Finding the Planck Length From Electron and Proton Fundamentals

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We suggest a way to find the Planck length by finding the Compton wavelength of the electron from Compton scattering, and then measuring the proton-electron ratio using cyclotron frequency. This gives us the Planck length using a Cavendish apparatus with no knowledge of Newton's gravitational constant. The Planck length is indeed important for gravity, but Newton's gravitational constant is likely a composite constant.

I. INTRODUCTION

In 1899, Max Planck [1, 2] introduced what he called the 'natural units': the Planck mass, the Planck length, the Planck time, and the Planck energy. He derived these units using dimensional analysis, assuming that the Newton gravitational constant, the Planck constant, and the speed of light were the most important universal constants. The Planck formula for the Planck length is given by

$$l_p = \sqrt{\frac{G\hbar}{c^3}} \tag{1}$$

where G is the Newton's gravitational constant, $\hbar$ is the Planck constant, and c is the speed of light. it has therefore been believed that the Planck length is a derived constant and that Newton's gravitational constant is a more fundamental constant, a view we will challenge here.

Any particle mass can be written as

$$m = \frac{\hbar}{\bar{\lambda}}\frac{1}{c} \tag{2}$$

where $\hbar$ is the Planck constant, $\bar{\lambda}$ is the reduced Compton wavelength, and c is the speed of light. As shown by [3], the electron's mass can be found experimentally from the electron's reduced Compton wavelength. So, now we have the electron mass. Further, all particles with the same charge-to-mass ratio have the same cyclotron frequency. From a cyclotron experiment, we can find the proton-electron mass ratio. For example, [4] measured it to be about

$$\frac{m_P}{m_e} = 1836.152470(76) \tag{3}$$

Thus we know the proton mass. Now assume we are able to count the number of protons and pack them together in a mass (we may use solid hydrogen at ultralow temperatures, or even better, we could use larger atoms that can be packed at room temperature). Assume we count up about $2 \times 5.98 \times 10^{26}$ protons. We then divide the proton mass clump into two masses that we will pack into balls. Next, we use a Cavendish apparatus and place the large balls there; we also have two much smaller balls. Then the following formula in combination with a Cavendish apparatus can be used to find the Planck length

$$l_p = \sqrt{\frac{\hbar L 2\pi^2 R^2 \theta}{MT^2c^3}} \tag{4}$$

where L is the distance between the small balls and R is the distance center to center between the small and large ball. T is the natural resonant oscillation period of a torsion balance, θ is the deflection angle of the balance, and $\hbar$ is the Planck constant. Notice that we never had to rely on the Newton's gravitational constant. Nor did we need to weigh something. The difference between this method and what we have suggested previously [5, 6], is that here we do not need to weigh any mass, in the traditional sense, beforehand. All we need is the electron's Compton wavelength measured through Compton scattering, and then the proton-electron mass ratio from a cyclotron. In addition, we need to know the Planck constant, which we can find from the Watt Balance [7–9].

From the measure Planck length, we can calculate the gravitational constant, as $G = \frac{l_p^2 c^3}{\hbar}$, as suggested by [10], see also [11, 12]

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