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P4_4 Travelling by Teleportation.

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Abstract

Teleportation of human beings is often featured in science fiction as being a marvel of transportation, instantaneously moving people large distances. This paper investigates the time and energy requirements for the data transfers required to teleport a human being. It is concluded that the data needed to fully map a human brain is so high that the time taken for a 0.5GHz bandwidth is 4.85×10^{15} years, making teleportation impractical.

P4_1 Travelling by teleportation.

Introduction

Teleportation has long been a staple of science fiction for transporting people over large distances very quickly. Star Trek made significant use of teleportation in many of the iterations of the show. The transporter sends the data wirelessly and will send it through atmosphere on a regular basis. This paper aims to calculate the power and time requirements to send the data needed to teleport a human being. For this investigation the transfer will be assumed to be from a location on the Earth's surface to a space station in geostationary orbit directly above it.

Human Data

To begin the teleportation process, every human that is teleported will need to be represented in transferable data. A human, at the basic level, is represented by the DNA pairs that make up the genomes in their cells. There are 4 possible combinations for DNA pairs [1], which when represented in binary data can be given by a minimum of 2 bits. For each human genome there are approximately 3 billion base pairs [1] giving a total data for a human genome of 6×10^{9} bits (b).

Human beings are diploid organisms [1] meaning that there are two genomes per cell and so each cell has a data value of 1.2×10^{10}b.

A cell contains enough information to replicate any other type of cell in the body. Therefore in this paper it is assumed that only the information of one cell is needed to rebuild the person physically. Mentally rebuilding a person is not as simple, as a full information transfer of the traveller's brain is required. The Bekenstein Bound Theorem allows for the calculation of the maximum amount of data to recreate the human brain on a quantum level. The value given by this is $\approx 2.6 \times 10^{42}$b [2]. Unfortunately errors can occur when sending data due to interference from noise. When rebuilding a human, an error in the data could potentially lead to deadly consequences so error prevention must be taken seriously. The assumption for this paper is that the minimum effort that will prevent fatal errors is using a (7,4) Hamming code[3], which brings up the total data for the subject to 4.55×10^{42}b.

Transportation time

The time t for transporting the data will be the amount of data D divided by the data transfer rate r plus the lag time; which will be the distance the information travels x divided by the speed of light c:

$$t = \frac{D}{r} + \frac{x}{c} \quad . \qquad (1)$$

The data transfer rate will be the amount of data per signal (d) times the signal rate (S):

$$r = dS = d\sum\frac{\nu}{2} \quad , \qquad (2)$$

where ν is the frequency of the signal and it is assumed that the transmitter and receiver are capable of reaching the Nyquist sampling limit (the maximum data sampling rate is equal to half of the signal frequency).

Assuming the bandwidth used is 29.5-30GHz, from the high end of Super High Frequency (SHF) range (3-30GHz), and using 1 signal stream per Hz gives $7.4\text{x}10^{18}$signal/s. The proposed data signalling method is Quadrature Phase Shift Keying (QPSK); which allows for four possible binary combinations (00, 01, 10, 11), i.e. 4 bits per signal. Using QSPK and a bandwidth of 29.5-30GHz would give a data transfer rate of $2.977\text{x}10^{19}$b/s. This data transfer rate would still require around $4.85\text{x}10^{15}$ years. Due to the large data transfer times, the speed that information has to travel is negligible.

Power requirements

While the speed of transit is very important when considering transportation, power is also a crucial criterion that must be considered. To calculate the power requirements of communication, one must work backwards making sure the received power is high enough to overcome the noise induced in transmission. A Signal to Noise Ratio (SNR) of 1000 is considered to be a very good signal strength [4] and so will be used for this investigation. The formula for SNR is:

$$SNR = \frac{P_{signal}}{P_{noise}} \quad , \qquad (3)$$

where P_{signal} is the power of the signal received and P_{noise} is the power of noise at the receiver; which are given by [5]:

$$P_{signal} = \frac{P_t G_A G_t}{\left\{\sum_f [\left(\frac{4\pi x f}{c}\right)^2]\right\} L} \quad , \qquad (4)$$

$$P_{noise} = kTB \quad , \qquad (5)$$

where P_t is the transmitter Power, G_a is the antenna gain, and G_t is the transmitter gain L is the line loss, T is the equivalent noise temperature, B is the bandwidth and k is Boltzmann's constant. Substituting in equations (4) and (5) into (3) then rearranging for signal power gives:

$$P_t = \frac{\left\{\sum_f \left[\left(\frac{4\pi x f}{c}\right)^2\right]\right\} L}{G_A G_t} SNR.kTB \quad . \qquad (6)$$

Assuming that the line loss is negligible for the frequency band used (L≈1) and assigning values of 30K for T, 10W for G_r and G_t, subbing in the values for the Boltzmann constant and the previously used bandwidth ($5\text{x}10^8$Hz); using the computer program R to compute the summing of equation 6 gives a required transmitter power of 1600W = 5.76MWhrs.

Conclusion

The requirements discussed in this paper illustrate that quick teleportation is beyond our means, and will be for a very long time. The energy requirement to send one person is shown to be dependent upon bandwidth, which means a decrease in time creates an increase in power consumption. Therefore, quick and energetically cheap teleportation is beyond the capability of current data transmission techniques.

References

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