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On the A. A. Faus arXiv article, The Speed of Gravity: What a Theory Says

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Abstract: The analysis of A. A. Faus' article: "The Speed of Gravity: What a Theory Says" [1], showing that A. A. Faus attributed superluminal speeds to the structures that have no gravitational force. The analysis discards A. A. Faus' formula for superluminal speeds as a mathematical construction which has no rational ground.

Keywords: superluminal speed, gravity, Mach's principle, universe

Introduction

Search term "superluminal gravity" at arXiv yields 140 articles, the "Speed of Gravity" search in the title yields 49 articles, while the article of A. A. Faus stands out with its attempt to theoretically explain the phenomenon of superluminal speeds, hence I decided to analyze it. I will be using the term "the speed of gravity", as in [1], even though there are other terms with the same meaning for the supposed occurrence of superluminal propagation of gravitational information.

I analyzed superluminal speeds of gravity suggested by A. A. Faus. Using a table 2, I analyzed certain real structures and structures that meet the requirement from the formula (10). For all the structures I determined the gravitational acceleration and speeds of gravity as suggested by A. A. Faus.

I will quote A. A.Faus [1, p3]: *And using Mach's principle one finally has:*

$$v_g = c\sqrt{M_u/m}$$

v_g – the speed of gravity, c – the speed of light, M_u – the mass of the universe, m – any mass.

The mentioned Mach's principle [2] I find to be crucial for understanding the universe, under the condition that it is used properly. Mach's principle has no strict definition, so I have used the following definition in my works:

"Parts are dependent on the whole (Universe) and are also an integral part of the whole; therefore, the whole is also dependent on the parts!"

Another common thing for the work of A. A. Faus and me is the use of the mass quantum.

A. A. Faus: [1, p2] *The uncertainty principle for a quantum of gravity of mass m_g and …*

B. Zivlak: [3, Table 2 *Hypothetical mass quantum*, $\mathbf{m_q}$=2.7233883•10^{-69} [kg].

In the next chapter, I will apply A. A. Faus' formula to arbitrary structures such as the Earth, the Sun, and the Milky Way, as well as to some structures which meet special requirements, see Table 2.

Values of physical quantities are the same as in my previous articles, for example in [4 appendix].

Table 1. The values of physical constants used

		System of measurement	
		Natural	[kg-m-s]
	T_u=	1	4.30849E+17
The speed of light	c=	1	299792458
The gravitational constant	G=	1	6.673836E-11
The Planck mass	m_{pl}=	1.2512639E-61	2.17651E-08
The Planck length	l_{pl}=	1.2512639E-61	1.61620E-35
The Planck constant	$h=c*m_{pl}*(2\pi l_{pl})$	9.8373405E-122	6.626070E-34

Superluminal speeds

To make this analysis clearer, below is a table showing the differences in labeling physical quantities:

Physical quantity	A. A. Faus:	Here:
Quantum of gravity of mass	m_g	m_q
Any gravitational cross section	σ_g	σ
The age of the universe	t	T_u
Any square root of cross section	$\sigma_g^{1/2}$	R
Any speed of gravity	v_g	V

These changes are not essentially important, but readers may find it really confusing to see the same suffix **g** being used for "quantum" and for "gravitational cross section". Moreover, if suffix **u** is used for the mass of the universe, it is expected that the same suffix be used for other parameters of the universe, therefore $t \rightarrow T_u$. If **m** is used for all masses without a suffix, then the principle is expected to be applied to all other parameters as well. In that case, suffixes can be used for specific structures (**u** – for the universe, **p** – for the proton, **q** – for quantum, etc.). Capital letters like **R** for any square root of cross section and **V** for any speed of gravity are used in order to distinguish them from **r** used for the radius of the structure and **v** for the speed of the structure.

Below is the original text of A.A. Faus in the left column and the text with the above-mentioned modifications in formula notations in the right column:

Original A. A. Faus' text	Text with changed notations
To determine the speed of gravity from a gravitational mass m one needs the concept of a quantum of gravity of mass m_g [4]:	To determine the speed of gravity from a gravitational mass m one needs the concept of a quantum of gravity of mass m_q [4]:

$m_g = \hbar/c^2\, t$ (1)

and a gravitational cross section σ_g [4]:

$\sigma_g = \frac{\mathrm{Gm}}{c^2} * \mathrm{ct}$ (2)

This gravitational cross section is the effective area of gravitational interaction for the mass m. It is given by the product of its gravitational radius Gm/c2 and the size of the seeable Universe ct (t the age of the Universe). Interpreting Mach's Principle under the view that the rest energy of any mass mc^2 is due to its gravitational potential with respect to the mass of the rest of the seeable Universe M_u:

$\frac{\mathrm{GM}_u m}{\mathrm{ct}} = \mathrm{mc}^2$ (3)

one has

$\frac{\mathrm{GM}_u}{c^2} = \mathrm{ct}$ (4)

Then the gravitational cross section of any mass given in (2) is the product of two gravitational radiuses Gm/c^2 and GM_u/c^2. The uncertainty principle for a quantum of gravity of mass m_g and speed v_g gives:

$m_g v_g \sigma_g^{1/2} \approx \hbar$ (5)

This is as much as to say that the de Broglie wavelength for the quantum of gravity has about the size of the effective gravitational cross section:

$\sigma_g^{1/2} \approx \hbar/m_g\, v_g$ (6)

Then from (1), (2) and (5) we get

$v_g^2 \approx \frac{c^5}{G} * \frac{t}{m}$ (7)

and using Mach's Principle in the form in (4) one finally has:

$v_g \approx c\sqrt{\frac{M_u}{m}}$ (8)

This is the speed of gravity as related to any mass m. For the Universe as a whole we have m = M_u and therefore $v_g \approx c$. There are about 10^{11} galaxies in the seeable Universe. Then gravity from a galaxy has a speed of about $3 \cdot 10^5$ c.

There are about 10^{11} equivalent solar systems in a galaxy. Then gravity inside a solar system has a speed of about 10^{11} c. Now, Van Flandern in [1]

$m_q = \hbar/c^2\, T_u$ (1b)

and a gravitational cross section σ [4]:

$\sigma = \frac{\mathrm{Gm}}{c^2} * \mathrm{cT}_u$ (2b)

This gravitational cross section is the effective area of gravitational interaction for the mass m. It is given by the product of its gravitational radius Gm/c^2 and the size of the seeable Universe cT_u (T_u „The time cycle of the Universe“, ZB). Interpreting Mach's Principle under the view that the rest energy of any mass mc^2 is due to its gravitational potential with respect to the mass of the rest of the seeable Universe M_u:

$\frac{\mathrm{GM}_u m}{\mathrm{cT}_u} = \mathrm{mc}^2$ (3b)

one has

$\frac{\mathrm{GM}_u}{c^2} = \mathrm{cT}_u$ (4b)

Then the gravitational cross section of any mass given in (2b) is the product of two gravitational radiuses Gm/c^2 and GM_u/c^2. The uncertainty principle for a quantum of gravity of mass m_q and speed v_q gives:

$m_q V_q R_q = \hbar$ (5b)

This is as much as to say that the de Broglie wavelength for the quantum of gravity has about the size of the effective gravitational cross section:

$R_q = \hbar/m_q\, V_q$ (6b)

Then from (1b), (2b) and (5b) we get

$V_q^2 = \frac{c^5}{G} * \frac{T_u}{m_q}$ (7b)

and using Mach's Principle in the form in (4b) one finally has:

$V_q = c\sqrt{\frac{M_u}{m_q}}$ (8b)

This is the speed of gravity as related to any mass m. For the Universe as a whole we have m = M_u and therefore $V_u = c$. There are about 10^{11} galaxies in the seeable Universe. Then gravity from a galaxy has a speed of about $3 \cdot 10^5$ c.

There are about 10^{11} equivalent solar systems in a galaxy. Then gravity inside a solar system has a speed of about 10^{11} c. Now, Van Flandern in [1]

finds from experiments a lower limit for the value of the speed of gravity $v_g \geq 2 \cdot 10^{10}$ c, which implies a complete agreement between our theory and the experiments.	finds from experiments a lower limit for the value of the speed of gravity $v_g \geq 2 \cdot 10^{10}$ c, which implies a complete agreement between our theory and the experiments.

In reality, A. A. Faus derived the formula (8) for a quantum of gravity of mass m_q. A. A. Faus does not explain how he arrived to the application of this formula to any mass, hence, all the conclusions derived from (8) are not valid.

Despite that, A. A. Faus' attempt is significant, because it traces the way to a rational solution. Hence, in Table 2 I will show the results obtained by using A. A. Faus' formula for certain structures. To make the results more obvious, they will be presented in natural units of measurement and the [kg-m-s] system.

Values in Table 2, obtained through the known formula for gravitational acceleration, will also be useful for the discussion of superluminal speeds.

$$a = \mathrm{Gm}/r^2 \qquad \textbf{(9)}$$

Instead of r, I will use R for radius, which allows the condition from text after formula 4: "*Then the gravitational cross section of any mass given in (2) is the product of two gravitational radiuses Gm/c^2 and Gm_u/c^2". So,* I will use the square root of that quantity R, (10), which I call **generalized radius** in my articles.

$$R = \sqrt{\mathrm{Gm}/c^2 * \mathrm{GM}_u/c^2} = \sqrt{\mathrm{Gm}/c^2 * \mathrm{cT}_u} = R_u * \sqrt{m/M_u} \qquad \textbf{(10)}$$

Note that $cT_u = R_u$, and $R_u = GM_u/c^2$.

Table 2. Gravitational acceleration and superluminal speeds for certain structures according to A. A. Faus' formula

System of measurement | System of measurement

Natural	$R=sq(Gm/c^2*GM_u/c^2)$			V=	[kg-m-s]	$R=sq(Gm/c^2*GM_u/c^2)$		V=
Structure	**m**	**R**	$a=Gm/R^2$	$c(M_u/m)^{1/2}$	**m**	**R**	$a=Gm/R^2$	$c(M_u/m)^{1/2}$
Universe	1	1	1	1	1.739E+53	1.292E+26	6.958E-10	2.998E+08
Galaxy	1.72E-11	4.15E-06	1	2.41E+05	3.000E+42	5.364E+20	6.958E-10	7.219E+13
Milky Way	1.32E-11	5.13E-05	5.00E-03	2.76E+05	2.287E+42	6.622E+21	3.481E-12	8.267E+13
Sun	1.14E-23	5.39E-18	3.93E+11	2.96E+11	1.989E+30	6.963E+08	2.738E+02	8.865E+19
Earth	3.43E-29	4.94E-20	1.41E+10	1.71E+14	5.974E+24	6.376E+06	9.807E+00	5.116E+22
Planck mass	1.25E-61	3.54E-31	1	2.83E+30	2.177E-08	4.569E-05	6.958E-10	8.475E+38
Proton	9.62E-81	9.81E-41	1	1.02E+40	1.673E-27	1.267E-14	6.958E-10	3.057E+48
Fundamental p.	6.26E-82	2.50E-41	1	4.00E+40	1.089E-28	3.231E-15	6.958E-10	1.198E+49
Electron	5.24E-84	2.29E-42	1	4.37E+41	9.109E-31	2.956E-16	6.958E-10	1.310E+50
Hmq	1.57E-122	1.25E-61	1	7.99E+60	2.723E-69	1.616E-35	6.958E-10	2.396E+69

Hypotetical mass quantum, Hmq [3, Table 2], Fundamental particle [5, f1]

The galaxy is an arbitrary galaxy which meets the condition for radius contained in (10). Acceleration in structures that meet the condition (10) are marked blue, a=1, i.e. there is neither attraction nor repulsion. For the proton, the generalized radius which complies with (10) is used too, and it is just several times larger than all the other known quantities of proton radiuses.

Column labeled "V=" shows results obtained through A. A. Faus' formula for the speed of gravity. The values are unrealistically high. A. A. Faus ingeniously introduced "*a gravitational cross section*" with his formula (2), here in the form (10).

A. A. Faus disregarded the fact that for that area, i.e. at an appropriate distance R which complies with (10), there is no gravitational attraction, a=1, hence it does not make sense to talk about the speed of gravity.

All these values are marked blue. Since there is neither attraction nor repulsion for them (a=1), meaning that there is no gravitational attraction, there is no need to propagate the information about the position of a gravitational object through the universe. Therefore, we shall dismiss A. A. Faus' superluminal speeds.
I will show what A. A. Faus' superluminal speeds represent on the example of the gravitational mass quantum, Hmq. In the last row of Table 2 we can see that the superluminal speed of that mass is $7.99*10^{60}$c. The same speed is obtained through the formula $V=2\pi R_u/t_{pl}$, while the same number, $7.99*10^{60}$c, is obtained as the quotient R_u/l_{pl}, where t_{pl}, and l_{pl}, are Planck's time and length. In other words, it is the speed which that hypothetical particle would have if it made a circle around an imagined radius of the universe in Planck's time. Therefore, it is one purely mathematical construction, without real physical significance. The same can be shown for all the other structures in Table 2.

Table 2 also presents real structures: the Milky Way, the Sun and the Earth. However, A. A. Faus' formulas do not refer to these structures, since he does not even mention the radiuses of structures, rather, he always says "*gravitational radiuses*". Mechanical application of A. A. Faus' formula to real structures also gives results that have no physical significance.

A. A. Faus states: "*The experimental results do not contradict this theoretical deduction*". An attempt to verify experimental proofs of superluminal speeds in the two suggested references in [1] has not confirmed the above statement.

Conclusion

A. A. Faus has not theoretically proven the existence of superluminal speeds, hence, the formula that he derived has no significance that he claims it has.

A. A. Faus is right in the sense that he realized the key role of gravitational radius, i.e. of "*a gravitational cross section*", but he did not apply that knowledge correctly.

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