BESSY II sheds light on how the internal compass is constructed in magnetotactic bacteria

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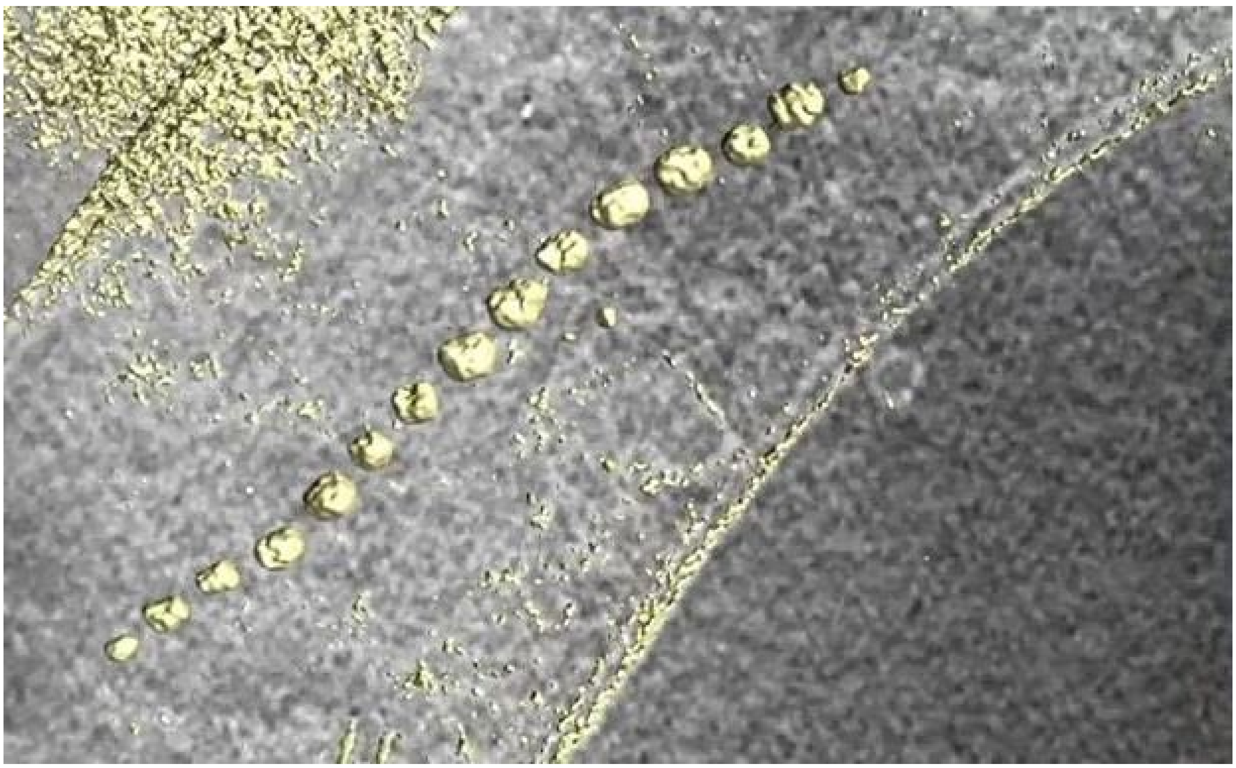


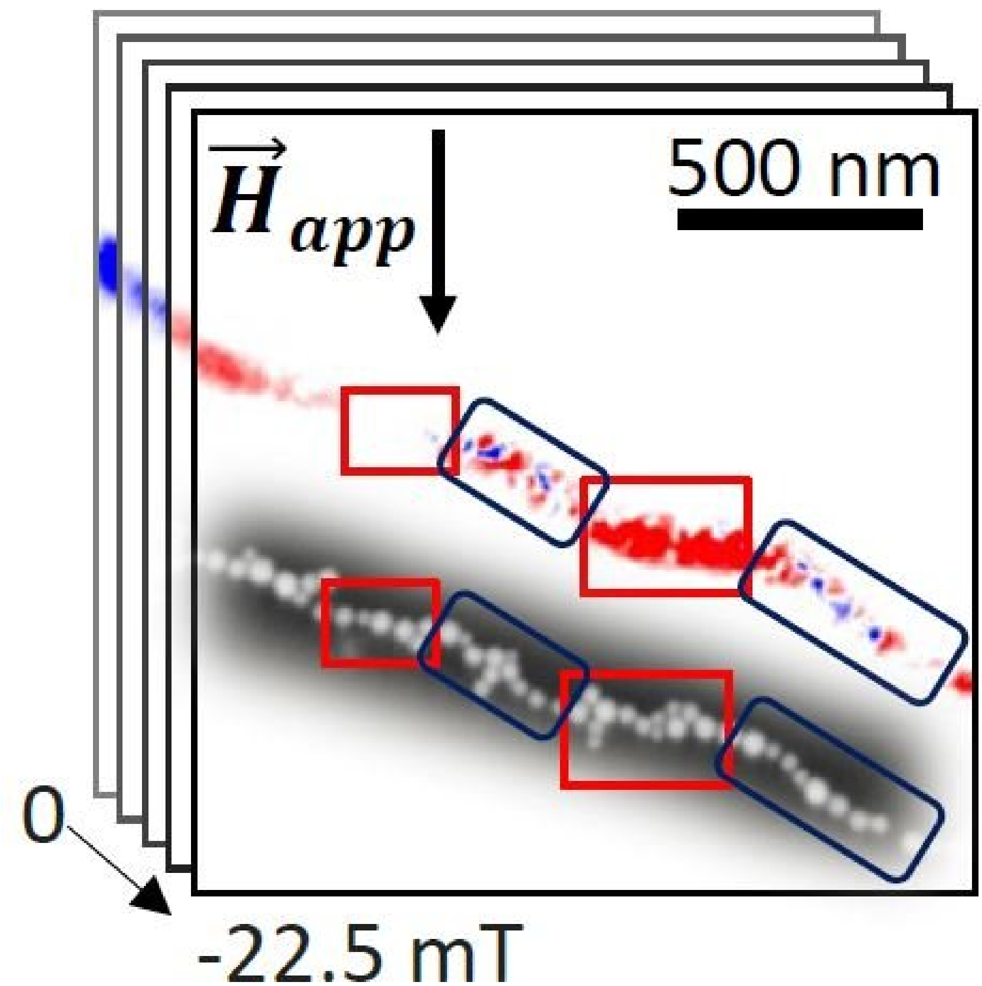
The magnetosomes form a chain inside the bacteria's cell shows the electron cryotomography (ECT). Credit: 10.1039/C7NR08493E

Magnetotactic bacteria can sense the Earth's magnetic field via magnetic nanoparticles in their interior that act as an internal compass. Spanish teams and experts at Helmholtz-Zentrum Berlin have now examined the magnetic compass of Magnetospirillum gryphiswaldense at BESSY II. Their results may be helpful in designing actuation devices for nanorobots and nanosensors for biomedical applications.

Magnetotactic bacteria are usually found in freshwater and marine sediments. One species, Magnetospirillum gryphiswaldense, is easily cultivated in the lab - with or without magnetic nanoparticles in their interior depending on the presence or absence of iron in the local environment. "So these microorganisms are ideal test cases for understanding how their internal compass is constructed," explains Lourdes Marcano, a PhD student in physics at Universidad del Pais Vasco in Leioa, Spain.

Magnetospirillum cells contain a number of small particles of magnetite (Fe_3O_4), each approximately 45 nanometers wide. These nanoparticles, called magnetosomes, are usually arranged as a chain inside the bacteria. This chain acts as a permanent dipole magnet and is able to passively reorient the whole bacteria along the Earth's magnetic field lines. "The bacteria exist preferentially at the oxy/anoxy transition zones," Marcano says, "and the internal compass might help them to find the best level in the stratified water column for satisfying their nutritional requirements." The Spanish scientists examined the shape of the magnetosomes and their arrangement inside the cells using various experimental methods such as electron cryotomography.

Samples of isolated magnetosome chains were analysed at BESSY II to investigate the relative orientation between the chain's direction and the magnetic field generated by the magnetosomes. "Current methods employed to characterise the magnetic properties of these bacteria require sampling over hundreds of non-aligned magnetosome chains. Using photoelectron emission microscopy (PEEM) and X-ray magnetic circular dichroism (XMCD) at HZB, we are able to detect and characterise the magnetic properties of individual chains," explains Dr. Sergio Valencia, HZB. "Being able to visualise the magnetic properties of individual magnetosome chains opens up the possibility of comparing the results with theoretical predictions."



Experiments at BESSY II revealed how an external magnetic field changes the orientiations of chain parts. Credit: 10.1039/C7NR08493E

Indeed, the experiments revealed that the magnetic field orientation of the magnetosomes is not directed along the chain direction, as assumed up to now, but is slightly tilted. As the theoretical modelling of the Spanish group suggests, this tilt might explain why magnetosome chains are not straight but helical in shape. A deeper understanding of the mechanisms determining the chain shape is very important, the scientists say. Nature's inventions could inspire new biomedical solutions such as nanorobots propelled by flagella systems in the direction provided by their magnetosome chain.

More information: I. Orue et al, Configuration of the magnetosome chain: a natural magnetic nanoarchitecture, *Nanoscale* (2018). DOI: 10.1039/C7NR08493E

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