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GLOBAL VAN-CONG EFFECTIVE KINETIC, GRAVITATIONAL POTENTIAL, AND TOTAL ENERGIES, OBTAINED IN THE PLANET-SUN INTERACTION SYSTEM, AND ENHANCED BY OUR EMPIRICAL GLOBAL EFFECTIVE KINETIC MASS OF THE PLANET, EXPRESSED AS A FUNCTION OF ANY SPEED (OR ANY RELATIVITY) (38)

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ABSTRACT

In this work, we present the new expressions of global effective kinetic, gravitational potential and total energies, obtained in the planet-sun interaction systems, as those given in Equations (4, 5, 6), and enhanced by a new global effective kinetic mass of the planet, as that given in Eq. (1). Some concluding remarks are given as follows. At the low speed v (<< c), c being the light speed, given in the non-relativistic case, they are found to be correct. At v=c, given in the relativistic case, the kinetic energy is found to be equal to: $m \times c^2 \times \left[\frac{2+p}{4}\right]$, $p > 0$, and, in particular, for p=2, to: $m \times c^2$, in good agreement with that proposed by Einstein in 1905 [1], m being the rest mass of the planet, as those shown in Tables 2-10, for various planet-sun interaction systems.

KEYWORDS: Global effective kinetic-potential-total energies, global effective kinetic mass, light speed, relativity, non-relativity.

First of all, from the expression of the kinetic energy of the planet, with its rest mass m, in motion with a speed v, being equal to the light speed c, $\frac{2m\times c^2}{2}$, and proposed by Einstein in 1905[1-3], we propose a **gobal effective kinetic mass**, valid at any v, by[4] :

$m^*(v; p > 0) = m \times (1 + p \times \frac{v^2}{c^2})$, (1)

increasing with increasing v and noting that at lowest v: $m^*(v; p) \simeq m$, given in the non-relativistic case, and then, at v=c, given in the relativistic case: $m^*(v = c; p) = m \times (1 + p)$. Here, the numerical results of m and c are given in Table 1 in Appendix 1.

Then, from Eq. (1), this planet is in motion, due to the **global effective Newton force**

$F^*_{GEN}(v; p) \equiv m^*(v; p) \times \frac{dv}{dt} = m \times \left(1 + p \times \frac{v^2}{c^2}\right) \times \frac{dv}{dt}$, (2)

where $\frac{dv}{dt}$ is its acceleration. Further, it is attracted by the sun of the mass M, due to the **global effective gravitational force**, defined as:

$F^*_{GEG}(v; p) \equiv -\frac{GMm^*(v;p)}{r^2} = -\frac{GMm\times(1+p\times\frac{v^2}{c^2})}{r^2}$, (3)

where r is the distace between the sun and the planet, and G is the universal gravitational constant, noting that the numerical values of M and G are given in Table 1 in Appendix 1.

From Eq. (2), noting that $\frac{dv}{dt} \times dr = vdv$, our **global effective kinetic energy** is defined by:

$K^*(v; p) \equiv \int F^*_{GEN}(v; p) \times dr = \int m \times \left(1 + p \times \frac{v^2}{c^2}\right) \times vdv = m \times v^2 \times \left[\frac{2+p\times\frac{v^2}{c^2}}{4}\right]$, (4)

being reduced to the correct result at the lowest v ($\ll$ c) as: $\frac{m\times v^2}{2}$, given in the non-relativistic case, and at v=c, to: $K_o(p) \equiv m \times c^2 \times \left[\frac{2+p}{4}\right]$, and for p=2, to: mc^2, for example, as that proposed by Einstein in the relativistic case [1].

Further, from Eq. (3), our global effective gravitational energy, $U^*(v, r; p)$, is defined by:

$U^*(v, r; p) \equiv -\int_\infty^r F^*_{GEG}(v; p) \times dx \equiv -\int_\infty^r -\frac{GMm^*(v;p)}{x^2} dx = -\frac{GMm^*(v;p)}{r} = -\frac{GMm\times(1+p\times\frac{v^2}{c^2})}{r}$,

being reduced to the correct result at the lowest v ($\ll$ c) as: $= -\frac{GMm}{r}$, given in the non-relativistic case, and at v=c, to: $-\frac{GMm\times(1+p)}{r}$, given in the relativistic case. Here, we choose: $r = r_P$, being the distance from the planet to the sun at perihelion, and $v_P \leq v \leq c$, v_P being

The planet speed at perihelion, noting that the values of r_P and v_P are found to be given in Table 1 in Appendix 1.That gives :

$$U^*(v;p) = -\frac{GMm\times(1+p\times\frac{v^2}{c^2})}{r_P}, \qquad (5)$$

according at v=c to: $U_o(p) \equiv = -\frac{GMm\times(1+p)}{r_P}$, given in the relativistic case.

Therefore, from Equations (4, 5), the **global effective total enegy**, $E^*(v;p)$, is found to be given by:

$$E^*(v;p) \equiv m\times v^2 \times \left[\frac{2+p\times\frac{v^2}{c^2}}{4}\right] - \frac{GMm\times(1+p\times\frac{v^2}{c^2})}{r_P} \qquad (6)$$

according at v=c to: $E_o(p) = K_o(p) + U_o(p) = m\times v^2 \times \left[\frac{2+p}{4}\right] - \frac{GMm\times(1+p)}{r_P}$.

Furthermore, it is interesting to evaluate the relative errors between $K^*(v;p)$ and $E^*(v;p)$, defined by:

$$RE(v;p) \equiv 1 - \frac{E^*(v;p)}{K^*(v;p)}. \qquad (7)$$

Then, in following Tables 2-10 in Appendix 1, the numerical results of $RE(v;p)$, $K^*(v;p)/K_o(p)$, $U^*(v;p)/U_o(p)$ and $E^*(v;p)/E_o(p)$ are obtained for p=1, 2 and 3, respectively, using Equations (7, 4, 5, 6), noting that, for a given p, $RE(v;p)$ decreases with increasing v, and at v=c, one obtains $K^*(v;p) \cong E^*(v;p)$, with highest precision.

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APPENDIX 1

Table 1. The numerical results of the planetary parameters are given by: the rest planet mass, m (Kg), the distance from the planet to the sun at perihelion, $r_P(m)$, and the planet speed at perihelion, $v_P\left(\frac{10^3\times m}{s}\right)$. Further, the sun mass M, universal gravitational constant G, and light speed c, are found to be given respectively by : $M = 1.988475\times10^{30}$ kg, $G = 6.6743\times10^{-11}\frac{m^3}{kg\times s^2}$, and $c = 2.9979\times10^{8}\left(\frac{m}{s}\right)$.

Celestial body	m (Kg)	$r_P(m)$	$v_P\left(\frac{10^3\times m}{s}\right)$
Mercury	3.30101×10^{23}	4.60009×10^{10}	47.87
Venus	4.86732×10^{24}	1.07477×10^{11}	35.02
Earth	5.97219×10^{24}	1.47100×10^{11}	29.78
Mars	6.41693×10^{23}	2.06645×10^{11}	24.13
Jupiter	1.89852×10^{27}	7.40603×10^{11}	13.06
Saturn	5.68460×10^{26}	1.35096×10^{12}	9.64
Uranus	8.68192×10^{25}	2.73854×10^{12}	6.79
Neptune	1.02431×10^{26}	4.46384×10^{12}	5.43
Moon	7.34581×10^{22}	3.62106×10^{8}	1.03

Table 2. In the **Mercury-Sun interaction system**, in which the values of m, r_P and v_P are given in Table 1, the numerical results of $RE(v;p)$, $K^*(v;p)/K_o(p)$, $U^*(v;p)/U_o(p)$ and $E^*(v;p)/E_o(p)$, are obtained by using Equations (7, 4, 5, 6), respectively, noting that $v_P \le v \le c$.

X(v)=v/c	$RE(v;p)$	$K^*(v;p)/K_o(p)$	$U^*(v;p)/U_o(p)$	$E^*(v;p)/E_o(p)$
Here, for **p=1** and at v=c, $K_o(p) = \left(\frac{3}{4}\right)\times mc^2 = 2.22506339\times10^{40}$ J, $U_o(p) = -1.90474291\times10^{33}$ J and $E_o(p) = 2.2250632\times10^{40}$ J, suggesting that $E_o(p) \cong K_o(p)$, with a precision of the order of 8.56039842×10^{-8}.				
0.00015968	**2.51799115**	**1.69984685×10^{-8}**	**0.50000001**	**-2.58035269×10^{-8}**
0.09	7.95826684×10^{-6}	0.00542187	0.50405	0.00542183
0.30	7.44085668×10^{-7}	0.0627	0.545	0.06269996
0.40	4.30992282×10^{-7}	0.1152	0.58	0.11519996
0.60	2.0554629×10^{-7}	0.2832	0.68	0.28319997
0.80	1.24636483×10^{-7}	0.5632	0.82	0.56319998

0.90	1.02110987$\times 10^{-7}$	0.7587	0.905	0.75869999
0.95	9.32589377$\times 10^{-8}$	0.87316875	0.95125	0.87316874
1	8.56039842$\times 10^{-8}$	**1**	**1**	**1**

Here, for **p=2** and at v=c, $\mathbf{K_o(p) = mc^2 = 2.96675118 \times 10^{40}}$ **J, in good agreement with that, proposed by Einstein in 1905**, $U_o(p) = -2.85711437 \times 10^{33}$ J and $E_o(p) = 2.9667509 \times 10^{40}$ J, suggesting that $E_o(p) \cong K_o(p)$, with a precision of the order of 9.63044823$\times 10^{-8}$.

0.00015968	**2.51799118**	**1.27488515$\times$ $\mathbf{10^{-8}}$**	**0.33333335**	**-1.93526461$\times$ $\mathbf{10^{-8}}$**
0.09	7.99013828$\times 10^{-6}$	0.00408281	0.33873333	0.00408277
0.30	7.72283469$\times 10^{-7}$	0.04905	0.39333333	0.04904997
0.40	4.56625013$\times 10^{-7}$	0.0928	0.44	0.09279997
0.60	2.25554126$\times 10^{-7}$	0.2448	0.57333333	0.24479997
0.80	1.39468061$\times 10^{-7}$	0.5248	0.76	0.52479998
0.90	1.14736457$\times 10^{-7}$	0.73305	0.87333333	0.73304999
0.95	1.0488774$\times 10^{-7}$	0.85850312	0.935	0.85850312
1	9.63044823$\times 10^{-8}$	**1**	**1**	**1**

Here, for **p=3** and further at v=c, $K_o(p) = \frac{5}{4} \times mc^2 = 3.70843898 \times 10^{40}$ J,$U_o(p) = -3.80948582 \times 10^{33}$ J and $E_o(p) = 3.7084386 \times 10^{40}$ J, suggesting that $E_o(p) \cong K_o(p)$, with a precision of the order of 1.02724781$\times 10^{-7}$.

0.00015968	**2.51799121**	**1.01990814$\times$ $\mathbf{10^{-8}}$**	**0.25000002**	**-1.54821175$\times$ $\mathbf{10^{-8}}$**
0.09	8.02144326$\times 10^{-6}$	0.00327937	0.256075	0.00327934
0.30	7.98216299$\times 10^{-7}$	0.04086	0.3175	0.04085997
0.40	4.78933581$\times 10^{-7}$	0.07936	0.37	0.07935997
0.60	2.40877012$\times 10^{-7}$	0.22176	0.52	0.22175997
0.80	1.49452109$\times 10^{-7}$	0.50176	0.73	0.50175998
0.90	1.2274127$\times 10^{-7}$	0.71766	0.8575	0.71765999
0.95	1.12054385$\times 10^{-7}$	0.84970375	0.926875	0.84970374
1	1.02724781$\times 10^{-7}$	**1**	**1**	**1**

Table 3. In the **Venus-Sun interaction system**, in which the values of m, r_P and v_P are given in above Table 1, the numerical results of $RE(v;p)$, $K^*(v;p)/K_o(p)$, $U^*(v;p)/U_o(p)$ and $E^*(v;p)/E_o(p)$, are obtained by using Equations (7, 4, 5, 6), respectively, noting that $v_P \le v \le c$.

X(v)=v/c	RE(v; p)	$K^*(v;p)/K_o(p)$	$U^*(v;p)/U_o(p)$	$E^*(v;p)/E_o(p)$
Here, for **p=1** and at v=c, $K_o(p) = \left(\frac{3}{4}\right) \times mc^2 = 3.28084299 \times 10^{41}$ J, $U_o(p) = -1.20207127 \times 10^{34}$ J and $E_o(p) = 3.28084287 \times 10^{41}$ J, suggesting that $E_o(p) \cong K_o(p)$, with a precision of the order of 3.66390978× 10^{-8}.				
0.00010681	**2.4086972**	**7.60558411×** $\mathbf{10^{-9}}$	**0.50000001**	**-1.07139654×** $\mathbf{10^{-8}}$
0.09	3.4061933× 10^{-6}	0.00542187	0.50405	0.00542185
0.30	3.18473817× 10^{-7}	0.0627	0.545	0.06269998
0.40	1.8446768× 10^{-7}	0.1152	0.58	0.11519998
0.60	8.79752348× 10^{-8}	0.2832	0.68	0.28319999
0.80	5.33452774× 10^{-8}	0.5632	0.82	0.56319999
0.90	4.37042093× 10^{-8}	0.7587	0.905	0.75869999
0.95	3.99154708× 10^{-8}	0.87316875	0.95125	0.87316875
1	3.66390978× 10^{-8}	**1**	**1**	**1**
Here, for **p=2** and at v=c, $\mathbf{K_o(p) = mc^2 = 4.37445732 \times 10^{41}}$ **J, in good agreement with that, proposed by Einstein in 1905**, $U_o(p) = -1.80310691 \times 10^{34}$ J and $E_o(p) = 4.37445714 \times 10^{41}$ J, suggesting that $E_o(p) \cong K_o(p)$, with a precision of the order of 4.1218985× 10^{-8}.				
0.00010681	**2.40869721**	**5.70418812×** $\mathbf{10^{-9}}$	**0.33333334**	**-8.03547421×** $\mathbf{10^{-9}}$
0.09	3.41976759× 10^{-6}	0.00408281	0.33873333	0.00408279
0.30	3.30536204× 10^{-7}	0.04905	0.39333333	0.04904999
0.40	1.95434843× 10^{-7}	0.0928	0.44	0.09279999
0.60	9.65368387× 10^{-8}	0.2448	0.57333333	0.24479999
0.80	5.96921278× 10^{-8}	0.5248	0.76	0.52479999
0.90	4.91070372× 10^{-8}	0.73305	0.87333333	0.73304999
0.95	4.48918005× 10^{-8}	0.85850312	0.935	0.85850312
1	4.1218985× 10^{-8}	**1**	**1**	**1**
Here, for **p=3** and further at v=c, $K_o(p) = \frac{5}{4} \times mc^2 = 5.46807165 \times 10^{41}$ J,$U_o(p) = -2.40414255 \times 10^{34}$ J and $E_o(p) = 5.46807141 \times 10^{41}$ J, suggesting that $E_o(p) \cong K_o(p)$, with a precision of the order of 4.39669173× 10^{-8}.				
0.00010681	**2.40869722**	**4.56335052×** $\mathbf{10^{-9}}$	**0.25000001**	**-6.42837949×** $\mathbf{10^{-9}}$
0.09	3.43323324× 10^{-6}	0.00327937	0.256075	0.00327935
0.30	3.41642102× 10^{-7}	0.04086	0.3175	0.04085999
0.40	2.04986888× 10^{-7}	0.07936	0.37	0.07935999
0.60	1.03097029× 10^{-7}	0.22176	0.52	0.22175999

0.80	6.39665372×10^{-8}	0.50176	0.73	0.50175999
0.90	5.2534×10^{-8}	0.71766	0.8575	0.71765999
0.95	4.79600526×10^{-8}	0.84970375	0.926875	0.84970375
1	4.39669173×10^{-8}	**1**	**1**	**1**

Table 4. In the **Earth-Sun interaction system**, in which the values of m, r_P and v_P are given in above Table 1, the numerical results of $RE(v;p)$, $K^*(v;p)/K_o(p)$, $U^*(v;p)/U_o(p)$ and $E^*(v;p)/E_o(p)$, are obtained by using Equations (7, 4, 5, 6), respectively, noting that $v_P \le v \le c$.

X(v)=v/c	$RE(v;p)$	$K^*(v;p)/K_o(p)$	$U^*(v;p)/U_o(p)$	$E^*(v;p)/E_o(p)$

Here, for **p=1** and at v=c, $K_o(p)=\left(\frac{3}{4}\right)\times mc^2 = 4.02558651\times 10^{41}$ J, $U_o(p) = -1.07764768\times 10^{34}$ J and $E_o(p) = 4.0255864\times 10^{41}$ J, suggesting that $E_o(p) \cong K_o(p)$, with a precision of the order of 2.67699546×10^{-8}.

$\mathbf{9.9336\times 10^{-5}}$	**2.03466914**	$\mathbf{6.57845405\times 10^{-9}}$	**0.50**	$\mathbf{-6.80652355\times 10^{-9}}$
0.09	2.48869774×10^{-6}	0.00542187	0.50405	0.00542186
0.30	2.32689398×10^{-7}	0.0627	0.545	0.06269999
0.40	1.34779285×10^{-7}	0.1152	0.58	0.11519999
0.60	6.42781395×10^{-8}	0.2832	0.68	0.28319999
0.80	3.89761413×10^{-8}	0.5632	0.82	0.56319999
0.90	3.19320006×10^{-8}	0.7587	0.905	0.7587
0.95	2.91638005×10^{-8}	0.87316875	0.95125	0.87316875
1	2.67699546×10^{-8}	**1**	**1**	**1**

Here, for **p=2** and at v=c, $\mathbf{K_o(p) = mc^2 = 5.36744867\times 10^{41}}$ **J, in good agreement with that, proposed by Einstein in 1905**, $U_o(p) = -1.61647152\times 10^{34}$ J and $E_o(p) = 5.36744851\times 10^{41}$ J, suggesting that $E_o(p) \cong K_o(p)$, with a precision of the order of 3.01161989×10^{-8}.

$\mathbf{9.9336\times 10^{-5}}$	**2.03466915**	$\mathbf{4.93384056\times 10^{-9}}$	**0.33333334**	$\mathbf{-5.10489275\times 10^{-9}}$
0.09	2.49861564×10^{-6}	0.00408281	0.33873333	0.00408279
0.30	2.41502648×10^{-7}	0.04905	0.39333333	0.04904999
0.40	1.42792322×10^{-7}	0.0928	0.44	0.09279999
0.60	7.05335813×10^{-8}	0.2448	0.57333333	0.24479999
0.80	4.36133978×10^{-8}	0.5248	0.76	0.52479999
0.90	3.58795175×10^{-8}	0.73305	0.87333333	0.73305
0.95	3.27997012×10^{-8}	0.85850312	0.935	0.85850312
1	3.01161989×10^{-8}	**1**	**1**	**1**

Here, for **p=3** and further at v=c, $K_o(p) = \frac{5}{4}\times mc^2 = 6.70931084\times 10^{41}$ J, $U_o(p) = -2.15529536\times 10^{34}$ J and $E_o(p) = 6.70931063\times 10^{41}$ J, suggesting that $E_o(p) \cong K_o(p)$, with a precision of the order of 3.21239455×10^{-8}.

9.9336×10^{-5}	**2.03466916**	**3.94707247×10^{-9}**	**0.25000001**	**$-4.08391427\times 10^{-9}$**
0.09	2.50845418×10^{-6}	0.00327937	0.256075	0.00327936
0.30	2.49617051×10^{-7}	0.04086	0.3175	0.04085999
0.40	1.49771419×10^{-7}	0.07936	0.37	0.07935999
0.60	7.5326712×10^{-8}	0.22176	0.52	0.22175999
0.80	4.6736448×10^{-8}	0.50176	0.73	0.50175999
0.90	$3.83834731 \times 10^{-8}$	0.71766	0.8575	0.71766
0.95	3.50414858×10^{-8}	0.84970375	0.926875	0.84970375
1	3.21239455×10^{-8}	**1**	**1**	**1**

Table 5. In the **Mars-Sun interaction system**, in which the values of m, r_P and v_P are given in above Table 1, the numerical results of $RE(v;p)$, $K^*(v;p)/K_o(p)$, $U^*(v;p)/U_o(p)$ and $E^*(v;p)/E_o(p)$, are obtained by using Equations (7, 4, 5, 6), respectively, noting that $v_P \leq v \leq c$.

X(v)=v/c	$RE(v;p)$	$K^*(v;p)/K_o(p)$	$U^*(v;p)/U_o(p)$	$E^*(v;p)/E_o(p)$

Here, for **p=1** and at v=c, $K_o(p) = \left(\frac{3}{4}\right) \times mc^2 = 4.32536587 \times 10^{40}$ J, $U_o(p) = -8.24248669 \times 10^{32}$ J and $E_o(p) = 4.32536579 \times 10^{40}$ J, suggesting that $E_o(p) \cong K_o(p)$, with a precision of the order of 1.90561606×10^{-8}.

8.0490×10^{-5}	**2.20605487**	**4.31905865×10^{-9}**	**0.50**	**$-5.20902183\times 10^{-9}$**
0.09	1.77157655×10^{-6}	0.00542187	0.50405	0.00542186
0.30	1.65639674×10^{-7}	0.0627	0.545	0.06269999
0.40	9.59424754×10^{-8}	0.1152	0.58	0.11519999
0.60	4.57563181×10^{-8}	0.2832	0.68	0.28319999
0.80	2.77451202×10^{-8}	0.5632	0.82	0.5632
0.90	2.27307571×10^{-8}	0.7587	0.905	0.7587
0.95	2.07602171×10^{-8}	0.87316875	0.95125	0.87316875
1	1.90561606×10^{-8}	**1**	**1**	**1**

Here, for **p=2** and at v=c, $\mathbf{K_o(p) = mc^2 = 5.7671545 \times 10^{40}}$ **J, in good agreement with that, proposed by Einstein in 1905**, $U_o(p) = -1.236373 \times 10^{33}$ J and $E_o(p) = 5.76715437 \times 10^{40}$ J, suggesting that $E_o(p) \cong K_o(p)$, with a precision of the order of 2.14381807×10^{-8}.

8.0490×10^{-5}	**2.20605488**	**3.239294×10^{-9}**	**0.33333334**	**$-3.90676642\times 10^{-9}$**
0.09	1.7786366×10^{-6}	0.00408281	0.33873333	0.0040828
0.30	1.71913376×10^{-7}	0.04905	0.39333333	0.04904999
0.40	1.01646547×10^{-7}	0.0928	0.44	0.09279999
0.60	5.02092468×10^{-8}	0.2448	0.57333333	0.24479999
0.80	3.10461459×10^{-8}	0.5248	0.76	0.52479999
0.90	2.55407924×10^{-8}	0.73305	0.87333333	0.73305
0.95	2.33484286×10^{-8}	0.85850312	0.935	0.85850312

1	2.14381807×10^{-8}	**1**	**1**	**1**

Here, for **p=3** and further at v=c, $K_o(p) = \frac{5}{4}\times mc^2 = 7.20894312\times 10^{40}$ J,$U_o(p) = -1.64849734\times 10^{33}$ J and $E_o(p) = 7.20894296\times 10^{40}$ J, suggesting that $E_o(p) \cong K_o(p)$, with a precision of the order of 2.28673928×10^{-8}.

$\mathbf{8.0490\times 10^{-5}}$	**2.20605489**	$\mathbf{2.59143521\times 10^{-9}}$	**0.25**	$\mathbf{-3.12541317\times 10^{-9}}$
0.09	1.78564015×10^{-6}	0.00327937	0.256075	0.00327936
0.30	1.77689604×10^{-7}	0.04086	0.3175	0.04085999
0.40	1.06614608×10^{-7}	0.07936	0.37	0.07935999
0.60	5.36212312×10^{-8}	0.22176	0.52	0.22175999
0.80	3.32692857×10^{-8}	0.50176	0.73	0.50175999
0.90	2.73232301×10^{-8}	0.71766	0.8575	0.71766
0.95	2.49442406×10^{-8}	0.84970375	0.926875	0.84970375
1	2.28673928×10^{-8}	**1**	**1**	**1**

Table 6. In the **Jupiter-Sun interaction system**, in which the values of m, r_P and v_P are given in above Table 1, the numerical results of $RE(v;p)$, $K^*(v;p)/K_o(p)$, $U^*(v;p)/U_o(p)$ and $E^*(v;p)/E_o(p)$, are obtained by using Equations (7, 4, 5, 6), respectively, noting that $v_P \le v \le c$.

X(v)=v/c	$RE(v;p)$	$K^*(v;p)/K_o(p)$	$U^*(v;p)/U_o(p)$	$E^*(v;p)/E_o(p)$

Here, for **p=1** and at v=c, $K_o(p) = \left(\frac{3}{4}\right)\times mc^2 = 1.27970753\times 10^{44}$ J, $U_o(p) = -6.80433307\times 10^{35}$ J and $E_o(p) = 1.27970752\times 10^{44}$ J, suggesting that $E_o(p) \cong K_o(p)$, with a precision of the order of 5.31710009×10^{-9}.

$\mathbf{4.3564\times 10^{-5}}$	**2.10128052**	$\mathbf{1.26520474\times 10^{-9}}$	**0.50**	$\mathbf{-1.39334534\times 10^{-9}}$
0.09	4.94309957×10^{-7}	0.00542187	0.50405	0.00542187
0.30	4.62172181×10^{-8}	0.0627	0.545	0.0627
0.40	2.67701222×10^{-8}	0.1152	0.58	0.1152
0.60	1.27670483×10^{-8}	0.2832	0.68	0.2832
0.80	7.74151654×10^{-9}	0.5632	0.82	0.5632
0.90	6.34239572×10^{-9}	0.7587	0.905	0.7587
0.95	5.79257042×10^{-9}	0.87316875	0.95125	0.87316875
1	5.31710009×10^{-9}	**1**	**1**	**1**

Here, for **p=2** and at v=c, $\mathbf{K_o(p) = mc^2 = 1.7062767\times 10^{44}}$ **J**, in good agreement with that, proposed by **Einstein in 1905**, $U_o(p) = -1.02064996\times 10^{36}$ J and $E_o(p) = 1.70627669\times 10^{44}$ J, suggesting that $E_o(p) \cong K_o(p)$, with a precision of the order of 5.98173766×10^{-9}.

$\mathbf{4.3564\times 10^{-5}}$	**2.10128052**	$\mathbf{9.48903557\times 10^{-10}}$	**0.33333333**	$\mathbf{-1.04500901\times 10^{-9}}$
0.09	4.96279871×10^{-7}	0.0040828	0.33873333	0.0040828
0.30	4.79677231×10^{-8}	0.04905	0.39333333	0.04905

0.40	2.83616872×10^{-8}	0.0928	0.44	0.0928
0.60	1.40095162×10^{-8}	0.2448	0.57333333	0.2448
0.80	8.66257732×10^{-9}	0.5248	0.76	0.5248
0.90	7.1264592×10^{-9}	0.73305	0.87333333	0.73305
0.95	6.51474008×10^{-9}	0.85850312	0.935	0.85850312
1	5.98173766×10^{-9}	**1**	**1**	**1**

Here, for **p=3** and further at v=c, $K_o(p) = \frac{5}{4}\times mc^2 = 2.13284588\times 10^{44}$ J,$U_o(p) = -1.36086661\times 10^{36}$ J and $E_o(p) = 2.13284586\times 10^{44}$ J, suggesting that $E_o(p) \cong K_o(p)$, with a precision of the order of 6.38052022×10^{-9}.

$\mathbf{4.3564\times 10^{-5}}$	**2.10128052**	$\mathbf{7.59122846\times 10^{-10}}$	**0.25**	$\mathbf{-8.36007211\times 10^{-10}}$
0.09	4.98234019×10^{-7}	0.00327937	0.256075	0.00327936
0.30	4.95794213×10^{-8}	0.04086	0.3175	0.04086
0.40	2.97478889×10^{-8}	0.07936	0.37	0.07936
0.60	1.49615371×10^{-8}	0.22176	0.52	0.22176
0.80	9.28288357×10^{-9}	0.50176	0.73	0.50176
0.90	7.6237997×10^{-9}	0.71766	0.8575	0.71766
0.95	6.96000757×10^{-9}	0.84970375	0.926875	0.84970375
1	6.38052022×10^{-9}	**1**	**1**	**1**

Table 7. In the **Saturn-Sun interaction system**, in which the values of m, r_P and v_P are given in above Table 1, the numerical results of $RE(v;p)$, $K^*(v;p)/K_o(p)$, $U^*(v;p)/U_o(p)$ and $E^*(v;p)/E_o(p)$, are obtained by using Equations (7, 4, 5, 6), respectively, noting that $v_P \le v \le c$.

X(v)=v/c	$RE(v;p)$	$K^*(v;p)/K_o(p)$	$U^*(v;p)/U_o(p)$	$E^*(v;p)/E_o(p)$

Here, for **p=1** and at v=c, $K_o(p) = \left(\frac{3}{4}\right)\times mc^2 = 3.83173493\times 10^{43}$ J, $U_o(p) = -1.11689739\times 10^{35}$ J and $E_o(p) = 3.83173492\times 10^{43}$ J, suggesting that $E_o(p) \cong K_o(p)$, with a precision of the order of 2.9148608×10^{-9}.

$\mathbf{3.2156\times 10^{-5}}$	**2.1142644**	$\mathbf{6.89332134\times 10^{-10}}$	**0.50**	$\mathbf{-7.68098259\times 10^{-10}}$
0.09	2.7098318×10^{-7}	0.00542187	0.50405	0.00542187
0.30	2.53365091×10^{-8}	0.0627	0.545	0.0627
0.40	1.46755144×10^{-8}	0.1152	0.58	0.1152
0.60	6.99895952×10^{-9}	0.2832	0.68	0.2832
0.80	4.24393787×10^{-9}	0.5632	0.82	0.5632
0.90	3.47693296×10^{-9}	0.7587	0.905	0.7587
0.95	3.17551596×10^{-9}	0.87316875	0.95125	0.87316875
1	2.9148608×10^{-9}	**1**	**1**	**1**

Here, for **p=2** and at v=c, $\mathbf{K_o(p) = mc^2 = 5.10897991 \times 10^{43}}$ **J**, in good agreement with that, proposed by **Einstein in 1905**, $U_o(p) = -1.67534608 \times 10^{35}$ J and $E_o(p) = 5.10897989 \times 10^{43}$ J, suggesting that $E_o(p) \cong K_o(p)$, with a precision of the order of 3.27921834×10^{-9}.

$\mathbf{3.2156 \times 10^{-5}}$	**2.1142644**	**5.16999101**$\times 10^{-10}$	**0.33333333**	**-5.76073695**$\times 10^{-10}$
0.09	2.72063096×10^{-7}	0.00408281	0.33873333	0.0040828
0.30	2.62961447×10^{-8}	0.04905	0.39333333	0.04905
0.40	1.55480181×10^{-8}	0.0928	0.44	0.0928
0.60	7.68008668×10^{-8}	0.2448	0.57333333	0.2448
0.80	4.74886808×10^{-9}	0.5248	0.76	0.5248
0.90	3.90676047×10^{-9}	0.73305	0.87333333	0.73305
0.95	3.57141294×10^{-9}	0.85850312	0.935	0.85850312
1	3.27921834×10^{-9}	**1**	**1**	**1**

Here, for **p=3** and further at v=c, $K_o(p) = \frac{5}{4} \times mc^2 = 6.38622489 \times 10^{43}$ J,$U_o(p) = -2.23379477 \times 10^{35}$ J and $E_o(p) = 6.38622487 \times 10^{43}$ J, suggesting that $E_o(p) \cong K_o(p)$, with a precision of the order of 3.49783291×10^{-9}.

$\mathbf{3.2156 \times 10^{-5}}$	**2.1142644**	**4.13599281**$\times 10^{-10}$	**0.25**	**-4.60858957**$\times 10^{-10}$
0.09	2.73134371×10^{-7}	0.00327937	0.256075	0.00327937
0.30	2.71796856×10^{-8}	0.04086	0.3175	0.04086
0.40	1.63079409×10^{-8}	0.07936	0.37	0.07936
0.60	8.2019892×10^{-9}	0.22176	0.52	0.22176
0.80	5.08892306×10^{-9}	0.50176	0.73	0.50176
0.90	4.17940482×10^{-9}	0.71766	0.8575	0.71766
0.95	3.81551091×10^{-9}	0.84970375	0.926875	0.84970375
1	3.49783291×10^{-9}	**1**	**1**	**1**

Table 8. In the **Uranus-Sun interaction system**, in which the values of m, r_P and v_P are given in above Table 1, the numerical results of $RE(v;p)$, $K^*(v;p)/K_o(p)$, $U^*(v;p)/U_o(p)$ and $E^*(v;p)/E_o(p)$, are obtained by using Equations (7, 4, 5, 6), respectively, noting that $v_P \le v \le c$.

X(v)=v/c	$RE(v;p)$	$K^*(v;p)/K_o(p)$	$U^*(v;p)/U_o(p)$	$E^*(v;p)/E_o(p)$

Here, for **p=1** and at v=c, $K_o(p) = \left(\frac{3}{4}\right) \times mc^2 = 5.85209446 \times 10^{42}$ J, $U_o(p) = -8.41496949 \times 10^{33}$ J and $E_o(p) = 5.85209445 \times 10^{42}$ J, suggesting that $E_o(p) \cong K_o(p)$, with a precision of the order of 1.43794143×10^{-9}.

$\mathbf{2.2649 \times 10^{-5}}$	**2.10231223**	**3.41990472**$\times 10^{-10}$	**0.50**	**-3.76980279**$\times 10^{-10}$
0.09	1.33679785×10^{-7}	0.00542187	0.50405	0.00542187
0.30	1.24988536×10^{-8}	0.0627	0.545	0.0627
0.40	7.23963600×10^{-9}	0.1152	0.58	0.1152
0.60	3.45268436×10^{-9}	0.2832	0.68	0.2832

0.80	2.09359374$\times 10^{-9}$	0.5632	0.82	0.5632
0.90	1.71521952$\times 10^{-9}$	0.7587	0.905	0.7587
0.95	1.56652635$\times 10^{-9}$	0.87316875	0.95125	0.87316875
1	1.43794143$\times 10^{-9}$	**1**	**1**	

Here, for **p=2** and at v=c, $\mathbf{K_o(p) = mc^2 = 7.80279261 \times 10^{42}}$ **J**, in good agreement with that, proposed by **Einstein in 1905**, $U_o(p) = -1.26224542 \times 10^{34}$ J and $E_o(p) = 7.80279260 \times 10^{42}$ J, suggesting that $E_o(p) \cong K_o(p)$, with a precision of the order of 1.61768410$\times 10^{-9}$.

$\mathbf{2.2649 \times 10^{-5}}$	**2.10231223**	**2.56492854$\times 10^{-10}$**	**0.33333333**	**-2.8273521$\times 10^{-10}$**
0.09	1.34212522$\times 10^{-7}$	0.00408281	0.33873333	0.0040828
0.30	1.29722553$\times 10^{-8}$	0.04905	0.39333333	0.04905
0.40	7.67005426$\times 10^{-9}$	0.0928	0.44	0.0928
0.60	3.78869391$\times 10^{-9}$	0.2448	0.57333333	0.2448
0.80	2.34268294$\times 10^{-9}$	0.5248	0.76	0.5248
0.90	1.92725935$\times 10^{-9}$	0.73305	0.87333333	0.73305
0.95	1.76182779$\times 10^{-9}$	0.85850312	0.935	0.85850312
1	1.61768410$\times 10^{-9}$	**1**	**1**	**1**

Here, for **p=3** and further at v=c, $K_o(p) = \frac{5}{4} \times mc^2 = 9.75349076 \times 10^{42}$ J,$U_o(p) = -1.6829939 \times 10^{34}$ J and $E_o(p) = 9.75349075 \times 10^{42}$ J, suggesting that $E_o(p) \cong K_o(p)$, with a precision of the order of 1.72552972$\times 10^{-9}$.

$\mathbf{2.2649 \times 10^{-5}}$	**2.10231223**	**2.05194283$\times 10^{-10}$**	**0.25**	**-2.26188168$\times 10^{-10}$**
0.09	1.34740997$\times 10^{-7}$	0.00327937	0.256075	0.00327937
0.30	1.34081182$\times 10^{-8}$	0.04086	0.3175	0.04086
0.40	8.04493483$\times 10^{-8}$	0.07936	0.37	0.07936
0.60	4.04615574$\times 10^{-9}$	0.22176	0.52	0.22176
0.80	2.51043675$\times 10^{-9}$	0.50176	0.73	0.50176
0.90	2.06175876$\times 10^{-9}$	0.71766	0.8575	0.71766
0.95	1.88224480$\times 10^{-9}$	0.84970375	0.926875	0.84970375
1	1.72552972$\times 10^{-9}$	**1**	**1**	**1**

Table 9. In the **Neptune-Sun interaction system**, in which the values of m, r_P and v_P are given in above Table 1, the numerical results of $RE(v;p)$, $K^*(v;p)/K_o(p)$, $U^*(v;p)/U_o(p)$ and $E^*(v;p)/E_o(p)$, are obtained by using Equations (7, 4, 5, 6), respectively, noting that $v_P \leq v \leq c$.

X(v)=v/c	$RE(v;p)$	$K^*(v;p)/K_o(p)$	$U^*(v;p)/U_o(p)$	$E^*(v;p)/E_o(p)$

Here, for **p=1** and at v=c, $K_o(p) = \left(\frac{3}{4}\right) \times mc^2 = 6.90441616 \times 10^{42}$ J, $U_o(p) = -6.09086043 \times 10^{33}$ J and $E_o(p) = 6.90441615 \times 10^{42}$ J, suggesting that $E_o(p) \cong K_o(p)$, with a precision of the order of 8.82168782$\times 10^{-10}$.

1.8113×10^{-5}	**2.01672915**	**2.18712758$\times 10^{-10}$**	**0.50**	**-2.22371636$\times 10^{-10}$**
0.09	8.2011774$\times 10^{-8}$	0.00542187	0.50405	0.00542187
0.30	7.66797437$\times 10^{-9}$	0.0627	0.545	0.0627
0.40	4.44147485$\times 10^{-9}$	0.1152	0.58	0.1152
0.60	2.11820184$\times 10^{-9}$	0.2832	0.68	0.2832
0.80	1.28440769$\times 10^{-9}$	0.5632	0.82	0.5632
0.90	1.05227727$\times 10^{-9}$	0.7587	0.905	0.7587
0.95	9.61054791$\times 10^{-10}$	0.87316875	0.95125	0.87316875
1	8.82168782$\times 10^{-10}$	**1**	**1**	**1**

Here, for **p=2** and at v=c, $\mathbf{K_o(p) = mc^2 = 9.20588821 \times 10^{42}}$ **J**, in good agreement with that, proposed by **Einstein in 1905**, $U_o(p) = -9.13629064 \times 10^{33}$ J and $E_o(p) = 9.20588820 \times 10^{42}$ J, suggesting that $E_o(p) \cong K_o(p)$, with a precision of the order of 9.92439908$\times 10^{-10}$.

1.8113×10^{-5}	**2.01672915**	**1.64034569$\times 10^{-10}$**	**0.33333333**	**-1.66778727$\times 10^{-10}$**
0.09	8.23386056$\times 10^{-8}$	0.00408281	0.33873333	0.0040828
0.30	7.95840338$\times 10^{-9}$	0.04905	0.39333333	0.04905
0.40	4.70553407$\times 10^{-9}$	0.0928	0.44	0.0928
0.60	2.32434172$\times 10^{-9}$	0.2448	0.57333333	0.2448
0.80	1.43722245$\times 10^{-9}$	0.5248	0.76	0.5248
0.90	1.18236254$\times 10^{-9}$	0.73305	0.87333333	0.73305
0.95	1.08087117$\times 10^{-9}$	0.85850312	0.935	0.85850312
1	9.92439908$\times 10^{-10}$	**1**	**1**	**1**

Here, for **p=3** and further at v=c, $K_o(p) = \frac{5}{4} \times mc^2 = 1.15073603 \times 10^{43}$ J,$U_o(p) = -1.21817209 \times 10^{34}$ J and $E_o(p) = 1.150736025 \times 10^{43}$ J, suggesting that $E_o(p) \cong K_o(p)$, with a precision of the order of 1.05860254$\times 10^{-9}$.

1.8113×10^{-5}	**2.01672915**	**1.31227655$\times 10^{-10}$**	**0.25**	**-1.33422982$\times 10^{-10}$**
0.09	8.26628215$\times 10^{-8}$	0.00327937	0.256075	0.00327937
0.30	8.22580293$\times 10^{-9}$	0.04086	0.3175	0.04086
0.40	4.93552099$\times 10^{-9}$	0.07936	0.37	0.07936
0.60	2.48229315$\times 10^{-9}$	0.22176	0.52	0.22176
0.80	1.54013835$\times 10^{-9}$	0.50176	0.73	0.50176
0.90	1.26487709$\times 10^{-9}$	0.71766	0.8575	0.71766
0.95	1.15474630$\times 10^{-9}$	0.84970375	0.926875	0.84970375
1	1.05860254$\times 10^{-9}$	**1**	**1**	**1**

Table 10. In the **Moon-Sun interaction system**, in which the values of m, r_P and v_P are given in above Table 1, the numerical results of $RE(v;p)$, $K^*(v;p)/K_o(p)$, $U^*(v;p)/U_o(p)$ and $E^*(v;p)/E_o(p)$, are obtained by using Equations (7, 4, 5, 6), respectively, noting that $v_P \leq v \leq c$.

X(v)=v/c	$RE(v;p)$	$K^*(v;p)/K_o(p)$	$U^*(v;p)/U_o(p)$	$E^*(v;p)/E_o(p)$

Here, for **p=1** and at v=c, $K_o(p) = \left(\frac{3}{4}\right) \times mc^2 = 4.95148239 \times 10^{39}$ J, $U_o(p) = -5.38467907 \times 10^{34}$ J and $E_o(p) = 4.95142854 \times 10^{39}$ J, suggesting that $E_o(p) \cong K_o(p)$, with a precision of the order of 1.08748828×10^{-5}.

X(v)=v/c	$RE(v;p)$	$K^*(v;p)/K_o(p)$	$U^*(v;p)/U_o(p)$	$E^*(v;p)/E_o(p)$
$\mathbf{3.4357 \times 10^{-6}}$	$\mathbf{6.90948509\times 10^{5}}$	$\mathbf{7.86953201\times 10^{-12}}$	**0.50**	$\mathbf{-5.43749267\times 10^{-6}}$
0.09	0.001011	0.00542187	0.50405	0.00541645
0.30	9.45264934×10^{-5}	0.0627	0.545	0.06269475
0.40	5.47520142×10^{-5}	0.1152	0.58	0.11519495
0.60	2.61120068×10^{-5}	0.2832	0.68	0.28319568
0.80	1.58334586×10^{-5}	0.5632	0.82	0.56319721
0.90	1.29718847×10^{-5}	0.7587	0.905	0.75869841
0.95	1.18473460×10^{-5}	0.87316875	0.95125	0.87316790
1	1.08748828×10^{-5}	**1**	**1**	**1**

Here, for **p=2** and at v=c, $\mathbf{K_o(p) = mc^2 = 6.60197652 \times 10^{39}}$ **J**, in good agreement with that, proposed by **Einstein in 1905**, $U_o(p) = -8.07701861 \times 10^{34}$ J and $E_o(p) = 6.60189575 \times 10^{39}$ J , suggesting that $E_o(p) \cong K_o(p)$, with a precision of the order of 1.22342432×10^{-5}.

X(v)=v/c	$RE(v;p)$	$K^*(v;p)/K_o(p)$	$U^*(v;p)/U_o(p)$	$E^*(v;p)/E_o(p)$
$\mathbf{3.4357 \times 10^{-6}}$	$\mathbf{6.90948509\times 10^{5}}$	$\mathbf{5.90214900\times 10^{-12}}$	**0.33333333**	$\mathbf{-4.07812505\times 10^{-6}}$
0.09	0.00101502	0.00408281	0.33873333	0.00407871
0.30	9.8106741×10^{-5}	0.04905	0.39333333	0.04904579
0.40	5.80071874×10^{-5}	0.0928	0.44	0.09279575
0.60	2.86531839×10^{-5}	0.2448	0.57333333	0.24479598
0.80	1.77172729×10^{-5}	0.5248	0.76	0.52479712
0.90	1.45755029×10^{-5}	0.73305	0.87333333	0.73304828
0.95	1.33243748×10^{-5}	0.85850312	0.935	0.85850219
1	1.22342432×10^{-5}	**1**	**1**	**1**

Here, for **p=3** and further at v=c, $K_o(p) = \frac{5}{4} \times mc^2 = 8.25247065 \times 10^{39}$ J,$U_o(p) = -1.07693581 \times 10^{35}$ J and $E_o(p) = 8.25236296 \times 10^{39}$ J, suggesting that $E_o(p) \cong K_o(p)$, with a precision of the order of 1.30498594×10^{-5}.

X(v)=v/c	$RE(v;p)$	$K^*(v;p)/K_o(p)$	$U^*(v;p)/U_o(p)$	$E^*(v;p)/E_o(p)$
$\mathbf{3.4357 \times 10^{-6}}$	$\mathbf{6.90948509\times 10^{5}}$	$\mathbf{4.72171920\times 10^{-12}}$	**0.25**	$\mathbf{-3.2625027\times 10^{-6}}$
0.09	0.00101902	0.00327937	0.256075	0.00327607
0.30	0.0001014	0.04086	0.3175	0.04085639
0.40	6.08423383×10^{-5}	0.07936	0.37	0.07935621
0.60	3.06003196×10^{-5}	0.22176	0.52	0.22175611

0.80	1.89859641×10^{-5}	0.50176	0.73	0.50175702
0.90	1.55926963×10^{-5}	0.71766	0.8575	0.71765818
0.95	1.42350654×10^{-5}	0.84970375	0.926875	0.84970274
1	1.30498594×10^{-5}	**1**	**1**	**1**