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GLOBAL VAN-CONG EFFECTIVE KINETIC, GRAVITATIONAL POTENTIAL, AND TOTAL ENERGIES, OBTAINED IN THE (MERCURY) 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) (36)

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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 (mercury) planet-sun interaction system, as those given in Equations (4, 5, 6), and enhanced by a new global effective kinetic mass of this 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: mc^2, in perfect agreement with that proposed by Einstein in 1905 [1], m being the rest mass of the planet, as that shown in Table 2. Finally, as given in Table 5, one notes that the global effective kinetic energy is approximatively equal to the global effective total one, obtained with lowest precision of the order of 8.0528×10^{-6} for $9 \times 10^{-2} \times c \leq v \leq c$.

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

First of all, inspired by the expression of the kinetic energy of a (mercury) planet of the rest mass : $m = 3.285 \times 10^{23}$ kg, in motion with a speed v, being equal to the light speed : $c = 2.9979 \times 10^8\ (\frac{m}{s})$, $\frac{2m\times c^2}{2}$, given in the relativistic case, we now propose a **gobal effective kinetic mass**, valid at any v, by[4] :

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

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: $m^*(v = c; p) = m \times (1 + p)$. Then, from Eq. (1), this planet is in motion, due the **global effective Newton force**, and defined by:

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

where $\frac{dv}{dt}$ is the acceleration of this one, being attracted by the sun of the mass : $M = 1.988475 \times 10^{30}$ kg, due to the **global effective gravitational force**, defined as:

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

where r is the distace between the sun and this planet, and $G = 6.6743 \times 10^{-11}\ \frac{m^3}{kg\times s^2}$ is the universal gravitational constant.

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

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

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: $r = r_M = 4.6 \times 10^{10}$ m, being the distance from mercury to the sun at perihelion, and $v_M \leq v \leq c$, $v_M = 5.8976 \times 10^5$ (m/s), being the mercury speed at perihelion. That gives :

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

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

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

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

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

Then, in following Tables 1-4 in Appendix 1, the numerical results of $\frac{m^*(v;p)}{m} = (1 + p \times \frac{v^2}{c^2})$, $K^*(v;p)/K_o(p)$, $U^*(v;p)/U_o(p)$ and $E^*(v;p)/E_o(p)$ are obtained for p=1, 2, 3 and 4, respectively, using Equations (1, 4, 5, 6).

It should be concluded that the Einstein's result is confirmed by choosing p=2, as given in Table 2 in Appendix 1, and other results, obtained in Tables 1, 3 and 4 for p=1, 3 and 4, respectively, (or simply for $p > 0$), could explain other future results, showing that this Einstein's result should be modified.

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

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

The numerical results of $RE(v;p)$, expressed as functions of v and for p=1, 2, 3 and 4, are given Table 5 in Appendix 1, noting that for a given v they increase with increasing p, and, for a given p they decrease with increasing v, and one can take an approximation: $E^*(v;p) \cong K^*(v;p)$, obtained with a lowest precision of the order of 8.0528×10^{-6} for p=4 and $9 \times 10^{-2} \times c \leq v \leq c$.

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APPENDIX 1

Table 1. For **p=1**, the numerical results of $\frac{m^*(v;p)}{m} = (1 + p \times \frac{v^2}{c^2})$, $K^*(v;p)/K_o(p)$, $U^*(v;p)/U_o(p)$ and $E^*(v;p)/E_o(p)$, are obtained by using Equations (1, 4, 5, 6), respectively, noting that $v_M \le v \le c$ where $v_M = 5.8976 \times 10^5 m$, and further at v=c, $\mathbf{K_o(p)} = \left(\frac{3}{4}\right) \times \mathbf{mc^2} = \mathbf{2.21427176 \times 10^{40}\ J}$, $U_o(p) = -1.89554193 \times 10^{33}\ J$ and $E_o(p) = 2.21427157 \times 10^{40}\ J$, suggesting that $E_o(p) \cong K_o(p)$, with a precision of the order of 8.56×10^{-8}.

X(v)=v/c	$m^*(v;p)/m$	$K^*(v;p)/K_o(p)$	$U^*(v;p)/U_o(p)$	$E^*(v;p)/E_o(p)$
0.00196724	**1.00000387**	$\mathbf{2.58002714 \times 10^{-6}}$	**0.50000194**	$\mathbf{2.53722436 \times 10^{-6}}$
9×10^{-2}	1.0081	0.00542187	0.50405	0.00542183
0.1	1.01	0.0067	0.505	0.00669996
0.13	1.0169	0.01136187	0.50845	0.01136183
0.16	1.0256	0.01728512	0.5128	0.01728504
0.19	1.0361	0.02450107	0.51805	0.02450103
0.25	1.0625	0.04296875	0.53125	0.04296871
0.30	1.09	0.0627	0.545	0.06269996
0.35	1.1225	0.08666875	0.56125	0.08666871
0.40	1.16	0.1152	0.58	0.11519996
0.45	1.2025	0.14866875	0.60125	0.14866871
0.50	1.25	0.1875	0.625	0.18749996
0.55	1.3025	0.23216875	0.65125	0.23216871
0.60	1.36	0.2832	0.68	0.28319997
0.65	1.4225	0.34116875	0.71125	0.34116872
0.70	1.49	0.4067	0.745	0.40669997
0.75	1.5625	0.48046875	0.78125	0.48046872
0.80	1.64	0.5632	0.82	0.56319998
0.85	1.7225	0.65566875	0.86125	0.65566873
0.90	1.81	0.7587	0.905	0.75869999
0.95	1.9025	0.87316875	0.95125	0.87316874
1	**2**	**1**	**1**	

Table 2. For **p=2**, the numerical results of $\frac{m^*(v;p)}{m} = (1 + p \times \frac{v^2}{c^2})$, $K^*(v;p)/K_o(p)$, $U^*(v;p)/U_o(p)$ and $E^*(v;p)/E_o(p)$, are obtained by using Equations (1, 4, 5, 6), respectively, noting that $v_M \le v \le c$ where $v_M = 5.8976 \times 10^5 m$, and further at v=c, $\mathbf{K_o(p) = mc^2 = 2.95236235 \times 10^{40}\ J}$, **in good agreement with that, proposed by Einstein in 1905**, $U_o(p) = -2.8433129 \times 10^{33}\ J$ and $E_o(p) = 2.95236206 \times 10^{40}\ J$, suggesting that $E_o(p) \cong K_o(p)$, with a precision of the order of 9.63$\times 10^{-8}$.

X(v)=v/c	$m^*(v;p)/m$	$K^*(v;p)/K_o(p)$	$U^*(v;p)/U_o(p)$	$E^*(v;p)/E_o(p)$
0.00196724	**1.00000774**	**1.9350241$\times 10^{-6}$**	**0.33333591**	**1.90292191$\times 10^{-6}$**
9×10^{-2}	1.0162	0.00408281	0.33873333	0.00408277
0.1	1.02	0.00505	0.34	0.00504997
0.13	1.0338	0.00859281	0.3446	0.00859277
0.16	1.0512	0.01312768	0.3504	0.01312765
0.19	1.0722	0.01870161	0.3574	0.01870157
0.25	1.125	0.03320313	0.375	0.03320309
0.30	1.18	0.04905	0.39333333	0.04904997
0.35	1.245	0.06875313	0.415	0.06875309
0.40	1.32	0.0928	0.44	0.09279997
0.45	1.405	0.12175313	0.46833333	0.12175309
0.50	1.5	0.15625	0.5	0.15624997
0.55	1.605	0.19700313	0.535	0.19700309
0.60	1.72	0.2448	0.57333333	0.24479997
0.65	1.845	0.30050313	0.615	0.30050309
0.70	1.98	0.36505	0.66	0.36504997
0.75	2.125	0.43945313	0.70833333	0.4394531
0.80	2.28	0.5248	0.76	0.52479998
0.85	2.445	0.62225312	0.815	0.62225311
0.90	2.62	0.73305	0.87333333	0.73304999
0.95	2.805	0.85850312	0.935	0.85850312
1	**3**	**1**	**1**	**1**

Table 3. For **p=3**, the numerical results of $\frac{m^*(v;p)}{m} = (1 + p \times \frac{v^2}{c^2})$, $K^*(v;p)/K_o(p)$, $U^*(v;p)/U_o(p)$ and $E^*(v;p)/E_o(p)$, are obtained by using Equations (1, 4, 5, 6), respectively, noting that $v_M \leq v \leq c$ where $v_M = 5.8976 \times 10^5 m$, and further at v=c, $\mathbf{K_o(p) = \frac{5}{4} \times mc^2 = 3.69045294 \times 10^{40}\ J}$, $U_o(p) = -3.79108387 \times 10^{33}$ J and $E_o(p) = 3.69045256 \times 10^{40}$ J, suggesting that $E_o(p) \cong K_o(p)$, with a precision of the order of 1.027268×10^{-7}.

X(v)=v/c	$m^*(v;p)/m$	$K^*(v;p)/K_o(p)$	$U^*(v;p)/U_o(p)$	$E^*(v;p)/E_o(p)$
0.00196724	**1.00001161**	**$1.54802227 \times 10^{-6}$**	**0.2500029**	**$1.52234043 \times 10^{-6}$**
9×10^{-2}	1.0243	0.00327937	0.256075	0.00327934
0.1	1.03	0.00406	0.2575	0.00405997
0.13	1.0507	0.00693137	0.262675	0.00693134
0.16	1.0768	0.01063322	0.2692	0.01063319
0.19	1.1083	0.01522193	0.277075	0.0152219
0.25	1.1875	0.02734375	0.296875	0.02734372
0.30	1.27	0.04086	0.3175	0.04085997
0.35	1.3675	0.05800375	0.341875	0.05800372
0.40	1.48	0.07936	0.37	0.07935997
0.45	1.6075	0.10560375	0.401875	0.10560372
0.50	1.75	0.1375	0.4375	0.13749997
0.55	1.9075	0.17590375	0.476875	0.17590372
0.60	2.08	0.22176	0.52	0.22175997
0.65	2.2675	0.27610375	0.566875	0.27610372
0.70	2.47	0.34006	0.6175	0.34005997
0.75	2.6875	0.41484375	0.671875	0.41484372
0.80	2.92	0.50176	0.73	0.50175998
0.85	3.1675	0.60220375	0.791875	0.60220373
0.90	3.43	0.71766	0.8575	0.71765999
0.95	3.7075	0.84970375	0.926875	0.84970374
1	**4**	**1**	**1**	**1**

Table 4. For **p=4**, the numerical results of $\frac{m^*(v;p)}{m} = (1 + p \times \frac{v^2}{c^2})$, $K^*(v;p)/K_o(p)$, $U^*(v;p)/U_o(p)$ and $E^*(v;p)/E_o(p)$, are obtained by using Equations (1, 4, 5, 6), respectively, noting that $v_M \leq v \leq c$ where $v_M = 5.8976 \times 10^5 m$, and further at v=c, $\mathbf{K_o(p) = \frac{3}{2} \times mc^2 = 4.42854352 \times 10^{40}\ J}$, $U_o(p) = -4.73885484 \times 10^{33}$ J and $E_o(p) = 4.42854305 \times 10^{40}$ J, suggesting that $E_o(p) \cong K_o(p)$, with a precision of the order of 1.07007$\times 10^{-7}$.

X(v)=v/c	$m^*(v;p)/m$	$K^*(v;p)/K_o(p)$	$U^*(v;p)/U_o(p)$	$E^*(v;p)/E_o(p)$
0.00196724	**1.00001548**	**1.29002106$\times 10^{-6}$**	**0.2000031**	**1.26861945$\times 10^{-6}$**
9×10^{-2}	1.0324	0.00274374	0.20648	0.00274375
0.1	1.04	0.0034	0.208	0.00339998
0.13	1.0676	0.00582374	0.21352	0.00582372
0.16	1.1024	0.00897024	0.22048	0.00897022
0.19	1.1444	0.01290214	0.22888	0.01290212
0.25	1.25	0.0234375	0.25	0.02343748
0.30	1.36	0.0354	0.272	0.03539997
0.35	1.49	0.0508375	0.298	0.05083747
0.40	1.64	0.0704	0.328	0.07039997
0.45	1.81	0.0948375	0.362	0.09483747
0.50	2.00	0.1250	0.4	0.12499997
0.55	2.21	0.1618375	0.442	0.16183747
0.60	2.44	0.2064	0.488	0.20639997
0.65	2.69	0.2598375	0.538	0.25983747
0.70	2.96	0.3234	0.592	0.32339997
0.75	3.25	0.3984375	0.65	0.39843747
0.80	3.56	0.4864	0.712	0.48639998
0.85	3.89	0.5888375	0.778	0.58883748
0.90	4.24	0.7074	0.848	0.70739998
0.95	4.61	0.8438375	0.922	0.84383749
1	**5**	**1**	**1**	**1**

Table 5. The numerical results of $\mathrm{RE}(v\,;p=1,2,3,4)$ are obtained by using Equations (7), noting that they, for a given v, increase with increasing p, and for a given p, decrease with increasing v, and one can also take an approximation such as: $E^*(v;p) \cong K^*(v;p)$, obtained with a lowest precision of the order of 8.0528×10^{-6} for p=4 and $9\times 10^{-2}\times c \le v \le c$.

X(v)=v/c	$\mathrm{RE}(v\,;p=1)$	$\mathrm{RE}(v\,;p=2)$	$\mathrm{RE}(v\,;p=3)$	$\mathrm{RE}(v\,;p=4)$
0.00196724	**0.01659013**	**0.01659017**	**0.01659020**	**0.01659023**
9×10^{-2}	7.9584×10^{-6}	7.9901×10^{-6}	8.0216×10^{-6}	8.0528×10^{-6}
0.1	6.4524×10^{-6}	6.4840×10^{-6}	6.5153×10^{-6}	6.5463×10^{-6}
0.13	3.8309×10^{-6}	3.8623×10^{-6}	3.8930×10^{-6}	3.9233×10^{-6}
0.16	2.5397×10^{-6}	2.5706×10^{-6}	2.6007×10^{-6}	2.6301×10^{-6}
0.19	1.8100×10^{-6}	1.8405×10^{-6}	1.8699×10^{-6}	1.8983×10^{-6}
0.25	1.0584×10^{-6}	1.0877×10^{-6}	1.1153×10^{-6}	1.1414×10^{-6}
0.30	7.4411×10^{-7}	7.7228×10^{-7}	7.9823×10^{-7}	8.2220×10^{-7}
0.35	5.5436×10^{-7}	5.8131×10^{-7}	6.0547×10^{-7}	6.2725×10^{-7}
0.40	4.3100×10^{-7}	4.5562×10^{-7}	4.7894×10^{-7}	4.9855×10^{-7}
0.45	3.4621×10^{-7}	3.7045×10^{-7}	3.9093×10^{-7}	4.0845×10^{-7}
0.50	2.8535×10^{-7}	3.0818×10^{-7}	3.2686×10^{-7}	3.4242×10^{-7}
0.55	2.4013×10^{-7}	2.6154×10^{-7}	2.7849×10^{-7}	2.9225×10^{-7}
0.60	2.0555×10^{-7}	2.2555×10^{-7}	2.4088×10^{-7}	2.5300×10^{-7}
0.65	1.7847×10^{-7}	1.9710×10^{-7}	2.1091×10^{-7}	2.2156×10^{-7}
0.70	1.5681×10^{-7}	1.7412×10^{-7}	1.8654×10^{-7}	1.9588×10^{-7}
0.75	1.3920×10^{-7}	1.5523×10^{-7}	1.6637×10^{-7}	1.7457×10^{-7}
0.80	1.2464×10^{-7}	1.3947×10^{-7}	1.4945×10^{-7}	1.5664×10^{-7}
0.85	1.1245×10^{-7}	1.2614×10^{-7}	1.3508×10^{-7}	1.4138×10^{-7}
0.90	1.0211×10^{-7}	1.1474×10^{-7}	1.2274×10^{-7}	1.2827×10^{-7}
0.95	9.3261×10^{-8}	1.0489×10^{-7}	1.1206×10^{-7}	1.1692×10^{-7}
1	8.5606×10^{-8}	9.6306×10^{-8}	1.0273×10^{-7}	1.0701×10^{-7}