One Kg

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Abstract

In this paper, we summarize a series of known and less-known things about one Kg.

Key Words: Kg, kilogram, fundamentals.

Things You Know and Did Not Know about One Kg

- 1797: The kilogram mass (kg) was introduced as the standard mass in France. Similar mass standards were adopted in England. The kg is a human-chosen clump of matter. Since weight was important for trade and science, it made sense to choose a standardized mass that was not too heavy to carry around, but not so light that it would make a weighing apparatus inaccurate for practical purposes. The one kg measure fit those requirements very well.
- 1875: The Metre Convention was signed in 1875.
- 1879: The Metre Convention led to the production of The International Prototype of the Kilogram (IPK) in 1879.
- 2019: The kg was redefined in terms of the Planck constant using a Watt balance, see [1–3].
- The rest-mass energy of one kg is: $E = mc^2 = 1\ kg \times c^2 = c^2 = 8.99 \times 10^{16} J$, which is approximately 2.5×10^{10} KwH.
- Half of the Schwarzschild radius of one kg is $\frac{1}{2} r_s = \frac{G \times 1\ kg}{c^2} = \frac{G}{c^2} \approx 7.44 \times 10^{-28}$ meters.
- The reduced Compton wavelength of one kg is $\bar{\lambda}_{1kg} = \frac{\hbar}{1kg \times c} = \frac{\hbar}{c} \approx 3.51 \times 10^{-43}$ meters. A one kg mass is a composite mass, so in reality, it does not have a Compton wavelength, but it consists of a massive amount of subatomic particles that do have Compton wavelengths. The reduced Compton wavelength of one kg is the sum of the following elements in the formula $\bar{\lambda}_{1kg} = \frac{1}{\sum_i^n \frac{1}{\bar{\lambda}_i}} \approx 3.51^{-43}$ meters. For the Compton wavelength, is this multiplied by 2π.
- There are about 5.98×10^{26} protons in one kg.
- The mass of one kg corresponds to the mass of about 1.097×10^{30} electrons.
- There are $\frac{c^2}{\hbar} \approx 8.52 \times 10^{50}$ internal collisions between indivisible particles in one kg per second, see [4]. This is equal to the reduced Compton frequency inside one kg per second because we have $f = \frac{c}{\bar{\lambda}} = \frac{c}{\frac{\hbar}{1kg \times c}} = \frac{c^2}{\hbar}$. This also gives us deeper insight on the Planck constant, which is linked to one collision relative to the number of collisions in one kg per second. In other words, $\hbar \approx \frac{1}{8.52 \times 10^{50}}$.
- There are $\frac{c^2}{\hbar} \times t_p \approx 45994327$ internal collisions between indivisible particles in one kg per Planck second (Planck time), see [4]. This is equal to the reduced Compton frequency inside one kg per Planck second, $\frac{c}{\bar{\lambda}_{1kg}} t_p \approx 45994327$. The Compton frequency per Planck time is $\frac{c^2}{h} \times t_p \approx 7320225$.
- The reduced Compton frequency per Planck time for one kg is also given by $N = 1kg \times \sqrt{\frac{G}{\hbar c}} = \sqrt{\frac{G}{\hbar c}} \approx 45994327$, this means we also have $N = \frac{l_p c}{\hbar} \approx 45994327$. One divided by this is the Planck mass, which is no surprise if we look at the Planck mass formula: $m_p = \sqrt{\frac{\hbar c}{G}}$. Further, the Compton frequency per Planck time is given by $N = 1kg \times \sqrt{\frac{G}{2\pi h c}} = \sqrt{\frac{G}{2\pi h c}} \approx 7320225$. On a side note, the reduced Compton frequency of any mass per Planck time is given by $f = m\sqrt{\frac{G}{\hbar c}} = \frac{m l_p c}{\hbar}$. For masses smaller than a Planck mass, it is less than one, and should then be considered a probability.

- One kg corresponds to the mass of approximately 45,994,327 Planck masses ($1/m_p$). Half of the Schwarzschild radius is given by this number multiplied by the Planck length.
- The orbital velocity of one kg, $v_{o,1kg} = \sqrt{\frac{G}{r}}$, at a radius equal to $r = 45994327 \times l_p$ is the speed of light, which is not a big surprise since $45994327 \times l_p = \frac{1}{2} r_s$, where r_s is the Schwarzschild radius.
- One kg has a collision time of $\frac{l_p}{c} \frac{l_p}{\lambda_{1kg}} \approx \frac{7.44 \times 10^{-28} m}{c} = 2.48 \times 10^{-36}$ seconds. This is shorter than one Planck second, can only happen for a composite mass, and one kg is indeed a composite mass. For a better understanding what collision-time is, see [4].
- With a KwH price of 5 cents, the value of the rest-mass energy stored in one kg is 1.25 billon USD. Unfortunately, modern technology is able to extract less than 1% of the energy in matter, and that is from Deuterium-type elements. Antimatter is an exception, but far from easy to produce in any sizable quanta. However, if we knew a simple way to convert all rest-mass to energy based on simple calculations from $E = Mc^2$, then that would be the potential value at that energy price. Think about that next time you call one kg dirt for a peach of dirt!
- There is a great movie about the kg with title 1001 gram. A creative place to start for more knowledge of the kg.

References

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