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Conservation of quality factor for superconducting cavity and heartbeat under relativistic motion

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Abstract

The conservation of quality factor under relativistic motion is applied to the superconducting cavity as well as the heartbeat of mammal. The quality factor of the superconducting cavity is conserved under relativistic motion. The frequency of the cavity decreases and the decay time increases as the velocity and acceleration are increased. The quality factor of the superconducting cavity is comparable with the total heartbeat of the mammal. The quality factor for the heartbeat of the mammal representing the total number of heartbeat is also conserved under relativistic motion. Therefore, the heart rate is inversely proportional to the life expectancy under relativistic motion.

Frequency-Energy relation

We can postulate the conservation of frequency-energy relation. The product of the frequency and energy for a particle is conserved as

$$E(i)f(i) = \text{constant}$$

$$E(0)f(0) = E(x)f(x) = E(v)f(v) = E(a)f(a)$$

Doppler effect

The frequency for constant velocity in reference frame is shifted to

$$f(v) = f_o\sqrt{1-(v/c)^2}$$

The frequency for constant acceleration in reference frame is shifted to

$$f(a) = f_o\sqrt{1-(2ax/c^2)}$$

Energy for motion

The frequency-energy relation for constant velocity is

$$E(v) = E(0)\frac{f(0)}{f(v)}$$

The energy for constant velocity can be expressed as

$$E(v) = \frac{m_o c^2}{\sqrt{1-(v/c)^2}}$$

The frequency-energy relation for constant acceleration becomes

$$E(a) = E(0)\frac{f(0)}{f(a)}$$

The energy for constant acceleration can be expressed as

$$E(a) = \frac{m_o c^2}{\sqrt{1-\frac{2ax}{c^2}}}$$

Energy conservation

Let us think that a rest mass locates at the height of h and it falls down to the ground under gravity acceleration. From the frequency-energy relation we can get

$$\frac{m_o c^2}{\sqrt{1-(\frac{v}{c})^2}} = \frac{m_o c^2}{\sqrt{1-\frac{2gh}{c^2}}}$$

$$v^2 = 2gh$$

Energy is conserved from potential energy to kinetic energy.

Quality factor of a superconducting cavity

The intensity of the radio frequency of the cavity decreases as follows

$$I = I_o e^{-\frac{2\pi f t}{Q}}$$

The quality factor for the superconducting cavity is measured as follows

$$Q = \frac{2\pi f \tau_{3.01dB}}{\ln 2}$$

Quality factor is expressed as follows

$$Q(0) = \frac{E}{\Delta E} \qquad Q(v) = \frac{E\sqrt{1-(v/c)^2}}{\Delta E\sqrt{1-(v/c)^2}} \qquad Q(a) = \frac{E\sqrt{1-(2ax/c^2)}}{\Delta E\sqrt{1-(2ax/c^2)}}$$

The quality factor is conserved for constant velocity and acceleration.

The frequency and decay time for constant velocity and acceleration are

$$f(v) = f(0)\sqrt{1-(\frac{v}{c})^2} \qquad \tau(v) = \frac{\tau(0)}{\sqrt{1-(\frac{v}{c})^2}} \qquad f(a) = f(0)\sqrt{1-\frac{2ax}{c^2}} \qquad \tau(a) = \frac{\tau(0)}{\sqrt{1-\frac{2ax}{c^2}}}$$

The resonance frequency for the cavity is inversely proportional to the decay time for the conserved quality factor.

Quality factor for heartbeat

The quality factor showing the total number of the heartbeat for constant velocity and acceleration can be expressed as

$$f_{heart}(0)t_{life}(0) = 3\times10^9$$

$$f_{heart}(v) = f_{heart}(0)\sqrt{1-(v/c)^2} \qquad t_{life}(v) = \frac{t_{life}(0)}{\sqrt{1-(v/c)^2}} \qquad f_{heart}(a) = f_{heart}(0)\sqrt{1-(2ax/c)^2} \qquad t_{life}(a) = \frac{t_{life}(0)}{\sqrt{1-(2ax/c)^2}}$$

The total number of the heartbeat is not changed by motion. The heart rate is inversely proportional to the lifespan of the mammal for constant velocity and acceleration. Therefore, the quality factor of the cavity and the heartbeat is conserved, which shows the total number of the heartbeat is conserved for the rest, the constant velocity, and the constant acceleration.

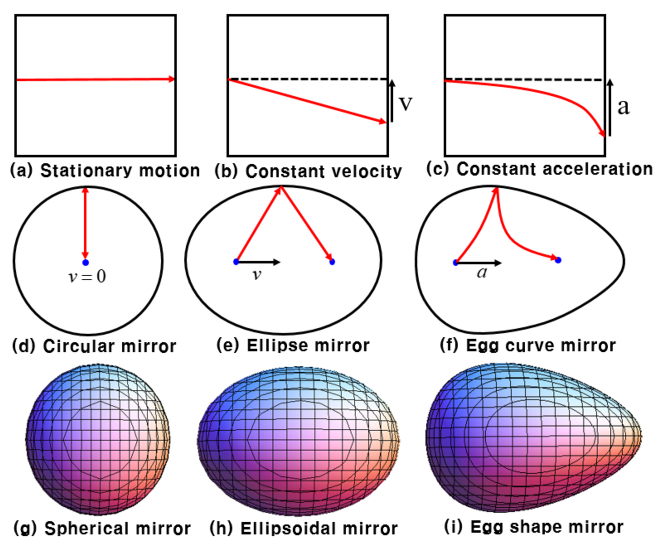

Figure 1: Light mirror. (a), (b), and (c) show the light path in one-dimensional motion for stationary motion, constant velocity, and constant acceleration, respectively. (d), (e), and (f) show the light paths and light clocks for two-dimensional motion. (d) circular mirror for stationary motion, (e) elliptical mirror for constant velocity, and (f) egg curve mirror for constant acceleration. (g), (h), and (i) show the light clock for three-dimensional motion. (g) spherical mirror for stationary motion, (h) ellipsoidal mirror for constant velocity, and (i) egg shape mirror for constant acceleration.

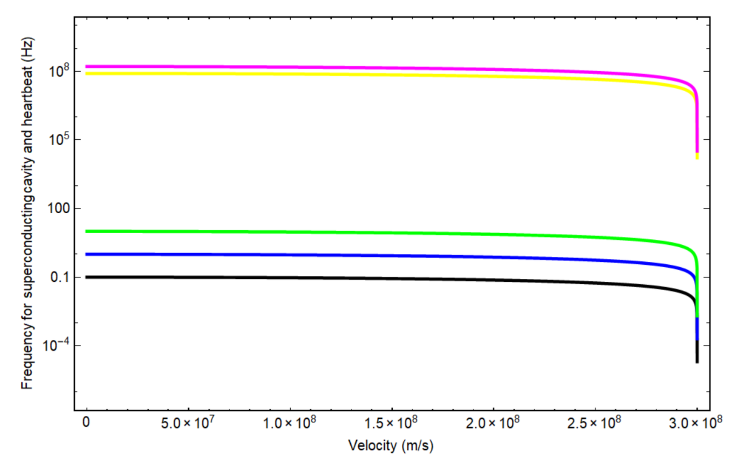

Figure 2: Frequency for the superconducting cavity and heartbeat as a function of velocity. The frequencies for 0.1, 1, and 10 Hz correspond to 6, 60, and 600 beats/min, respectively. The other two frequencies correspond to the QWR resonance frequency of 81.25 MHz and the HWR resonance frequency of 162.5 MHz, respectively. The quality factors for the cavity and the heartbeat of the mammal are almost the same. The resonance frequency for the cavity and heartbeat decreases as the relative velocity is increased. Because of the quality factor conservation, the decay time of the cavity is inversely proportional to resonance frequency and the life expectancy of the mammal is also inversely proportional to the heart rate.

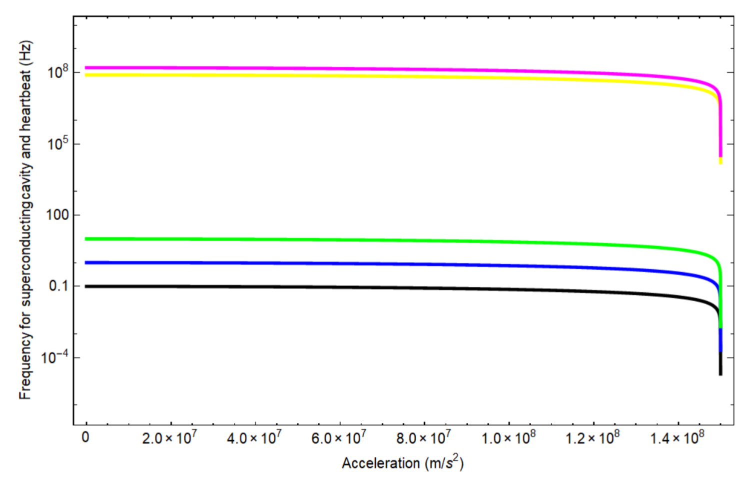

Figure 3: Frequency for the superconducting cavity and heartbeat as a function of acceleration. The resonance frequency for the cavity and the heartbeat of the mammal decreases as the acceleration is increased. Because of the quality factor conservation, the decay time of the cavity is inversely proportional to resonance frequency and the life expectancy of mammal is also inversely proportional to the heart rate.

Summary

- ☐ Frequency-energy relation is introduced.
- ☐ Doppler effect, energy for motion, and energy conservation are shown.
- ☐ The quality factor for the superconducting cavity is conserved.
- ☐ The quality factor for the heartbeat of mammal is conserved.
- ☐ Light paths in light mirrors are presented.
- ☐ The frequency and heat rate are shown as a function of velocity.
- ☐ The frequency and heat rate are shown as a function of acceleration.