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P1_9 Reversing Gravity

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Abstract

In the year 2000, Andre Geim and Michael Berry won the Ig Nobel Prize for levitating a live frog by using its own induced magnetic field. This discovery, which was found to contradict Earnshaw's theorem, was living proof of the potential for living organisms to interfere with the unbending law of gravity. In this paper, we investigate the possibility for the effect of gravity to be reversed.

Introduction

Over the past two decades, certain video-game characters such as "Sonic the hedgehog" or "gravity guy" have explored the ability to run upside down in a sustained way that defies common sense. The means by which many of these video games explore this phenomenon are often not well thought through. For example, if the character Sonic ran upside down thanks to his shoes being physically attracted to the ceiling, his blood circulation would still be dangerously constrained towards his head for long periods of time and his arms would have to continuously fight gravity to remain by his sides. As it turns out, a famous experiment has been carried out in which a live frog was successfully levitated by a powerful magnetic field [1]. As such, we explore the possibility for humans and animals to walk upside down - as if gravity were reversed - using a large and powerful magnetic field in an empty room. The field would have to be uniform and counteract the force of gravity by just the right amount so that an acceleration of $9.807m/s^2$ is felt in the opposite direction, allowing a person to walk, jump and interact as if gravity itself were acting away from the centre of Earth.

Theory and Results

The properties of diamagnetism result in the opposition of external magnetic fields. This is due to the creation of small magnetic fields that are induced by the external field and which persistently align in the opposite direction due to quantum orbital effects. This effect is very weak and only dominates in materials with a magnetic susceptibility $\chi_m < 0$ which we call diamagnetic. Most living mammals can be considered "diamagnetic" since they primarily consist of diamagnetic molecules or components (water, proteins, bones etc). In a non-uniform magnetic field resulting from an infinitesimal solenoid [2], the force of the field B and the magnetic moment M in 3D can be expressed as:

$$\boldsymbol{F} = \nabla(\boldsymbol{M}.\boldsymbol{B}) \quad (1)$$

$$or \quad F = M(\frac{\partial B}{\partial x} + \frac{\partial B}{\partial y} + \frac{\partial B}{\partial z}) \quad (2)$$

The magnetic force has to be twice as strong and in the same axis z as gravity. If we express the force required and the magnetisation [2] of a body due to an external field as:

$$F_{reversal} = 2 \times F_{gravity} = 2\rho V g \quad (3)$$

$$and\ M = \frac{\chi_m B V}{\mu_0}\ where\ \frac{dB}{dz} = B'(z) \quad (4)$$

Then, equating (2) to (3) in 1D, we get:

$$B\frac{dB}{dz} = \frac{2\mu_0 \rho g}{\chi_m} \quad (5)$$

The body of an average healthy man is composed of roughly 62% water and 16% protein [3], and since these substances are independent (unlike bone and fat), we approximate the human body to be 80 percent water ($\rho = 1kg/m^3$, $\chi_m =$ -9.035 x 10^{-6}), and 20 percent protein ($\rho = 1.35kg/m^3$, $\chi_m =$ -9.726 x 10^{-6}), and hence use a mean density of $1.07kg/m^3$ and a mean magnetic susceptibility of $\chi_m =$ -9.173 x 10^{-6}. While the magnetic field inside a solenoid is constant, its magnitude begins to drop and its direction around the central axis begins to diverge past the point of inflection, as seen in figure 1. Thus, the relatively large height of a person would require them to be located inside the solenoid in order to experience a fully uniform field analogous to gravity. As such, we set a height of 2.43m, similar to a typical room, for our solenoid. The point of inflection z_i of a thin solenoid of length L and with a field B_c at the center is situated at $L/2$ from the center. At that inflection point, we can approximate $B\frac{dB}{dz} \approx B_c^2/L$ [1]. Making use of this relation with (5) allows us to derive a central magnetic field of 83 Tesla for the desired "reversal" effect of gravity on a human adult. This field strength is far from achievable with today's technology[4]. A more feasible solution would be to reduce the length of the solenoid to reduce the required field strength. In addition, if we increase the radius of the solenoid, we reduce the effects of field divergence past the point of inflection and allow for a smaller sized solenoid to still produce a fairly uniform reversal of gravity beyond z_i. A length of $L = 0.7m$ for example, would bring B_c down to a much more feasible 44.86T [4] at the expense of a slightly less uniform field for the size of a human. Nevertheless, this would be the perfect size for a child, a young chimpanzee, or even an Emperor tamarin. We further note that our solenoid would have to be solid enough to withstand 44.86T. We can currently only achieve such high fields with the use of bitter solenoids. Their main disadvantages are that they require very high drive currents and dissipate large quantities of heat. A more efficient set-up might involve purely super-conducting magnets, though these require intense engineering efforts to surpass 20T and are thus not viable yet [5].

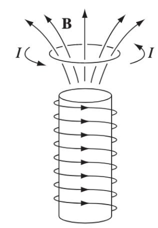

Figure 1: Example solenoid with a magnetic field moving in the positive z direction [2]

Conclusion

The possibility for children, young monkeys or other small animals to walk upside down is not unrealistic, although state of the art technology is required to create the extreme magnetic fields that we need.

References

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