Bacteria behave like spin system: Why?

M. Pitkänen
Email: matpitka6@gmail.com.
http://tgdtheory.com/.

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Abstract

The recent study about the flow of bacteria in a lattice formed by wells connected by thin channels shows that the bacteria flows associated with given well behave like spins below critical radius of well. Below critical thickness for channels the flow pattern is analogous to antiferromagnetic state and above it to ferromagnetic state of spin system. TGD suggests that this behavior is induced from that for genuine dark spin system (large $h_{eff} = n \times h$ assignable to the magnetic bodies of bacteria, bacterium populations inside wells, and the lattice formed by these.

1 Introduction

In Physorg there was an interesting article titled "Bacteria streaming through a lattice behave like electrons in a magnetic material" (see http://tinyurl.com/hysxsl6). The popular article tells about article with title Ferromagnetic and antiferromagnetic order in bacterial vortex lattices by Dunkel et al [I1] (see http://arxiv.org/abs/1511.05000) . The following summarizes what has been studied and observed.

1. The researchers have studied a square lattice of about 100 wells with well radius below 50 microns and well depth about 18 microns. The wells are connected by thin channels. Also triangular lattice has been studied.

2. Below a critical radius about 35 microns an ordered flow is generated. The flow involves interior flow and edge flow in opposite direction consisting of single bacterium layer. One can understand this from angular momentum conservation. The coherence of this flow is however surprising. If one believes that each bacterium in principle chooses its swimming direction, one must understand what forces bacteria to select the same swimming direction.

3. Below a critical radius of channel about d=4 microns the flow directions in the neighboring wells are opposite for the square lattice. One has superposition of lattice and its dual with opposite flow directions. In the case of triangular lattice analogous cituation is encountered. In this situation there is no flow between the wells but there is an interaction. The minimization of dissipative losses requires minimization of velocity gradients inside channels. made possible by same local flow direction for the edge currents of neighboring wells.

4. Above the critical radius the flow changes its character. The flows synchronize and the interior flows rotate in the same direction as do also edge flows which occur also between the neighboring channels and give rise to closed flows around the boundaries of square like regions behind wells having larger scale. This flow pattern is consistent with angular momentum conservation: the angular momenta of lattice and its dual cancel each other.

5. The phase transition is analogous to that from antiferromagnetism to ferromagnetism. The total angular momenta of bacteria, their colonies, are analogous to spins. The situation can be modelled as 2-D Ising model consisting of lattice of spins with nearest neighbor interactions. Usually the spins are assigned with electrons but now they are assigned with bacteria.

This raises interesting questions. Bacteria swim by using flagellae. They can decide the swimming direction and control it by controlling the flagellae. Bacteria are living organisms and have a free will. Why would bacterium colory behave like quantal many-spin system. What happens when the swimming direction becomes same for the bacteria inside single well: does the colony become an entity with collective consciousness and do bacteria obey "social pressure". Does this happen also for the colony formed by these colonies in transition to ferromagnetism like state?

2 Could spin system like behave induced by dark spin system associated with magnetic body?

If one takes TGD inspired quantum biology as starting point, one can represent more concrete questions and possible answers to them.

1. Magnetic body (MB) controls the biological body (BB) be it organism or part of it [K1]. MB contains dark matter as cyclotron Bose-Einstein condensates of bosonic ions. Pairs of parallel flux tubes could also contain members of Cooper pairs whose spin depends on whether the magnetic fields at flux tubes are parallel or antiparallel [**?**, **?**].

2. What could be the mechanism of control? MB is assumed to send dark photon signals from MB to biological body to control it and an attractive idea is that control is by angular momentum conservation. Since the angular momentum transfer involve is due to a phase transition analogous to the change of the direction of magnetization or generation of magnetization the angular momentum transfer is large irrespective of the value of unit of angular momentum for dark photon (see discussion below). This large angular momentum could be transformed to angular momentum of ordinary matter and in recent case be responsible for generating the rotational motion of bacterium or larger unit.

   The transfer of dark photons induced by a phase transition changing the direction of dark magnetization might thus induce a large transfer of angular momentum to BB and generate macroscopic rotation. If this were the case the rotational state of dark MB of bacterium would serve as a template for bacterium.

   The bacterium colony associated with the well below critical size would correspond to super-organism having MB whose rotational state could serve as template for the bacterial MBs in turn serving as a similar template for the bacteria.

3. If the net angular momenta of MB and corresponding BB (bacterium, well colony, colony of these) vanish separately, the model is consistent with the model of the article in which local considerations determine the rotational directions. In this case the MBs of well colonies would behave like spins with nearest neighbor interactions.

   One can also consider the possibility that at quantum criticality long range quantum fluctuations occur and the local equilibrium conditions do not hold true. Even more, the net angular momenta of MB and BB would cancel each other but would not necessarily separately. This would imply apparent non-conservation of angular momentum at the level of bacterium colony at criticality and might allow to find experimental support for the notion of magnetic body. The proof of MB carrying dark matter as a concept would be very much like that of neutrino the existence of which was deduced from apparenent energy non-conservation in beta decays.

3 More detailed view about the situation

The model has a problem to worry about. I still am not quite sure whether $h_{eff}/h = n$ means that that the unit of spin is scaled up by n or that a fractionization of angular momentum by $1/n$ for single sheet of associated n-fold covering of space-time surface takes place. The control mechanism based on angular momentum conservation could however be at work in both cases. The option assuming fractionization seems to be the realistic one and only this will be considered in the following. Reader can ponder the option assuming scaled up unit of angular momentum (the scaling up of angular momentum of dark photon is not in coherence with the assumption that dark photon has same four-momentum as ordinary photon to which it should be able to transform).

1. Consider first the simplest variant for the effective fractionization of quantum numbers. If one has n-fold covering singular at the boundaries of CD then spin fractionization can be considered such that one has effectively n spin $1/n$ photons - one per sheet - and the net spin is just the standard spin. This picture fits with the vision that the n-fold covering means that one must make n full 2π turns before turning to the original point at space-time sheet: this allows at space-time surface wave functions with fractional spin which would be many-valued in Minkowski space. Similar fractionization would occur to other quantum numbers such as four-momentum so that net four-momentum would not change. The wavelength of these building bricks of dark photon analogous to Bose-Einstein condensate have frequencies scaled down by factor $1/n$.

   In this case the direct decay to single ordinary photon interpreted as bio-photon is allowed by conservation laws. Of course, also decays to several ordinary photons are possible. The decay to a bunch of n ordinary photons with total momenta $1/n$ times that of dark photon is possible if the spins of ordinary photons sum up to the spin of dark photon.

   The total angular momentum liberated from the cyclotron Bose-Einstein condensate spin could be transferred to spin of ordinary particles, say proton or ion for which the natural scale of orbital angular momentum is much larger (proportional to the rest energy). Simple order of magnitude estimate for orbital angular momentum with respect to the symmetry axis of possibly helical magnetic flux tube shows that in this case the spin could be transformed to angular momentum in the scale of organism and to the motion of organism itself.

   Note that dark photon could also decay to a bunch of ordinary photons with momentum scaled down by $1/n$ since the spins of the photons can sum up to spin 1.

2. A many-sheeted analog of second quantization generalizes the above picture. The n space-time sheets can be labelled by an integer $m = 1, ..., n$ defining an analog of discrete position variable. One can second quantize the fundamental fermions in this discrete space so that one has not only the ordinary many fermion states with $N = 0/1$ fermions in given mode but also states with fractionization of fermion number and other quantum numbers by $q = m/n < 1$ in a given mode. This would induce fractionization of bosons identified as fractional many-fermion states.

   Particle with fractional spin cannot decay directly to ordinary particle unless one has m=n: this correspond to the first option. Fractional particles characterized by q and 1-q can however fuse to ordinary particle. An attractive additional hypothesis is that the net quantum numbers are integer multiples of the basic unit.

   I have discussed the possibility of molecular sex: the opposite molecular sexes would have fractional charges summing up to ordinary charges. If magnetic bodies with opposite molecular sexes are paired they have ordinary total quantum numbers and can control ordinary matter by the proposed mechanism based on conservation of angular momentum (or some other charges). Dark matter would serve as template for ordinary matter and dark phase transitions would induce those of visible matter. The proposal that DNA, RNA, tRNA, and amino-acids are accompanied by dark proton sequences (or more general dark nuclei) could realize this picture. DNA double strand could be seen as an outcome of a molecular marriage in this framework! At higher level brain hemispheres might be a seen as a dark matter marriage. This picture can be also seen as emergence of symbols and dynamics based on symbol sequences at the molecular level with molecular marriage making possible very precise selection rules.

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