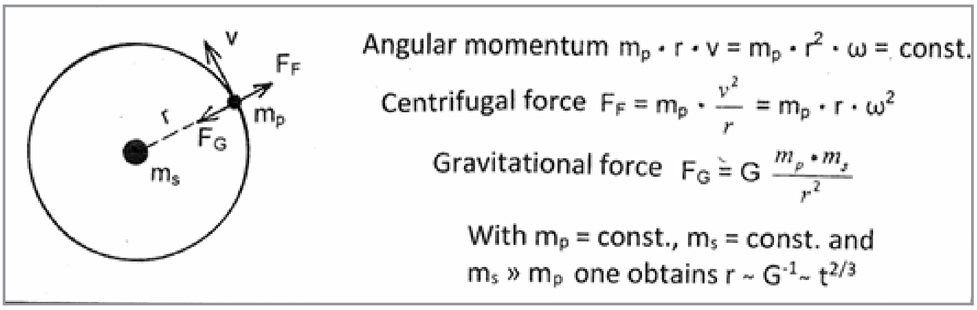

Figure 3: Expanding local structures

Unification of the Strong Nuclear Force with the Gravitational Force

Paul Dirac noticed that there are two extremely large, almost identical numbers, one of which comes from the subatomic world and expresses the ratio of electromagnetic force (Fe) and gravitational force (FG) between nucleons and electrons ($N_1 = e^2/G \cdot m_n \cdot m_e \approx 10^{39}$) and the other measures the scale of the universe ($N_2 = R/r_e \approx 10^{41}$) [6]

Dirac did not believe that the equality ($N_1 \approx N_2$) is just an accident of the moment. To ensure that $N_1 \approx N_2$ is valid at all times, he proposed that the gravitational constant should decrease to the same extent as the size of the universe increases ($G \cdot R$ = constant), which incidentally also applies to the ATH. The ATH offers an alternative to the Dirac hypothesis by linking the gravitational force (F_G) with the strong nuclear force (F_S). This is obvious because there is a special relationship between the two forces.

B. Geene points out[10] that although the gravitational force and the strong force have very different properties, they have a similar function: Both are necessary for the universe to exhibit certain symmetries. The same applies to the weak and electromagnetic forces: their existence is also linked to certain gauge symmetries.

As the strong nuclear force F_S is greater than the gravitational force F_G by a factor of 10^{41}, N_1 and N_2 correspond almost exactly.

$$N = N_1 = N_2 = F_s/F_G = R/r_e = (t/t_p)^{2/3} \qquad (13)$$

With $G \sim F_G \sim t^{-2/3}$, it follows that the gravitational force F_G at Planck time ($t_p = 5.4 \cdot 10^{-44}$ seconds) was 10^{41} times greater than today and thus equal to the strong nuclear force F_S (see Figure 4). This corresponds exactly to what supersymmetry (SUSY) requires, namely that at Planck time all forces of nature were united in a single force.

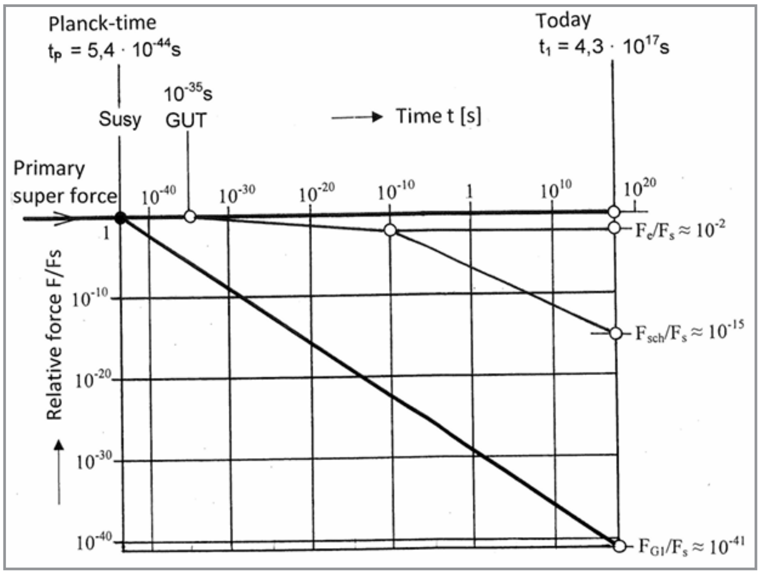

Figure 4: The fundamental forces of nature (F_s= strong nuclear force, F_{sch} = weak nuclear force, F_e = electromagnetic force, F_G = gravitational force

Summary of the Results

- The ATH elegantly solves some old problems of the Big Bang theory, the problem of the horizon, flatness, galaxy formation and the age of the world. The theory of inflation thus becomes superfluous.
- It explains why, despite the vanishing cosmological constant (Λ = o), the vacuum contains positive energy and why the vacuum energy density ε_v is $\approx 10^{-122}$ times smaller than the value resulting from quantum field theory. A result that is compatible with the observations. $\Lambda = 0$ means: There is no dark energy.
- The measurement data obtained from observations of SNIa supernovae, which suggest a currently accelerated expansion of the universe, result - if they are interpreted from the perspective of the ATH - in a decelerated expansion, as required by the Einstein- de Sitter universe.
- Dark matter could also possibly not exist because the ATH demands that the 'gravitational constant' is time-dependent and becomes greater the further the observed objects are spatially and therefore also temporally removed from us.
- The ATH answers the question: Why did supermassive black holes already exist in the early universe?
- Gravitationally bound local systems, e.g. Earth - Moon or Sun - Earth, expand according to the same law as the universe. This explains why Hubble's law also applies within very small groups of galaxies, as observations show.
- The ATH requires that the strongest force (strong nuclear force) and the weakest (gravitational force) at the Planck time ($t_p \approx 10^{-43}$ seconds after the Big Bang), when all natural forces are said to have been united in a single superforce, were the same size and had the same range. According to the ATH, the product of the strength and range of the gravitational force is constant, i.e. independent of time, and is identical to the product of the strength and range of the strong nuclear force.
- The ATH explains why the cosmic expansion is permanently in the state of a long-term flat (Euclidean), evolutionary developing universe.
- There was no big bang in asymmetrical time. The universe is infinitely old.
- Asymmetric time measures the speed of light and the speed of expansion of the universe as a constant quantity.

- It has a clear (cosmological) arrow of time. There is - which conventional theories allow - no time reversal.

These results show that the ATH explains reality better than conventional theories.

Formula Symbol

c = vacuum speed of light
E = total energy of the universe
G = Gravitational constant
h = Hubble expansion (=H/c = 1/R)
k = curvature constant
M = total mass of the universe ($=E/c^2$)
R = radius of the universe
t = 'present time' = Newtonian time
$\varkappa$ = Coupling constant ($= 8\pi G/c^2$)
Λ = Cosmological constant
τ = Asymmetric time
$\mathcal{E}$ = Total energy density of the universe
$\mathcal{E}v$ = Vacuum energy density ($= 0.75 \cdot \mathcal{E}$)

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