

Radius of unit particles and photons

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Introduction

When we think, in the radius of a particle we must think of the equilibrium model of particle interaction with the surrounding universe.

The universal density of potential energy will exert traction on the particle and there will be part of a reaction of equal magnitude but opposite direction.

This reaction implies that the energy of the particle necessarily has tendency to borrow, if it were not, she would dissolve in the universe.

If the particle has a tendency to contract, then it will have an elastic nature, the energy will have a modulus contract.

Condition base of balance

For the particle is in equilibrium, then the energy density of the contract, at the inner edge of its surface, must be equal to the energy density potential universal in its outer surface.

The energy contract of the matter

If we admit that the matter has a tensile modulus K' , then your energy contract, should be proportional to its mass and its volume:

$$E_c = K m \left(\frac{4}{3} \pi r^3\right)$$

So, its contractive surface energy density is given by:

$$U_c = \frac{K m \left(\frac{4}{3} \pi r^3\right)}{4 \pi r^2}$$

$$U_c = K m \frac{1}{3} r$$

Where:

ρ_u – Density of universal potential energy of all universal matter (with the exclusion of the particle in question).

ρ_m – Density of potential energy of the particle itself on its surface.

ρ'_u – Superficial universal density of potential energy at the particle.

$$\rho'_u = \rho_u + \rho_m$$

$$U_c = \rho'_u$$

$$K m \frac{1}{3} r = \rho_u + \rho_m$$

What is the value of K?

Imagine the absence of all other universal mass. The universal density of potential energy that we would find would be the particle itself.

$$\rho_u = 0$$

$$\frac{1}{3} K m_o r_o = \frac{m_o}{r_o}$$

$$K = \frac{3}{r_o^2}$$

Regardless of the mass of the particle, all particles in the conditions now presented will tend to the same radius regardless of their mass.

Generally we have:

$$\frac{m r}{r_o^2} = \frac{m}{r}$$

$$r^2 = r_o^2$$

$$r = r_o$$

So we can say that in the limit of no universal masses if the masses are too far apart and the density of potential energy generated by them will tend to zero, we can imagine that all bodies regardless of their quantity will tend to the same radius, r_o .

Looking at the Big Bang, in which there was no mass outside that we can say that the whole universal mass would be contained in r_o .

The balance between tensile strength and tensile universal particle will be:

$$K m \frac{1}{3} r = \rho_u + \frac{m}{r}$$

$$\frac{3}{r_o^2} m \frac{1}{3} r = \rho_u + \frac{m}{r}$$

$$\frac{m r}{r_o^2} = \rho_u + \frac{m}{r}$$

Impact of measurement of the proton radius

According to the latest news was possible to measure the radius of the proton, using this new information we can calculate the value of the elastic constant r_o of matter:

$$R_{proton} = 8,4184E-16 \text{ m}$$

Taking into account the proton mass and radius, we can develop numerically, the present theory:

$$M_{prot\tilde{a}o} = 1,6726231E-27 \text{ m}$$

$$r_o^2 = \frac{m r}{\rho_u + \frac{m}{r}}$$

$$r_o = \sqrt{\frac{m r}{\rho_u + \frac{m}{r}}}$$

Considering the values of the proton:

$$r_o = 4,5725205E - 35 \text{ m}$$

What is the greatest mass possible for a particle?

As we saw before we know what the radius of the particle depending on its mass. The highest possible mass for a particle is what is on the cusp of turning into a black hole.

$$C^2 = \frac{2 G m}{r}$$

$$\frac{m}{r} = \frac{C^2}{2 G}$$

$$\frac{m}{r} = \rho_u$$

$$m = r \rho_u$$

$$\frac{r \rho_u r}{r_o^2} = \rho_u + \rho_u$$

$$\frac{\rho_u r^2}{r_o^2} = 2 \rho_u$$

$$r^2 = 2 r_o^2$$

$$r = \sqrt{2} r_o$$

$$r = 6,4665205E - 35 \text{ m}$$

$$m = \frac{2 \rho_u r_o^2}{r}$$

$$m = 4,3549882E-08 \text{ Kg}$$

In general terms and specific, we have:

$$K m r = \rho_u + \rho_m$$

$$K m r = \rho_u + \frac{m}{r}$$

$$\frac{m r}{r_o^2} = \rho_u + \frac{m}{r}$$

$$\frac{m}{r_o^2} r^2 - \rho_u r - m = 0$$

$$r = \frac{\rho_u + \sqrt{\rho_u^2 + 4 \frac{m^2}{r_o^2}}}{2 \frac{m}{r_o^2}}$$

Generalization for all particles

The expression found for the radius of photons, the principle of definition of mass, mC^2 should apply to any particles, even at rest.

| | m | eV | Raio |
|----------|---------------|-------------|---------------|
| Neutrão | 1,6749286E-27 | 939565635,5 | 8,4068123E-16 |
| Protão | 1,6726231E-27 | 938272345,4 | 8,4184000E-16 |
| Electrão | 9,1093897E-31 | 510999,0672 | 1,5457468E-12 |

Particles in a different referential with different universal density of potential energy.

Let us now analyze the behavior of particles/photons subject to a potential energy density of our site other than Earth.

ρ_l - Density of potential energy in another referential.

$$\rho_l = A \rho_u$$

$$r = k (A\rho_u + \rho_{fA})$$

Solving the equation to r:

$$\frac{r_l}{r} = \frac{k (A\rho_u + \rho_{fA})}{k (\rho_u + \rho_f)}$$

$$\frac{r_l}{r} = \frac{(A\rho_u + \rho_{fA})}{(\rho_u + \rho_f)}$$

$$\frac{r_l}{r} = A + \frac{\rho_{fA}}{A\rho_u} - \frac{A\rho_f}{\rho_u} + \dots\dots$$

$$\frac{\rho_{fA}}{A\rho_u} = \sim 0 \text{ and } - \frac{A\rho_f}{\rho_u} = \sim 0$$

$$\frac{r_l}{r} = \sim A$$

With computer support, for a photon of 1E24 eV:

| Density of potential energy d/do | Radius of photon m | R/Ro | Difference to C m/s | dV/dVo % |
|-------------------------------------|-----------------------|---------|------------------------|-------------|
| 0,5 | 3,94938E-31 | 0,50000 | 2,009 | 400,00% |
| 1 | 7,89875E-31 | 1 | 0,502 | 0,00% |
| 2 | 1,57975E-30 | 2,00000 | 0,126 | 25,00% |

The radius of the photon varies almost in proportion to the potential energy density of the medium in which they move.

The slope of the speed of propagation of photons for C varies practically in inverse proportion to the potential energy density of the medium.

The photon in a medium with lower density of potential energy will move more slowly.

As the density of potential in the local earth will diminish in the future, then the radius of the photon will decrease, as well as its speed.

Summary

- The low-energy photons move almost at the speed C, but never C.
- Photons of higher energy are those with greater deviation from C.

Values

We are now able to display tables with figures for both the travel speed of photons taking into account the deviation of its speed in relation to C or to its radius.

V – Velocity of photon.

ρ_u – Universal density of potential energy.

ρ_m – Density of potential energy on photon's surface generated by itself.

$$V = C \sqrt{\frac{\rho_u}{\rho_u + \rho_m}}$$

| Energy of photon eV | Mass of photon m | Energy of photon 1,275^n eV | Radius of photon m | Velocity of photon m/s | Energy of photon 1,275^n eV | Deviation of velocity on the photon from C m/s |
|------------------------|---------------------|-----------------------------------|-----------------------|---------------------------|-----------------------------------|---|
| 1,000E+00 | 1,783E-36 | 1 | 7,9E-07 | 299792458,8 | 1 | 5,02403E-49 |
| 1,275E+00 | 2,273E-36 | 2 | 6,2E-07 | 299792458,8 | 2 | 8,16719E-49 |
| 1,626E+00 | 2,898E-36 | 3 | 4,86E-07 | 299792458,8 | 3 | 1,32768E-48 |
| 2,073E+00 | 3,695E-36 | 4 | 3,81E-07 | 299792458,8 | 4 | 2,15831E-48 |
| 2,643E+00 | 4,711E-36 | 5 | 2,99E-07 | 299792458,8 | 5 | 3,5086E-48 |
| 3,369E+00 | 6,006E-36 | 6 | 2,34E-07 | 299792458,8 | 6 | 5,70367E-48 |
| 4,296E+00 | 7,658E-36 | 7 | 1,84E-07 | 299792458,8 | 7 | 9,27202E-48 |
| 5,477E+00 | 9,764E-36 | 8 | 1,44E-07 | 299792458,8 | 8 | 1,50728E-47 |

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|-----------|-----------|----|----------|-------------|----|-------------|
| 6,984E+00 | 1,245E-35 | 9 | 1,13E-07 | 299792458,8 | 9 | 2,45028E-47 |
| 8,904E+00 | 1,587E-35 | 10 | 8,87E-08 | 299792458,8 | 10 | 3,98323E-47 |
| 1,135E+01 | 2,024E-35 | 11 | 6,96E-08 | 299792458,8 | 11 | 6,47524E-47 |
| 1,447E+01 | 2,58E-35 | 12 | 5,46E-08 | 299792458,8 | 12 | 1,05263E-46 |
| 1,846E+01 | 3,29E-35 | 13 | 4,28E-08 | 299792458,8 | 13 | 1,71118E-46 |
| 2,353E+01 | 4,195E-35 | 14 | 3,36E-08 | 299792458,8 | 14 | 2,78174E-46 |
| 3,000E+01 | 5,348E-35 | 15 | 2,63E-08 | 299792458,8 | 15 | 4,52207E-46 |
| 3,825E+01 | 6,819E-35 | 16 | 2,06E-08 | 299792458,8 | 16 | 7,35119E-46 |
| 4,877E+01 | 8,694E-35 | 17 | 1,62E-08 | 299792458,8 | 17 | 1,19503E-45 |
| 6,218E+01 | 1,109E-34 | 18 | 1,27E-08 | 299792458,8 | 18 | 1,94267E-45 |
| 7,928E+01 | 1,413E-34 | 19 | 9,96E-09 | 299792458,8 | 19 | 3,15805E-45 |
| 1,011E+02 | 1,802E-34 | 20 | 7,81E-09 | 299792458,8 | 20 | 5,1338E-45 |
| 1,289E+02 | 2,298E-34 | 21 | 6,13E-09 | 299792458,8 | 21 | 8,34564E-45 |
| 1,643E+02 | 2,929E-34 | 22 | 4,81E-09 | 299792458,8 | 22 | 1,35669E-44 |
| 2,095E+02 | 3,735E-34 | 23 | 3,77E-09 | 299792458,8 | 23 | 2,20547E-44 |
| 2,671E+02 | 4,762E-34 | 24 | 2,96E-09 | 299792458,8 | 24 | 3,58526E-44 |
| 3,406E+02 | 6,072E-34 | 25 | 2,32E-09 | 299792458,8 | 25 | 5,82829E-44 |
| 4,343E+02 | 7,741E-34 | 26 | 1,82E-09 | 299792458,8 | 26 | 9,47461E-44 |
| 5,537E+02 | 9,87E-34 | 27 | 1,43E-09 | 299792458,8 | 27 | 1,54022E-43 |
| 7,060E+02 | 1,258E-33 | 28 | 1,12E-09 | 299792458,8 | 28 | 2,50382E-43 |
| 9,001E+02 | 1,605E-33 | 29 | 8,78E-10 | 299792458,8 | 29 | 4,07026E-43 |
| 1,148E+03 | 2,046E-33 | 30 | 6,88E-10 | 299792458,8 | 30 | 6,61672E-43 |
| 1,463E+03 | 2,608E-33 | 31 | 5,4E-10 | 299792458,8 | 31 | 1,07563E-42 |
| 1,866E+03 | 3,326E-33 | 32 | 4,23E-10 | 299792458,8 | 32 | 1,74857E-42 |
| 2,379E+03 | 4,24E-33 | 33 | 3,32E-10 | 299792458,8 | 33 | 2,84252E-42 |
| 3,033E+03 | 5,406E-33 | 34 | 2,6E-10 | 299792458,8 | 34 | 4,62088E-42 |
| 3,867E+03 | 6,893E-33 | 35 | 2,04E-10 | 299792458,8 | 35 | 7,51181E-42 |
| 4,930E+03 | 8,789E-33 | 36 | 1,6E-10 | 299792458,8 | 36 | 1,22114E-41 |
| 6,286E+03 | 1,121E-32 | 37 | 1,26E-10 | 299792458,8 | 37 | 1,98511E-41 |
| 8,015E+03 | 1,429E-32 | 38 | 9,86E-11 | 299792458,8 | 38 | 3,22705E-41 |
| 1,022E+04 | 1,822E-32 | 39 | 7,73E-11 | 299792458,8 | 39 | 5,24598E-41 |
| 1,303E+04 | 2,323E-32 | 40 | 6,06E-11 | 299792458,8 | 40 | 8,52799E-41 |

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|-----------|-----------|----|----------|-------------|----|-------------|
| 1,661E+04 | 2,961E-32 | 41 | 4,76E-11 | 299792458,8 | 41 | 1,38633E-40 |
| 2,118E+04 | 3,776E-32 | 42 | 3,73E-11 | 299792458,8 | 42 | 2,25365E-40 |
| 2,700E+04 | 4,814E-32 | 43 | 2,93E-11 | 299792458,8 | 43 | 3,6636E-40 |
| 3,443E+04 | 6,138E-32 | 44 | 2,29E-11 | 299792458,8 | 44 | 5,95564E-40 |
| 4,390E+04 | 7,826E-32 | 45 | 1,8E-11 | 299792458,8 | 45 | 9,68163E-40 |
| 5,597E+04 | 9,978E-32 | 46 | 1,41E-11 | 299792458,8 | 46 | 1,57387E-39 |
| 7,136E+04 | 1,272E-31 | 47 | 1,11E-11 | 299792458,8 | 47 | 2,55852E-39 |
| 9,099E+04 | 1,622E-31 | 48 | 8,68E-12 | 299792458,8 | 48 | 4,1592E-39 |
| 1,160E+05 | 2,068E-31 | 49 | 6,81E-12 | 299792458,8 | 49 | 6,7613E-39 |
| 1,479E+05 | 2,637E-31 | 50 | 5,34E-12 | 299792458,8 | 50 | 1,09913E-38 |
| 1,886E+05 | 3,362E-31 | 51 | 4,19E-12 | 299792458,8 | 51 | 1,78678E-38 |
| 2,404E+05 | 4,286E-31 | 52 | 3,29E-12 | 299792458,8 | 52 | 2,90463E-38 |
| 3,066E+05 | 5,465E-31 | 53 | 2,58E-12 | 299792458,8 | 53 | 4,72184E-38 |
| 3,909E+05 | 6,968E-31 | 54 | 2,02E-12 | 299792458,8 | 54 | 7,67595E-38 |
| 4,984E+05 | 8,884E-31 | 55 | 1,58E-12 | 299792458,8 | 55 | 1,24782E-37 |
| 6,354E+05 | 1,133E-30 | 56 | 1,24E-12 | 299792458,8 | 56 | 2,02849E-37 |
| 8,102E+05 | 1,444E-30 | 57 | 9,75E-13 | 299792458,8 | 57 | 3,29756E-37 |
| 1,033E+06 | 1,841E-30 | 58 | 7,65E-13 | 299792458,8 | 58 | 5,3606E-37 |
| 1,317E+06 | 2,348E-30 | 59 | 6E-13 | 299792458,8 | 59 | 8,71432E-37 |
| 1,679E+06 | 2,993E-30 | 60 | 4,7E-13 | 299792458,8 | 60 | 1,41662E-36 |
| 2,141E+06 | 3,817E-30 | 61 | 3,69E-13 | 299792458,8 | 61 | 2,3029E-36 |
| 2,730E+06 | 4,866E-30 | 62 | 2,89E-13 | 299792458,8 | 62 | 3,74365E-36 |
| 3,480E+06 | 6,204E-30 | 63 | 2,27E-13 | 299792458,8 | 63 | 6,08577E-36 |
| 4,438E+06 | 7,911E-30 | 64 | 1,78E-13 | 299792458,8 | 64 | 9,89317E-36 |
| 5,658E+06 | 1,009E-29 | 65 | 1,4E-13 | 299792458,8 | 65 | 1,60826E-35 |
| 7,214E+06 | 1,286E-29 | 66 | 1,09E-13 | 299792458,8 | 66 | 2,61443E-35 |
| 9,198E+06 | 1,64E-29 | 67 | 8,59E-14 | 299792458,8 | 67 | 4,25008E-35 |
| 1,173E+07 | 2,091E-29 | 68 | 6,74E-14 | 299792458,8 | 68 | 6,90903E-35 |
| 1,495E+07 | 2,665E-29 | 69 | 5,28E-14 | 299792458,8 | 69 | 1,12315E-34 |
| 1,906E+07 | 3,398E-29 | 70 | 4,14E-14 | 299792458,8 | 70 | 1,82582E-34 |
| 2,431E+07 | 4,333E-29 | 71 | 3,25E-14 | 299792458,8 | 71 | 2,9681E-34 |
| 3,099E+07 | 5,524E-29 | 72 | 2,55E-14 | 299792458,8 | 72 | 4,82501E-34 |

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| 3,951E+07 | 7,044E-29 | 73 | 2E-14 | 299792458,8 | 73 | 7,84366E-34 |
| 5,038E+07 | 8,981E-29 | 74 | 1,57E-14 | 299792458,8 | 74 | 1,27509E-33 |
| 6,423E+07 | 1,145E-28 | 75 | 1,23E-14 | 299792458,8 | 75 | 2,07281E-33 |
| 8,190E+07 | 1,46E-28 | 76 | 9,64E-15 | 299792458,8 | 76 | 3,36961E-33 |
| 1,044E+08 | 1,861E-28 | 77 | 7,56E-15 | 299792458,8 | 77 | 5,47773E-33 |
| 1,331E+08 | 2,373E-28 | 78 | 5,93E-15 | 299792458,8 | 78 | 8,90473E-33 |
| 1,697E+08 | 3,026E-28 | 79 | 4,65E-15 | 299792458,8 | 79 | 1,44758E-32 |
| 2,164E+08 | 3,858E-28 | 80 | 3,65E-15 | 299792458,8 | 80 | 2,35321E-32 |
| 2,759E+08 | 4,919E-28 | 81 | 2,86E-15 | 299792458,8 | 81 | 3,82544E-32 |
| 3,518E+08 | 6,272E-28 | 82 | 2,25E-15 | 299792458,8 | 82 | 6,21874E-32 |
| 4,486E+08 | 7,997E-28 | 83 | 1,76E-15 | 299792458,8 | 83 | 1,01093E-31 |
| 5,719E+08 | 1,02E-27 | 84 | 1,38E-15 | 299792458,8 | 84 | 1,6434E-31 |
| 7,292E+08 | 1,3E-27 | 85 | 1,08E-15 | 299792458,8 | 85 | 2,67155E-31 |
| 9,297E+08 | 1,657E-27 | 86 | 8,5E-16 | 299792458,8 | 86 | 4,34294E-31 |
| 1,185E+09 | 2,113E-27 | 87 | 6,66E-16 | 299792458,8 | 87 | 7,05999E-31 |
| 1,511E+09 | 2,694E-27 | 88 | 5,23E-16 | 299792458,8 | 88 | 1,14769E-30 |
| 1,927E+09 | 3,435E-27 | 89 | 4,1E-16 | 299792458,8 | 89 | 1,86571E-30 |
| 2,457E+09 | 4,38E-27 | 90 | 3,21E-16 | 299792458,8 | 90 | 3,03295E-30 |
| 3,133E+09 | 5,585E-27 | 91 | 2,52E-16 | 299792458,8 | 91 | 4,93044E-30 |
| 3,994E+09 | 7,12E-27 | 92 | 1,98E-16 | 299792458,8 | 92 | 8,01504E-30 |
| 5,093E+09 | 9,078E-27 | 93 | 1,55E-16 | 299792458,8 | 93 | 1,30295E-29 |
| 6,493E+09 | 1,157E-26 | 94 | 1,22E-16 | 299792458,8 | 94 | 2,1181E-29 |
| 8,279E+09 | 1,476E-26 | 95 | 9,54E-17 | 299792458,8 | 95 | 3,44324E-29 |
| 1,056E+10 | 1,882E-26 | 96 | 7,48E-17 | 299792458,8 | 96 | 5,59741E-29 |
| 1,346E+10 | 2,399E-26 | 97 | 5,87E-17 | 299792458,8 | 97 | 9,0993E-29 |
| 1,716E+10 | 3,059E-26 | 98 | 4,6E-17 | 299792458,8 | 98 | 1,4792E-28 |
| 2,188E+10 | 3,9E-26 | 99 | 3,61E-17 | 299792458,8 | 99 | 2,40463E-28 |
| 2,789E+10 | 4,973E-26 | 100 | 2,83E-17 | 299792458,8 | 100 | 3,90903E-28 |
| 3,556E+10 | 6,34E-26 | 101 | 2,22E-17 | 299792458,8 | 101 | 6,35461E-28 |
| 4,534E+10 | 8,083E-26 | 102 | 1,74E-17 | 299792458,8 | 102 | 1,03302E-27 |
| 5,781E+10 | 1,031E-25 | 103 | 1,37E-17 | 299792458,8 | 103 | 1,67931E-27 |
| 7,371E+10 | 1,314E-25 | 104 | 1,07E-17 | 299792458,8 | 104 | 2,72992E-27 |

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|-----------|-----------|-----|----------|-------------|-----|-------------|
| 9,399E+10 | 1,675E-25 | 105 | 8,4E-18 | 299792458,8 | 105 | 4,43783E-27 |
| 1,198E+11 | 2,136E-25 | 106 | 6,59E-18 | 299792458,8 | 106 | 7,21425E-27 |
| 1,528E+11 | 2,724E-25 | 107 | 5,17E-18 | 299792458,8 | 107 | 1,17277E-26 |
| 1,948E+11 | 3,473E-25 | 108 | 4,05E-18 | 299792458,8 | 108 | 1,90648E-26 |
| 2,484E+11 | 4,428E-25 | 109 | 3,18E-18 | 299792458,8 | 109 | 3,09922E-26 |
| 3,167E+11 | 5,645E-25 | 110 | 2,49E-18 | 299792458,8 | 110 | 5,03817E-26 |
| 4,038E+11 | 7,198E-25 | 111 | 1,96E-18 | 299792458,8 | 111 | 8,19017E-26 |
| 5,148E+11 | 9,177E-25 | 112 | 1,53E-18 | 299792458,8 | 112 | 1,33141E-25 |
| 6,564E+11 | 1,17E-24 | 113 | 1,2E-18 | 299792458,8 | 113 | 2,16438E-25 |
| 8,369E+11 | 1,492E-24 | 114 | 9,44E-19 | 299792458,8 | 114 | 3,51847E-25 |
| 1,067E+12 | 1,902E-24 | 115 | 7,4E-19 | 299792458,8 | 115 | 5,71972E-25 |
| 1,360E+12 | 2,425E-24 | 116 | 5,81E-19 | 299792458,8 | 116 | 9,29811E-25 |
| 1,735E+12 | 3,092E-24 | 117 | 4,55E-19 | 299792458,8 | 117 | 1,51152E-24 |
| 2,212E+12 | 3,942E-24 | 118 | 3,57E-19 | 299792458,8 | 118 | 2,45717E-24 |
| 2,820E+12 | 5,027E-24 | 119 | 2,8E-19 | 299792458,8 | 119 | 3,99444E-24 |
| 3,595E+12 | 6,409E-24 | 120 | 2,2E-19 | 299792458,8 | 120 | 6,49346E-24 |
| 4,584E+12 | 8,171E-24 | 121 | 1,72E-19 | 299792458,8 | 121 | 1,05559E-23 |
| 5,844E+12 | 1,042E-23 | 122 | 1,35E-19 | 299792458,8 | 122 | 1,716E-23 |
| 7,451E+12 | 1,328E-23 | 123 | 1,06E-19 | 299792458,8 | 123 | 2,78957E-23 |
| 9,501E+12 | 1,694E-23 | 124 | 8,31E-20 | 299792458,8 | 124 | 4,5348E-23 |
| 1,211E+13 | 2,159E-23 | 125 | 6,52E-20 | 299792458,8 | 125 | 7,37188E-23 |
| 1,544E+13 | 2,753E-23 | 126 | 5,11E-20 | 299792458,8 | 126 | 1,19839E-22 |
| 1,969E+13 | 3,51E-23 | 127 | 4,01E-20 | 299792458,8 | 127 | 1,94813E-22 |
| 2,511E+13 | 4,476E-23 | 128 | 3,15E-20 | 299792458,8 | 128 | 3,16694E-22 |
| 3,201E+13 | 5,707E-23 | 129 | 2,47E-20 | 299792458,8 | 129 | 5,14825E-22 |
| 4,081E+13 | 7,276E-23 | 130 | 1,94E-20 | 299792458,8 | 130 | 8,36912E-22 |
| 5,204E+13 | 9,277E-23 | 131 | 1,52E-20 | 299792458,8 | 131 | 1,36051E-21 |
| 6,635E+13 | 1,183E-22 | 132 | 1,19E-20 | 299792458,8 | 132 | 2,21167E-21 |
| 8,459E+13 | 1,508E-22 | 133 | 9,34E-21 | 299792458,8 | 133 | 3,59535E-21 |
| 1,079E+14 | 1,923E-22 | 134 | 7,32E-21 | 299792458,8 | 134 | 5,84469E-21 |
| 1,375E+14 | 2,452E-22 | 135 | 5,74E-21 | 299792458,8 | 135 | 9,50127E-21 |
| 1,753E+14 | 3,126E-22 | 136 | 4,5E-21 | 299792458,8 | 136 | 1,54455E-20 |

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|-----------|-----------|-----|----------|-------------|-----|-------------|
| 2,236E+14 | 3,985E-22 | 137 | 3,53E-21 | 299792458,8 | 137 | 2,51086E-20 |
| 2,850E+14 | 5,081E-22 | 138 | 2,77E-21 | 299792458,8 | 138 | 4,08172E-20 |
| 3,634E+14 | 6,479E-22 | 139 | 2,17E-21 | 299792458,8 | 139 | 6,63534E-20 |
| 4,634E+14 | 8,26E-22 | 140 | 1,7E-21 | 299792458,8 | 140 | 1,07866E-19 |
| 5,908E+14 | 1,053E-21 | 141 | 1,34E-21 | 299792458,8 | 141 | 1,75349E-19 |
| 7,532E+14 | 1,343E-21 | 142 | 1,05E-21 | 299792458,8 | 142 | 2,85052E-19 |
| 9,604E+14 | 1,712E-21 | 143 | 8,22E-22 | 299792458,8 | 143 | 4,63388E-19 |
| 1,224E+15 | 2,183E-21 | 144 | 6,45E-22 | 299792458,8 | 144 | 7,53295E-19 |
| 1,561E+15 | 2,783E-21 | 145 | 5,06E-22 | 299792458,8 | 145 | 1,22458E-18 |
| 1,991E+15 | 3,549E-21 | 146 | 3,97E-22 | 299792458,8 | 146 | 1,9907E-18 |
| 2,538E+15 | 4,524E-21 | 147 | 3,11E-22 | 299792458,8 | 147 | 3,23613E-18 |
| 3,236E+15 | 5,769E-21 | 148 | 2,44E-22 | 299792458,8 | 148 | 5,26074E-18 |
| 4,126E+15 | 7,355E-21 | 149 | 1,91E-22 | 299792458,8 | 149 | 8,55199E-18 |
| 5,260E+15 | 9,377E-21 | 150 | 1,5E-22 | 299792458,8 | 150 | 1,39023E-17 |
| 6,707E+15 | 1,196E-20 | 151 | 1,18E-22 | 299792458,8 | 151 | 2,26E-17 |
| 8,551E+15 | 1,524E-20 | 152 | 9,24E-23 | 299792458,8 | 152 | 3,67391E-17 |
| 1,090E+16 | 1,944E-20 | 153 | 7,24E-23 | 299792458,8 | 153 | 5,97239E-17 |
| 1,390E+16 | 2,478E-20 | 154 | 5,68E-23 | 299792458,8 | 154 | 9,70887E-17 |
| 1,772E+16 | 3,16E-20 | 155 | 4,46E-23 | 299792458,8 | 155 | 1,5783E-16 |
| 2,260E+16 | 4,029E-20 | 156 | 3,5E-23 | 299792458,8 | 156 | 2,56572E-16 |
| 2,881E+16 | 5,136E-20 | 157 | 2,74E-23 | 299792458,8 | 157 | 4,1709E-16 |
| 3,674E+16 | 6,549E-20 | 158 | 2,15E-23 | 299792458,8 | 158 | 6,78032E-16 |
| 4,684E+16 | 8,35E-20 | 159 | 1,69E-23 | 299792458,8 | 159 | 1,10223E-15 |
| 5,972E+16 | 1,065E-19 | 160 | 1,32E-23 | 299792458,8 | 160 | 1,79181E-15 |
| 7,614E+16 | 1,357E-19 | 161 | 1,04E-23 | 299792458,8 | 161 | 2,9128E-15 |
| 9,708E+16 | 1,731E-19 | 162 | 8,14E-24 | 299792458,8 | 162 | 4,73513E-15 |
| 1,238E+17 | 2,207E-19 | 163 | 6,38E-24 | 299792458,8 | 163 | 7,69754E-15 |
| 1,578E+17 | 2,813E-19 | 164 | 5E-24 | 299792458,8 | 164 | 1,25133E-14 |
| 2,012E+17 | 3,587E-19 | 165 | 3,93E-24 | 299792458,8 | 165 | 2,0342E-14 |
| 2,566E+17 | 4,574E-19 | 166 | 3,08E-24 | 299792458,8 | 166 | 3,30684E-14 |
| 3,271E+17 | 5,831E-19 | 167 | 2,41E-24 | 299792458,8 | 167 | 5,37568E-14 |
| 4,171E+17 | 7,435E-19 | 168 | 1,89E-24 | 299792458,8 | 168 | 8,73884E-14 |

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|-----------|-----------|-----|----------|-------------|-----|-------------|
| 5,318E+17 | 9,479E-19 | 169 | 1,49E-24 | 299792458,8 | 169 | 1,42061E-13 |
| 6,780E+17 | 1,209E-18 | 170 | 1,17E-24 | 299792458,8 | 170 | 2,30938E-13 |
| 8,644E+17 | 1,541E-18 | 171 | 9,14E-25 | 299792458,8 | 171 | 3,75418E-13 |
| 1,102E+18 | 1,965E-18 | 172 | 7,17E-25 | 299792458,8 | 172 | 6,10289E-13 |
| 1,405E+18 | 2,505E-18 | 173 | 5,62E-25 | 299792458,8 | 173 | 9,92101E-13 |
| 1,792E+18 | 3,194E-18 | 174 | 4,41E-25 | 299792458,8 | 174 | 1,61278E-12 |
| 2,284E+18 | 4,072E-18 | 175 | 3,46E-25 | 299792458,8 | 175 | 2,62178E-12 |
| 2,913E+18 | 5,192E-18 | 176 | 2,71E-25 | 299792458,8 | 176 | 4,26203E-12 |
| 3,714E+18 | 6,62E-18 | 177 | 2,13E-25 | 299792458,8 | 177 | 6,92847E-12 |
| 4,735E+18 | 8,441E-18 | 178 | 1,67E-25 | 299792458,8 | 178 | 1,12631E-11 |
| 6,037E+18 | 1,076E-17 | 179 | 1,31E-25 | 299792458,8 | 179 | 1,83096E-11 |
| 7,697E+18 | 1,372E-17 | 180 | 1,03E-25 | 299792458,8 | 180 | 2,97645E-11 |
| 9,814E+18 | 1,749E-17 | 181 | 8,05E-26 | 299792458,8 | 181 | 4,83859E-11 |
| 1,251E+19 | 2,231E-17 | 182 | 6,31E-26 | 299792458,8 | 182 | 7,86573E-11 |
| 1,595E+19 | 2,844E-17 | 183 | 4,95E-26 | 299792458,8 | 183 | 1,27867E-10 |
| 2,034E+19 | 3,626E-17 | 184 | 3,88E-26 | 299792458,8 | 184 | 2,07864E-10 |
| 2,593E+19 | 4,623E-17 | 185 | 3,05E-26 | 299792458,8 | 185 | 3,37909E-10 |
| 3,307E+19 | 5,895E-17 | 186 | 2,39E-26 | 299792458,8 | 186 | 5,49314E-10 |
| 4,216E+19 | 7,516E-17 | 187 | 1,87E-26 | 299792458,8 | 187 | 8,92979E-10 |
| 5,375E+19 | 9,582E-17 | 188 | 1,47E-26 | 299792458,8 | 188 | 1,45165E-09 |
| 6,854E+19 | 1,222E-16 | 189 | 1,15E-26 | 299792458,8 | 189 | 2,35984E-09 |
| 8,738E+19 | 1,558E-16 | 190 | 9,04E-27 | 299792458,8 | 190 | 3,83621E-09 |
| 1,114E+20 | 1,986E-16 | 191 | 7,09E-27 | 299792458,8 | 191 | 6,23624E-09 |
| 1,421E+20 | 2,532E-16 | 192 | 5,56E-27 | 299792458,8 | 192 | 1,01378E-08 |
| 1,811E+20 | 3,229E-16 | 193 | 4,36E-27 | 299792458,8 | 193 | 1,64802E-08 |
| 2,309E+20 | 4,117E-16 | 194 | 3,42E-27 | 299792458,8 | 194 | 2,67907E-08 |
| 2,944E+20 | 5,249E-16 | 195 | 2,68E-27 | 299792458,8 | 195 | 4,35516E-08 |
| 3,754E+20 | 6,692E-16 | 196 | 2,1E-27 | 299792458,8 | 196 | 5,96046E-08 |
| 4,786E+20 | 8,532E-16 | 197 | 1,65E-27 | 299792458,8 | 197 | 1,19209E-07 |
| 6,102E+20 | 1,088E-15 | 198 | 1,29E-27 | 299792458,8 | 198 | 1,78814E-07 |
| 7,781E+20 | 1,387E-15 | 199 | 1,02E-27 | 299792458,8 | 199 | 2,98023E-07 |
| 9,920E+20 | 1,768E-15 | 200 | 7,96E-28 | 299792458,8 | 200 | 4,76837E-07 |

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|-----------|-----------|-----|----------|-------------|-----|-------------|
| 1,265E+21 | 2,255E-15 | 201 | 6,24E-28 | 299792458,8 | 201 | 7,7486E-07 |
| 1,613E+21 | 2,875E-15 | 202 | 4,9E-28 | 299792458,8 | 202 | 1,3113E-06 |
| 2,056E+21 | 3,665E-15 | 203 | 3,84E-28 | 299792458,8 | 203 | 2,14577E-06 |
| 2,622E+21 | 4,673E-15 | 204 | 3,01E-28 | 299792458,8 | 204 | 3,45707E-06 |
| 3,343E+21 | 5,959E-15 | 205 | 2,36E-28 | 299792458,8 | 205 | 5,60284E-06 |
| 4,262E+21 | 7,597E-15 | 206 | 1,85E-28 | 299792458,8 | 206 | 9,11951E-06 |
| 5,434E+21 | 9,687E-15 | 207 | 1,45E-28 | 299792458,8 | 207 | 1,48416E-05 |
| 6,928E+21 | 1,235E-14 | 208 | 1,14E-28 | 299792458,8 | 208 | 2,41399E-05 |
| 8,833E+21 | 1,575E-14 | 209 | 8,94E-29 | 299792458,8 | 209 | 3,91603E-05 |
| 1,126E+22 | 2,008E-14 | 210 | 7,01E-29 | 299792458,8 | 210 | 6,37174E-05 |
| 1,436E+22 | 2,56E-14 | 211 | 5,5E-29 | 299792458,8 | 211 | 0,000103593 |
| 1,831E+22 | 3,264E-14 | 212 | 4,31E-29 | 299792458,8 | 212 | 0,000168383 |
| 2,334E+22 | 4,161E-14 | 213 | 3,38E-29 | 299792458,8 | 213 | 0,000273705 |
| 2,976E+22 | 5,306E-14 | 214 | 2,65E-29 | 299792458,8 | 214 | 0,000444949 |
| 3,795E+22 | 6,765E-14 | 215 | 2,08E-29 | 299792458,8 | 215 | 0,000723302 |
| 4,838E+22 | 8,625E-14 | 216 | 1,63E-29 | 299792458,8 | 216 | 0,00117588 |
| 6,169E+22 | 1,1E-13 | 217 | 1,28E-29 | 299792458,8 | 217 | 0,001911521 |
| 7,865E+22 | 1,402E-13 | 218 | 1E-29 | 299792458,8 | 218 | 0,003107429 |
| 1,003E+23 | 1,788E-13 | 219 | 7,88E-30 | 299792458,8 | 219 | 0,005051553 |
| 1,279E+23 | 2,279E-13 | 220 | 6,18E-30 | 299792458,8 | 220 | 0,008211911 |
| 1,630E+23 | 2,906E-13 | 221 | 4,85E-30 | 299792458,8 | 221 | 0,013349533 |
| 2,079E+23 | 3,705E-13 | 222 | 3,8E-30 | 299792458,8 | 222 | 0,021701336 |
| 2,650E+23 | 4,724E-13 | 223 | 2,98E-30 | 299792458,8 | 223 | 0,035278261 |
| 3,379E+23 | 6,023E-13 | 224 | 2,34E-30 | 299792458,7 | 224 | 0,057349205 |
| 4,308E+23 | 7,68E-13 | 225 | 1,83E-30 | 299792458,7 | 225 | 0,093228281 |
| 5,493E+23 | 9,792E-13 | 226 | 1,44E-30 | 299792458,6 | 226 | 0,151554286 |
| 7,003E+23 | 1,248E-12 | 227 | 1,13E-30 | 299792458,6 | 227 | 0,246370435 |
| 8,929E+23 | 1,592E-12 | 228 | 8,85E-31 | 299792458,4 | 228 | 0,40050596 |
| 1,138E+24 | 2,03E-12 | 229 | 6,94E-31 | 299792458,1 | 229 | 0,651072443 |
| 1,452E+24 | 2,588E-12 | 230 | 5,44E-31 | 299792457,7 | 230 | 1,058399677 |
| 1,851E+24 | 3,299E-12 | 231 | 4,27E-31 | 299792457,1 | 231 | 1,720560968 |
| 2,360E+24 | 4,207E-12 | 232 | 3,35E-31 | 299792456 | 232 | 2,796986938 |

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|-----------|-----------|-----|----------|-------------|-----|-------------|
| 3,009E+24 | 5,363E-12 | 233 | 2,63E-31 | 299792454,3 | 233 | 4,546851754 |
| 3,836E+24 | 6,838E-12 | 234 | 2,06E-31 | 299792451,4 | 234 | 7,391475677 |
| 4,891E+24 | 8,719E-12 | 235 | 1,62E-31 | 299792446,8 | 235 | 12,01576704 |
| 6,236E+24 | 1,112E-11 | 236 | 1,27E-31 | 299792439,3 | 236 | 19,53312951 |
| 7,951E+24 | 1,417E-11 | 237 | 9,93E-32 | 299792427 | 237 | 31,7535392 |
| 1,014E+25 | 1,807E-11 | 238 | 7,79E-32 | 299792407,2 | 238 | 51,61933517 |
| 1,292E+25 | 2,304E-11 | 239 | 6,11E-32 | 299792374,9 | 239 | 83,9136501 |
| 1,648E+25 | 2,938E-11 | 240 | 4,79E-32 | 299792322,4 | 240 | 136,4120439 |
| 2,101E+25 | 3,746E-11 | 241 | 3,76E-32 | 299792237 | 241 | 221,7546079 |
| 2,679E+25 | 4,776E-11 | 242 | 2,95E-32 | 299792098,3 | 242 | 360,4892506 |
| 3,416E+25 | 6,089E-11 | 243 | 2,31E-32 | 299791872,8 | 243 | 586,018795 |
| 4,355E+25 | 7,763E-11 | 244 | 1,81E-32 | 299791506,2 | 244 | 952,6427261 |
| 5,552E+25 | 9,898E-11 | 245 | 1,42E-32 | 299790910,2 | 245 | 1548,629056 |
| 7,079E+25 | 1,262E-10 | 246 | 1,12E-32 | 299789941,3 | 246 | 2517,461635 |
| 9,026E+25 | 1,609E-10 | 247 | 8,75E-33 | 299788366,4 | 247 | 4092,373323 |
| 1,151E+26 | 2,052E-10 | 248 | 6,86E-33 | 299785806,3 | 248 | 6652,465544 |
| 1,467E+26 | 2,616E-10 | 249 | 5,38E-33 | 299781644,9 | 249 | 10813,88889 |
| 1,871E+26 | 3,335E-10 | 250 | 4,22E-33 | 299774880,9 | 250 | 17577,9399 |
| 2,385E+26 | 4,252E-10 | 251 | 3,31E-33 | 299763887,3 | 251 | 28571,47097 |
| 3,041E+26 | 5,422E-10 | 252 | 2,6E-33 | 299746022 | 252 | 46436,8097 |
| 3,878E+26 | 6,913E-10 | 253 | 2,04E-33 | 299716995,5 | 253 | 75463,25616 |
| 4,944E+26 | 8,813E-10 | 254 | 1,6E-33 | 299669851,4 | 254 | 122607,4307 |
| 6,304E+26 | 1,124E-09 | 255 | 1,25E-33 | 299593323,2 | 255 | 199135,6054 |
| 8,037E+26 | 1,433E-09 | 256 | 9,85E-34 | 299469208,2 | 256 | 323250,647 |
| 1,025E+27 | 1,827E-09 | 257 | 7,74E-34 | 299268208 | 257 | 524250,7981 |
| 1,307E+27 | 2,329E-09 | 258 | 6,08E-34 | 298943456,6 | 258 | 849002,2472 |
| 1,666E+27 | 2,97E-09 | 259 | 4,79E-34 | 298420729,9 | 259 | 1371728,879 |
| 2,124E+27 | 3,786E-09 | 260 | 3,77E-34 | 297584349 | 260 | 2208109,823 |
| 2,708E+27 | 4,827E-09 | 261 | 2,99E-34 | 296258598 | 261 | 3533860,83 |
| 3,453E+27 | 6,155E-09 | 262 | 2,38E-34 | 294187233 | 262 | 5605225,776 |
| 4,402E+27 | 7,848E-09 | 263 | 1,9E-34 | 291019814,5 | 263 | 8772644,293 |
| 5,613E+27 | 1,001E-08 | 264 | 1,54E-34 | 286322952,6 | 264 | 13469506,21 |

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|-----------|-----------|-----|----------|-------------|-----|-------------|
| 7,156E+27 | 1,276E-08 | 265 | 1,27E-34 | 279640116,9 | 265 | 20152341,88 |
| 9,124E+27 | 1,627E-08 | 266 | 1,06E-34 | 270608880,5 | 266 | 29183578,3 |
| 1,163E+28 | 2,074E-08 | 267 | 9,09E-35 | 259100076 | 267 | 40692382,81 |
| 1,483E+28 | 2,644E-08 | 268 | 7,95E-35 | 245301736 | 268 | 54490722,77 |
| 1,891E+28 | 3,371E-08 | 269 | 7,12E-35 | 229690345,4 | 269 | 70102113,39 |
| 2,411E+28 | 4,298E-08 | 270 | 6,49E-35 | 212908447,4 | 270 | 86884011,41 |

In red – approximate value.

Porto, 2/11/2011

José Luís Pereira Rebelo Fernandes