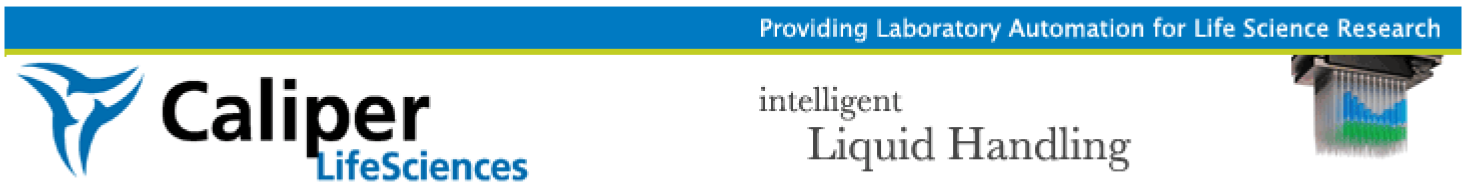

Ice film structure in astrophysical conditions

An European Science Foundation product story

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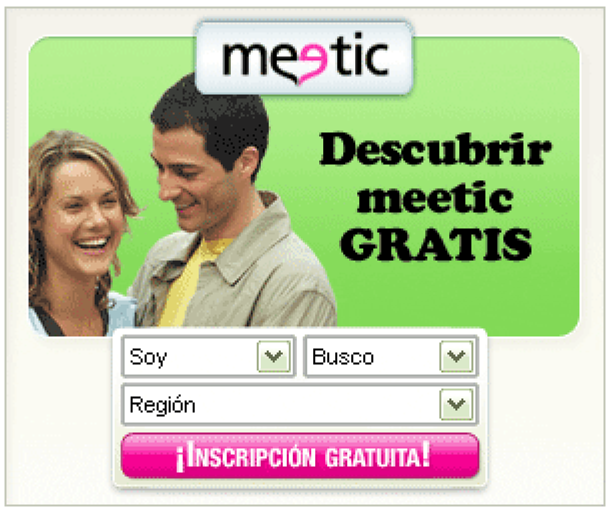
The European Science Foundation (ESF) recently organised a workshop that discussed recent discoveries about the structure of ice films in astrophysical conditions at the mesoscale.

Could life have started in a lump of ice? The universe is full of water, mostly in the form of very cold ice films deposited on interstellar dust particles, but until recently little was known about the detailed small scale structure.



Now the latest quick freezing techniques, coupled with sophisticated scanning electron microscopy techniques, are allowing physicists to create ice films in cold conditions similar to outer space and observe the detailed molecular organisation, yielding clues to fundamental questions including possibly the origin of life.

Researchers have been surprised by some of the results, not least by the sheer beauty of some of the images created, according to Julyan Cartwright, a specialist in ice structures at the Andalusian Institute for Earth Sciences (IACT) of the Spanish Research Council (CSIC) and the University of Granada in Spain.

Recent discoveries around the structure of ice films in astrophysical conditions at the mesoscale - which is the size just above the molecular level - were discussed at a recent workshop organised by the European Science Foundation (ESF) and co-chaired by Cartwright alongside C Ignacio Sainz-Diaz, also from the IACT.

As Cartwright noted, many of the discoveries about ice structures at low temperatures were made possible by earlier research into industrial applications involving deposits of thin films upon an underlying substrate (in other words, the surface, such as a rock, to which the film is attached), such as manufacture of ceramics and semiconductors.

In turn, the study of ice films could lead to insights of value in such industrial applications.

But the ESF workshop's main focus was on ice in space, usually formed at temperatures far lower than even the coldest places on earth, between three and 90 degrees above absolute zero (3-90K).

Most of the ice is on dust grains because there are so many of them, but some ice is on larger bodies such as asteroids, comets, cold moons or planets, and occasionally planets capable of supporting life, such as Earth.

At low temperatures, ice can form different structures at the mesoscale than under terrestrial conditions, and in some cases can be amorphous in form; that is like a glass with the molecules in effect frozen in space, rather than as crystals.

For ice to be amorphous, water has to be cooled to its glass transition temperature of about 130K without ice crystals having formed first.

To do this in the laboratory requires rapid cooling, which Cartwright and colleagues achieved in their work with a helium 'cold finger' incorporated in a scanning electron microscope to take the images.

As Cartwright observed, ice can exist in a combination of crystalline and amorphous forms, in other words as a mixture of order and disorder, with many variants depending on the temperature at which freezing actually occurred.

In his latest work, Cartwright and colleagues have shown that ice at the mesoscale comprises all sorts of different characteristic shapes associated with the temperature and pressure of freezing, also depending on the surface properties of the substrate.

For example, when formed on a titanium substrate at the very low temperature of 6K, ice has a characteristic cauliflower structure.

Most intriguingly, ice under certain conditions produces biomimetic forms, meaning that they appear lifelike, with shapes like palm leaves or worms, or even at a smaller scale like bacteria.

This led Cartwright to point out that researchers should not assume that lifelike forms in objects obtained from space, like Mars rock, is evidence that life actually existed there.

He said: 'If one goes to another planet and sees small wormlike or palm like structures, one should not immediately call a press conference announcing alien life has been found.' On the other hand, the existence of lifelike biomimetic structures in ice suggests that nature may well have copied physics.

It is even possible that while ice is too cold to support most life as we know it, it may have provided a suitable internal environment for prebiotic life to have emerged.

Cartwright added: 'It is clear that biology does use physics.

'Indeed, how could it not do? So we shouldn't be surprised to see that sometimes biological structures clearly make use of simple physical principles.

'Then, going back in time, it seems reasonable to posit that when life first emerged, it would have been using as a container something much simpler than today's cell membrane, probably some sort of simple vesicle of the sort found in soap bubbles.

'This sort of vesicle can be found in abiotic systems today, both in hot conditions, in the chemistry associated with 'black smokers' on the sea floor, which is currently favoured as a possible origin of life, but also in the chemistry of sea ice.' This is an intriguing idea that will be explored further in projects spawned by the ESF workshop.

This may provide a new twist to the idea that life arrived from space.

It may be that the precursors of life came from space, but that the actual carbon-based biochemistry of all organisms on Earth evolved on this planet.