Journal of Physics Special Topics

A3_3 Pandora's Floating Mountains

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October 16, 2014

Abstract
The mountains in the film "Avatar" are shown to naturally float in the air, unaided by mechanical flight. This paper discusses whether this phenomenon could be created by the mountains containing superconducting materials and floating on the planet's Earth-like magnetic field. The results show that a much larger field would be needed to float any material of a substantial size, so the effect is probably not caused by this method.

Introduction

The floating mountains of Pandora in the film Avatar are shown to be free floating mountains, not aided by any mechanical flight mechanisms. The presence of these floating mountains could be attributed to many naturally occurring effects. This paper discussed the possibility of mountains floating due to the presence of superconducting materials within them, causing them to float on the planet's Earth-like magnetic field. The strength of magnetic field will be calculated for varying sizes and flight altitudes of mountain, as in the film the mountains are shown to be floating over a range of altitudes.

Theory

Superconductors can float due to the effect of magnetic pressure [1]:

$$P_{mag} = \frac{B^2}{2\mu_0}, \quad (1)$$

where B is the magnetic field strength and μ_0 is the vacuum permeability.
This pressure results in a force on the object; this force has to be equalled by the object's weight to cause it to float:

$$F = \frac{B^2 A}{2\mu_0} = mg, \qquad (2)$$

where A is the surface area, taken to be 100m^2 for all calculations, m is the mass of the object and g is the acceleration due to gravity taken to be the same as Earth as there appears to be no difference from Earth gravity shown in the film.

The strength of the magnetic field will become weaker further away from the planet's surface. Pandora is shown to be a very Earth-like planet [2] so we consider the field to behave as a dipole, the same way as Earth's magnetic field. The decrease in field due to distance is given by [3],

$$B = \frac{\mu_0}{4\pi}\frac{m}{r^3}\sqrt{1 + 3\sin^2\gamma} \quad (3).$$

Where m is the dipole moment, which for Earth is approximately 4×10^{22}Am^2 [4], γ is the magnetic latitude which is taken to be 90^0 to maximise the field. All other symbols have their usual meaning.

Rearranging equation 2, the mass of object that can be floated by different field strength can be found.

$$m = \frac{B^2 A}{2g\mu_0} \quad (4)$$

Discussion

Calculating the changing magnetic field, then converting each field strength into a floatable weight, gives the plot shown in figure 1. The plot of height from the centre of the planet using the same radius as that of Earth shows that with a similar magnetic field to Earth, only very small rocks (approximately 0.001kg) could be floated at the surface; and that as the height increases, the weight that could be lifted drops off very quickly to microscopic particles.

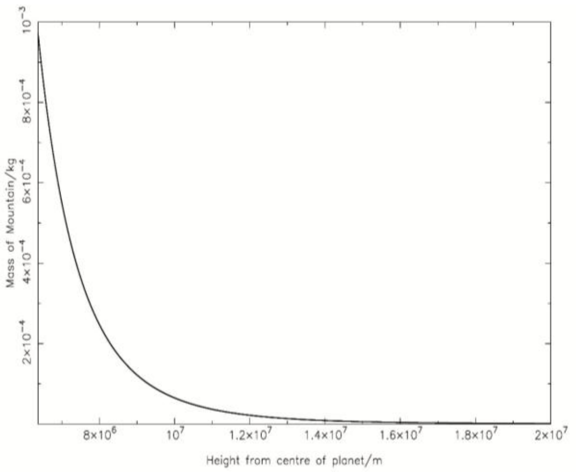

Figure 1 Plot of height vs mass of mountain

A much larger field with a much higher magnetic dipole moment would be required to float objects of a substantial weight.

For a typical large rock size of 100 tonnes the required magnetic field, found rearranging equation 4, is seen to be 0.157T at the surface. This number is 4 orders of magnitude higher than at the Earth's surface magnetic field, meaning a huge increase in magnetic field is required to float a large rock.

Conclusion

It has been shown that the magnetic field of Pandora would have to be much stronger in order to create the effect of floating mountains shown in the film by magnetic levitation. Therefore if this effect is entirely natural, some other mechanism must be behind the phenomenon as the magnetic field required to produce the effect could cause many problems for the planet and its inhabitants.

References

[1]http://en.wikipedia.org/wiki/Magnetic_levitation
Accessed on 15/10/2014
[2]http://james-camerons-Avatar.wikia.com/wiki/Pandora
Accessed on 15/10/2014
[3]http://en.wikipedia.org/wiki/Dipole
Accessed on 15/10/2014
[4]http://en.wikipedia.org/wiki/Earth's_magnetic_field
Accessed on 15/10/2014