The Physics of Cables – An Overview

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Abstract: It is shown that the physics of cables can not be described by classical physics. From experimental results it can be demonstrated that the general behaviour of cables is different between an observed state and an unobserved state. In the unobserved state entanglement of cables happens routinely. Following the description of experiments demonstrating this point, a short outlook on the phenomenology of cables is presented discussing topology and energetics. It is then argued that the physics of cables is connected to the thermodynamics of an extradimensional space (altroverse) which produces as one observable effect the cosmological constant. Connections to cold dark matter will also be discussed.

I. Introduction

It is generally acknowledged that cables do not obey classical physics. This is obvious to anybody who tried for minutes or hours to disentangle cables[1] which a short time before had been arranged in perfect order. While this seems to be a manifestation of the second law of thermodynamics, i.e. an expected entropy increase, a short inspection of this assumption shows that this cannot be the case[2]. While cables are or at least can be certainly in a thermodynamical equilibrium with their respective environment, the typical forces excerpted by for instance air molecules on a typical cable are far too weak to explain such an effect. With masses of grams to kilograms, cables should be expected to be in the groundstate relative to their macroscopic environment at least on timescales of days to years. And yet unexplained movements and entanglements happen to cables in such timescales. In general, the movements are of a nature that is both attractive and increases curvature, even for a single cable. Topologically the formation of nodes and closed pseudoloops is favoured.

It may be argued that these phenomenons are due to quantum mechanical effects, e.g. applying another Planck constant to cables than to the rest of nature. Certainly the connection to observation is intriguing in this case. However, while the creation of the universe may be explained in such a way, a local change of the Planck constant just for cables seems to be arbitrary. Such a change of the Planck constant should have also consequences for the immediate neighbourhood of cables, like desktop computers (typically entangled in cables) suddenly jumping up as a consequence of quantum fluctuations[3].

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1 This is also true for ropes and similar objects. In general, a cable is an object that exceeds a ratio of 50 between length and diameter (or a similar dimensional number). On the atomic and molecular level the physics presented does not hold, owing to often restricted degrees of freedom and the nature of the forces applied. However, there is some evidence that some effects of entanglement also exist on the molecular level, see N. Bryton et al., Nature **80**, 265 (2005). The maximum length of cables for which such entanglement takes place is hard to determine experimentally, because it is difficult to have long cables completely unobserved for any period of time. At the moment cable forces are confirmed for lengths of at least a 100 m.

2 Of course, over a long time like thousands of years cables will disintegrate and thus the 2nd law of thermodynamics remains valid.

3 The quantum jump upwards would be unobservable; however, the descend of the computer and its consequences would be simple Newtonian physics.

I shall argue for a different explanation. While the effect of entangling cables has been known since the electric revolution, little research has been done in this field. Therefore we will have to start out with reviewing existing publications and will then report on our own research; a first step to a more general theory. As the behaviour of cables is of great practical consequences, we will then try to describe in general terms the topology and energetics of cables which will also lead us to a parameter description of this phenomenon. After this we will try to derive the outlines of a theory to explain the dynamics of cables finding a connection to modern cosmology.

II. Experiments

A first and now classical experiment in this field has been performed by B. Brownmeyer et al. (Phys. Rev., **80**, 1133 (1950)) . In this experiment two cables of three meters length were laid out parallel (within 1 cm precision) on a smooth floor with 1 m distance between the cables. The setup was done in a room which could be perfectly sealed against observation (no windows or other observational possibilities, one door only). In the first experiment, the door was closed and sealed and the light extinguished. Temperature and humidity in the room were controlled, no earthquake exceeding Richter 2.5 was recorded in all the experiments. After two weeks, the seal on the door was broken and the room inspected. As expected the two cables were wildly entangled and knotted up. In a second experiment, the previously opaque door was replaced with a glass door and the light in the room left on. This time the cables were observed permanently (requiring strict discipline for the graduate students). As expected nothing happened to the cables. While B. Brownmeyer et al. could only speculate about the nature of their observation, their seminal article was unfortunately largely ignored. A follow-up article was published two years later (B. Brownmeyer et al. (Phys. Rev., **82**, 672 (1952))). Additional literature search on our part produced only anecdotal, but plenty of evidence of these common features of cables. No other peer reviewed publications on experimental cable physics are known to us.

To further investigate this issue, we[4] refined the Brownmeyer experiment. We used six adjoining rooms[5] of the same dimensions in which set ups were randomly permuted for these experiments. As in the Brownmeyer experiment the rooms were sealed and temperature and humidity controlled. As previously earth movements and oscillations were recorded (and turned out to be irrelevant). In extension of the Brownmeyer experiment the rooms were constantly lighted. Four cameras in each room transmitted permanently signals to the outside world. This signals were either recorded (observation) or not recorded (no observation). In short, geometry and energetics of each room was as identical as possible.

In a first step we repeated Brownmeyer's experiment, however in six rooms simultaneously for two weeks under non observant conditions. The result was as expected: all pairs of cables were entangled and twisted. Furthermore, it could be immediately observed that these entanglements, twists and knots were unequal in all cases, the process was certainly at random, and, as we explain later, apparently thermodynamically induced. In a control experiment we recorded observing camera signals (no immediate human involvement was necessary) continuously (observing state). Nothing happened in the two weeks to the cables as one might expect. It can be concluded that observation is an objective state not dependent upon the presence of humans.

4 The experimental group is named in L.Buchmann et al., Phys. Rev. A, **45**, 365 (2001).

5 We wish to thank our local telephone company (Telus) for making this experiment possible.

We then varied observational times. In a first round we did the two weeks non observational experiment. As previously, we observed then and found the cables entangled[6]. Then we switched to non observational mode again. for two weeks and observed thereafter. We found that only slight changes to the cable entanglements had occurred. From this, we concluded that within two weeks the cables reach the state of maximum entropy with not much further changes possible. Indeed, in the history of mankind it has never been observed that a twisted and knotted cable has straightened out itself. In this, the 2[nd] law of thermodynamics is observed.

We went through other variations of the experiment: Varying the number of cables does not change the principal outcome. In particular, also a single cable can twist up, pointing to self energy imposed onto the cable. Furthermore we fixed cables on one end or both ends. We found that the length of a cable is conserved in the process under discussion and that posing boundary conditions restricts the possible movement of the cable. However, if there is length to spare[7], the cables will entangle. This was found to depend also on the mechanical properties of the cables. Some of these relations, we will discuss in the next section.

All experiments were done in two dimensions on the floor, as, at this stage, we did not wish to complicate our observations by including three spacial dimensions and gravity.

We then varied observational and non-observational times systematically and at random. We find two distributions: one of the likely occurrence of an entanglement event, and one of the time duration of such an event. The former is peaked at about one day with a steep increase at small times and a slowly falling tail[8]. The latter shows a roughly symmetric distribution around 8 seconds with 4 seconds width. Indeed, if observation and non observation were switched within less than one seconds, no entanglement events could be observed, for somewhat longer times, their occurrences were reduced according to the interval chosen.

Summary of the experimental results:

1. Cable entanglement events only happen under non-observation. The state of observation does not require a conscientious observer, but just recording.
2. Entangled cables will quickly reach a state of maximum entropy.
3. Entanglement happens at random both for the event to happen as well as the duration of the event. The time distributions are described above.
4. The length and number of of cables is conserved in an entanglement event.

III. Energetics and topology of entanglement events

The treatment of cables or idealized one-dimensional strings in classical topology is beyond the mathematical scope of this paper, even if we restrict ourselves to not closed loop cables[9]. However, for practical reasons we will have to give some expressions that allow experimenters and otherwise

6 I will call such an occurrence of twisted up cables from now on 'entanglement event'.
7 Needs further theoretical treatment.
8 For two weeks duration, the likelihood of an entanglement event is 98.3%.
9 The normal functions of cables typically prevent the existence of closed loop cables. However, when forced into a closed loop, the entanglement behaviour is similar as with an open cable, as our experiments show. A loop is not to be confused with a pseudoloop, i.e. the crossing or knotting of a cable by itself forming a loop like structure.

interested parties[10] to reasonably classify and describe cable entanglement with a minimum effort and set of numbers. At first, the length of a cable is a conserved number[11]. Furthermore, there are some simple topological numbers which describe a cable manifold to some degree, first, of course the number of cables and then for each cable the number of crossings, cables crossing other cables or self crossings (pseudoloops) and the numbers of knots. These numbers can then be normalized to the length of the particular cable. Another number to characterize a single cable in a manifold is the integrated curvature D over the cable length defined (in two dimensions) as the path integral of the squared sum of the two derivatives in x and y normalized to the total length of the cable. Thus this number is dimensionless.

To describe the energetics and geometry of cable entanglement we have to study the so called bendebility β of cables. Obviously it requires different kind of forces to bend different kind of cables around a given radius. We define this quantity by the force required to bend a cable in a half circle to a radius R. Thus $\beta=F/R$. However, unenforced cable bend is only possible, if the restoring Hook constant is approximately zero or very small. Thus spring like materials like metal rods do not qualify, and, indeed, such objects are not observed to tangle up[12]. Nevertheless, there is some energy stored in bent cables.

In typical cable entanglements which are close to maximum entropy we find numbers around for each cable:

crossings:	(1-5)/m
knots:	0.01-0.3/m
integrated curvature D:	0.5-3
typical force in bending:	0.1-2 N
bendebility β:	1-20 N/m

Bendebility β and integrated curvature D are correlated roughly linear. So the number $s=D/\beta$ shows less scatter than the other numbers for given classes of cables that actually group around certain values of s. In this article, we will not further discuss these details. A more detailed description with examples can be found in K. Mohler et al., Rev. Scient. Inst., **34**, 286 (2003).

In general, we therefore find 0.5 to a few Joule (~3) needed per meter cable length to cause entanglement, or for an event of 10 s duration a power of 0.05 to 0.3 W. This kind of energy scale explains why other linear objects that take more force to bend do not show a tendency to entanglement. It also explains, why fixed cable boundaries (anchors) are generally conserved. Another obvious fact not stated yet is that entanglement requires varying directional forces over the cable length over the duration of approximately a second. Again this points to some random fluctuations. These observed scales together with the above experimental observations will now form the basis of our general model of cable forces.

10 Often urged by necessity.
11 I do not consider elastic changes of length resulting from high forces.
12 Some other objects like hoses with similar geometry show tendencies of entangling.

IV Cosmological Model of Cable Entanglement

Cables are human artifacts manufactured largely by industry and made to macroscopic dimensions. The only possibility then why cables behave outside of classical mechanics[13](and other objects of similar dimensions not) is that this whole phenomenon is resonant to some force because of the typical and unique mechanical and geometrical properties of cables. As the four standard forces of physics are either too short ranged or too weak (gravity), this can only be the result of strong resonances using a fifth force exerted by structures outside our usual dimensions in a bran like alternate universe. Lately, other multidimensional universes with additional limited or unlimited dimensions have been proposed for example in string theory[14]. They can be directly part of out universe or move close by. To explain cable behaviour one must introduce an additional universe of which we are either part or which is close to us with spacial dimensions five to seven[15]. The major time axis in this universe is assumed to be either shared with ours or is at least linear dependent. Of course, a second time axis, be it limited or unlimited in dimension is possible, but at the moment not necessary.

In this universe (dim. 5-7), named here altroverse, our spacial dimensions 1-3 are limited, in particular they are curled up in strings of cm or meter dimensions[16]. It can be assumed that these strings form a warm gas in the altroverse there floating around in random fashion. In addition, these stings can be assumed have a multitude of excited states like vibrations in one to three dimensions. The energy source of the this gas in the altroverse is likely some force of medium range which leads to energy gains when strings approach each other. One may therefore assume a strong chemical potential between the curled up strings that yet needs to be determined. Likely the initial Big Bang, as in our Universe, did not lead to complete thermalization and left excess energy that is now accessed by this gas[17]. It also has to be that cold matter in large quantities is absent in the altroverse to otherwise prevent gravitational accumulation of these strings. However, because the altroverse is coupled to ours and these strings can be very close to cables in the combined hyperverse, a resonance force exerted by an apparent fifth (pseudo) force existent in both universes can be found between the 1-3 strings in the altroverse and objects in our 1-3 universe. This force must be able to change arbitrarily (though one should look for systematic patterns) directions to produce phenomena like knots in our cables. Fluctuations in the positioning of the hyperstrings by thermodynamical effects and change of excitation by collision in the altroverse explains this easily.

Both universes therefore interact in a weak, but observable way. The gross result of this interaction is that the altroverse results in an expanding space force on our universe, commonly described by the cosmological constant. The reason for this is that both universes never were in thermodynamic equilibrium. It can be safely assumed that the altroverse has a higher energy density and likely a higher mass which leads to the tearing of our spacial dimensions. Thus cable entanglements and the apparent cosmological constant Λ are deeply related and detection should eventually lead to better understanding and determination of the cosmological constant Λ.

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13 I do not consider here additional forces in electric current bearing cables.

14 Strings in elementary particle theory have dimensions of 10^{-35} m, while cables have dimensions of 1 m.

15 Of course, the numbering is arbitrary.

16 We cannot know at this stage if a meter can be defined in the altroverse in the usual way of being a multitude of the wavelength of some atomic transition. Some sort of scaling between the fundamental constants of nature is always allowed. However, the effect is at least as if 1-3 strings in the altroverse were of approximately meter dimensions.

17 Like in our universe nuclear energy in the hot interior of stars.

As a candidate for dark matter we propose that in the altroverse, objects of order of meter length curled up in dimensions 5-7 form dark matter in our universe. These objects both obey gravity and the fifth force which is, however, far shorter ranged. It can be assumed that these objects communicate with the altroverse in some form, so the gravitational effect of this dark matter may be modified. However, such objects will be hard to detect observationally as to their relatively low density and their very weak interactions with standard matter. Luckily a three string resonance between these objects, a hyperstring in the altroverse and cables could be observable. We therefore propose an extended cable detector to measure these effects and get indirect proof of the existence of this form of dark matter.

As a direct observation of cable entanglement is a direct assessment of the altroverse, and as we saw, such an observation is impossible, we may safely assume that indeed Planck's constant is at least different or not even a constant in the altroverse which leaves the hyperstrings also open to quantum uncertainties. Thus any observation forces the wavefunction of the hyperstring in the altroverse to collapse preventing cable entanglement.

V. Conclusion

We have shown experimentally that cables indeed show a nonclassical, non-Newtonian behaviour. We have presented several observations that show patterns of the movements of cables demonstrating spontaneous entanglement behaviour at a time of non-observation[18]. At the moment we are developing parameters based on topological considerations that describe entangled cables in practical terms of a general classification. We have started to derive these parameters automatically from several camera images so that the present human classification can be shortened in time and a machine based cable detector can be built. However, even this step in technology requires massive parallel computing.

While the various movements of cables may be considered just a curiosity, except for their practical consequences, this is not the case. The only plausible explanation (so far found) for this phenomenon is the existence of an altroverse to which cables show by their mechanical properties a resonance response. Such an altroverse explains both the existence of a non-zero cosmological constant as well as the apparent presence of cold dark matter in our universe. Therefore the observation of cable entanglement offers the one of the best observational possibilities to gain information about additional dimensions in an hyperverse encompassing the usual four dimensional spacetime.

I therefore propose the construction of a massive entanglement detector based on the observation of a million cables. Such a detector would work on a one day not observational period per cell, after which time the entanglement is read out automatically. However, the biggest challenge is given by the fact that after the data recording the cables need to be straightened out again including the presence of possible nods. At the moment this is a challenge to the most advanced robotics. As an alternate approach we try to develop cables that when hanging freely would memorize internally by material structure the application of a previously applied, but unobserved force.

18 Indeed, nobody has ever observed cable to entangle, except in a trivial, made-up way.