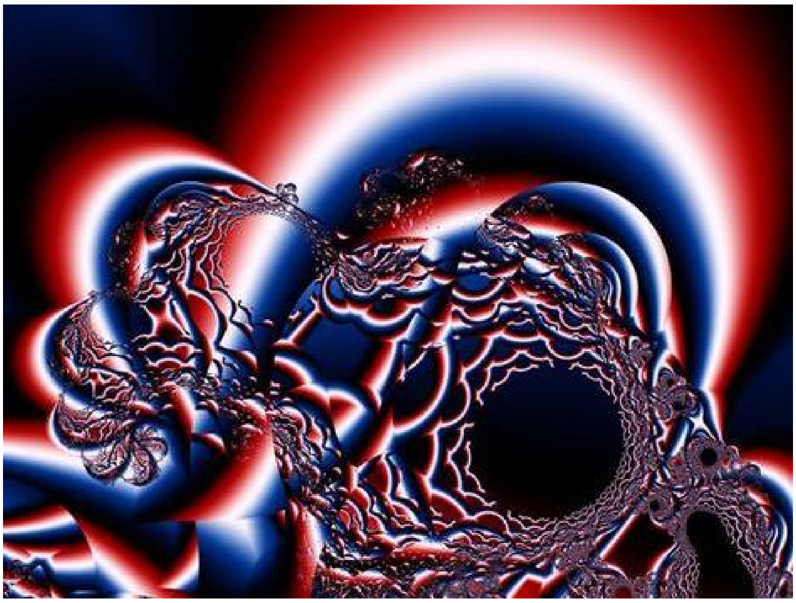
UNIVERSITY OF OXFORD

Fractals: a curvy problem

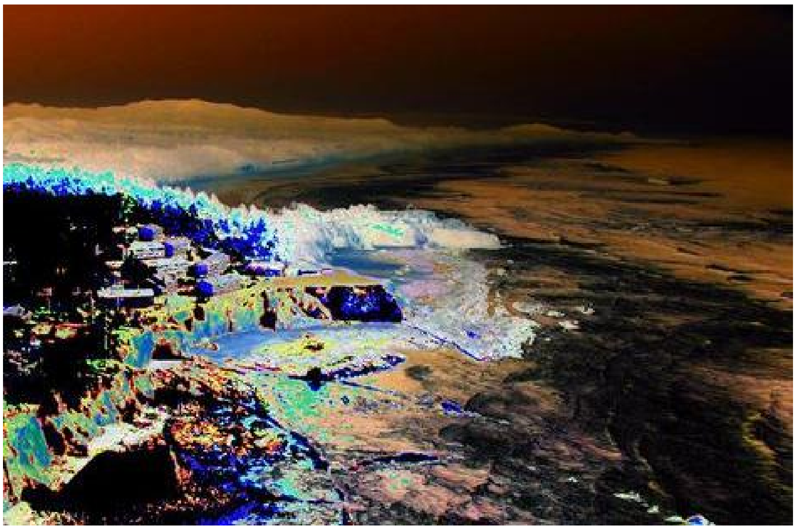
Science

Pete Wilton | 28 Mar 08



We all know fractals are pretty - and pretty cool - but it's not often highlighted how useful an understanding of them can be to areas such as medicine and manufacturing. In this week's *Physical Review Letters* Oxford mathematician Carlos Escudero reports on his research into fractal geometry, in particular how fractals behave in curved spaces. Carlos explains that studying the geometrical properties of these systems sheds light on their physical properties, and helps us understand important phenomena such as crystal and tumor growth. The ultimate goal is to one day be able to understand the basic growth mechanisms and even to control them. I quizzed him about why fractals matter...

OxSciBlog: Why is understanding fractals important?
Carlos Escudero: Fractals appear everywhere in the natural world; clouds, snow flakes, bacterial colonies, crystals, lightning bolts, systems of blood and pulmonary vessels and coastlines are all examples of fractals. Fractals are important because we live surrounded by them and these complex geometrical entities are much more realistic than ideal simple forms such as as spheres and cubes. If we want to understand the natural world we have to understand fractal geometry - otherwise we can't, for instance, develop effective strategies for stopping bacterial infections.



OSB: How might your work help in the analysis of semiconductor surfaces/spherical tumour growth?
CE: When growing layers of semiconductors using a thin film deposition technique, the resulting semiconductor surface is rough and islands of adsorbed atoms (adatoms) form on it. If we knew the fundamental processes that drive the growth of these structures, we could try to introduce some correction mechanism that would allow us to obtain smoother surfaces - something that's desirable for industrial purposes, since smooth surfaces make better contact that rough ones. Applying the Non-Euclidian picture to these islands might help in understanding how they form and grow. With respect to tumours, the fractal properties of in-vitro tumour spheroids have been studied previously, and from them some authors try to obtain possible strategies that could slow down tumour growth or detect possible malignancy in the in-vivo situation. The analyses performed so far have not considered the Non-Euclidean symmetry of the spheroids' surface, and so the results need to be re-analyzed under the light of this new framework. This way we discovered how the conclusions obtained from the planar analysis need to be modified or even erased.

OSB: What is it about curved spaces that make them difficult to understand in relation to fractals?
CE: The mathematical way of describing a curved (or Non-Euclidean) surface is a bit more involved than describing a planar one. Imagine for instance measuring some basic properties of a planar triangular grass field: we know that the sum of the three angles is pi radians or 180 degrees. But imagine now that the triangle is on a sphere's surface (like a triangular portion of the Earth's surface); then the simple trigonometric identities do not hold: the sum of the three angles is always greater than 180 degrees. These mathematical questions make studying curved surfaces a bit harder than the planar ones.

OSB: What might be the benefits if we could learn how to control the basic growth mechanisms of fractals?

CE: As I mentioned before, one finds growing fractals in many different natural situations. Bacterial and fungal colonies develop rough interfaces in the process of growth. Both bacteria and fungi can act as infectious agents in the human body, so understanding how their colonies develop might help in proposing new strategies to eradicate these types of infection. Tumour growth is also characterised by a rough surface, and a control strategy could be targeted in trying to slow down and even stop the growth. Controlling the rough peripheries of adatom islands on semiconductor surfaces might help in growing smoother thin films, of a better quality for the electronic industry. In general, as many of the structures that we find in nature are fractals, if we want to control them, we need to understand the dynamics of growing fractals.

Images: (Top) Fractal art by Ralph Langendam (Middle) Oregon coastline from an orginal image by Jan Tik (Bottom) Bacterial colonies at a hot spring by Walter Siegmund

Previous post
Next post

Your comments

There are currently no comments on this page.
Post a comment