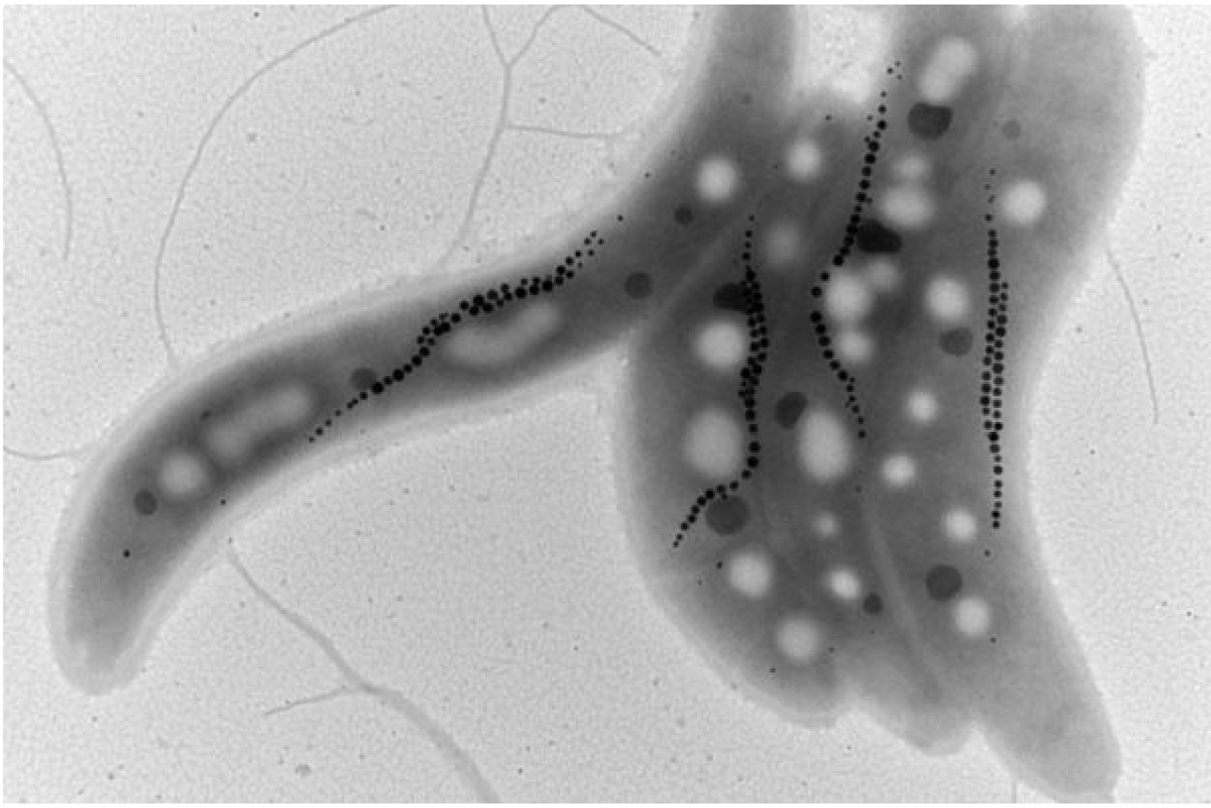

What do magnetic bacteria do to relax?

ICFO researchers report the first precision measurements of the magnetic field produced by magnetotactic bacteria, as they lose their orientation (relax) after being polarized in a strong magnetic field. They observed small but significant deviations from ideal exponential decay, implying that some bacteria have a harder time relaxing than others. The results have appeared in EPJ Quantum Technology.

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Magnetospirillum gryphiswaldense is a special kind of bacterium. Inside its body, it grows magnetic nanocrystals, organized in a linear chain to form a tiny but powerful bar magnet. In a magnetic field - like that of the Earth - the whole bacterium aligns to the field in the same way as a magnetic compass needle. This property helps it to navigate and find food, by reducing to one dimension its movement. For this reason, M. gryphiswaldense and its cousins are known as **magnetotactic bacteria**. Due to these nano-magnets, a suspension of bacteria is also a strongly magnetic material - applying a small field polarizes the material as

the many tiny magnets line up.
Now ICFO researchers **Maria Hernandez Ruiz**, **Dr. Christopher Kiehl** and **Dr. Vito Giovanni Lucivero**, led by **ICREA Prof. Morgan W. Mitchell**, report an **optically pumped magnetometer** (a magnetic field sensor) that can precisely measure how the bacteria align to an applied field, and how they lose that alignment (how they relax) when the field is turned off. Usin
the precision sensor, the team saw that the relaxation is**nearly but not exactly exponential**, a result that was predicted by theory but had never been observed. Moreover, the exact form of the relaxation showed that **a fraction of the bacteria** was **relaxing more slowly** than others.
The experiment consisted of applying a constant magnetic field to a population of MSR-1 (a much-studied magnetotactic bacterium), causing the bacteria to orient in that direction. Then, a much stronger magnetic field, perpendicular to the original one, was also applied for three seconds. Consequently, the bacteria lost their previous orientation, shifting toward the new field. When the strong field was switched off and only the constant background field remained, the bacteria were left to re-orient themselves, and their magnetic signals spontaneously ï¿½relaxedï¿½ toward equilibr
um. The OPM, which used a vapor of rubidium atoms to sense the field, measured precisely how these weak magnetic signals changed after the removal of the strong field. The ove
all relaxation resembles an exponential approach to a steady value. However, the researc
ers did not observe exactly that, and saw instead small, quantifiable departures from this i
eal exponential decay. These subtle differences likely indicate that the individual bacteria wi
hin the population have different relaxation rates, rather than these being perfe
tly homogene
us. ï¿½To the best of our knowledge, **this is the first time such magnetic inhomogeneities and relaxation deviations have been directly observed**,ï¿½ says Prof. Morgan Mitchell, supervis
r of the study. ï¿½For this proof-of-principle experiment, we worked with non-living bacteria
to keep things simple. It will be very interesting to see how living bacteria, which swim in the magnetic field, compare,ï¿½ adds lead researcher Maria Hernandez
Ruiz. Moreover, the OPM was shown to work efficiently with opaque samples and in the pr
sence of light scattering - two conditions that typically hinder traditional optical techn
ques. Together, these results highlight the capability of compact atomic magnetometers to image and quantify magnetic properties in biological samples, positioning them as pro
ising alternatives for such research. Thus, the study marks a key step forward t
wards understanding the magnetic behavior of magnetotactic bacteria, a fundamental re
earch topic in biophysics that, **in the long term, could unlock targeted tumour therapy and other biomedical applications**.

Reference:

Hernandez Ruiz, M., Kiehl, C., Lucivero, V.G. et al. Magnetotactic bacterial population
studied with a Pound-Drever-Hall atomic magnetometer.EPJ Quantum Technol. **13**, 45

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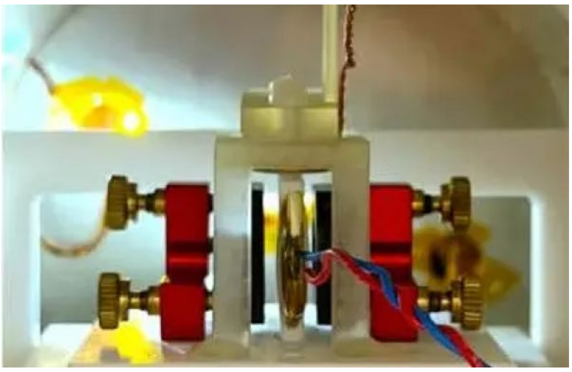

Picture of the optical cavity in the shield with one cap open. Positioned above this is the bacteria holder, which incorporates the polarizing coil. Source: EPJ Quantum Technology.