Test of neutrality

Phys. Rev. Lett. (in the press); preprint at http://arxiv.org/abs/0711.4636 (2007)

Do atoms really carry zero electrical charge? Several theoretical scenarios that explore physics beyond the standard model suggest that this cannot be taken for granted. And so Asimina Arvanitaki and colleagues propose to put the neutrality of atoms (and neutrons) to the test. They describe a set-up that should enable charge detection at the level of 10^{-28} e — surpassing the sensitivity of current best tests by eight orders of magnitude.

The proposed experiment is based on a beam of cold rubidium atoms that is split by a series of laser pulses into a superposition of two states having different momentum. When the atoms are shot through a flight corridor — a 10-m-high apparatus is currently under construction — the two components take different trajectories, and can be made to interact with electrical fields of different strength. Therefore, the wave functions of the fast and slow atoms will acquire different phase shifts, and, when their trajectories rejoin, a phase difference can be detected — if their charge is not zero.

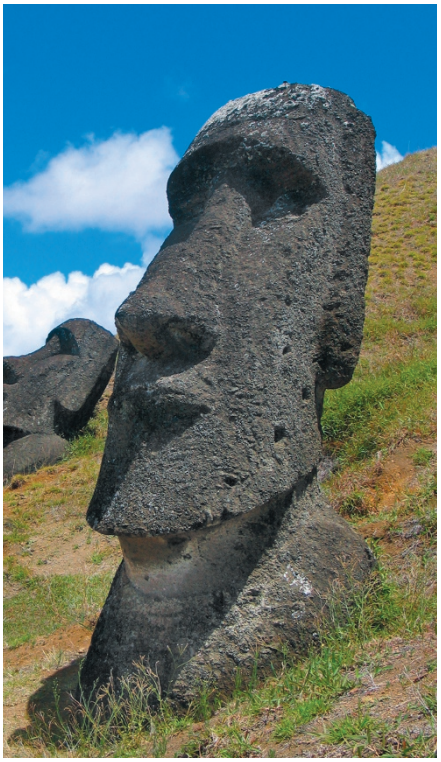
Roll with it

Phys. Rev. D **77,** 023510 (2008)

An inflationary phase of exponential expansion during the early history of the Universe seems to be supported by the data collected so far on the cosmic microwave background radiation, and work is underway to connect inflation to the elegant framework of string theory. E. J. Copeland and colleagues, however, consider how inflation sits within the context of loop quantum cosmology, a formulation based on an alternative approach to the reconciliation of general relativity and quantum mechanics, that of loop quantum gravity.

Their analysis centres on a period of 'superinflation' — during which the Hubble parameter increases rapidly (rather than remaining almost constant as it does in 'normal' inflation), and which arises robustly in loop quantum cosmology — and the scalar perturbations that may have resulted from it. The calculations develop a new set of 'fast-roll' parameters, and suggest that only a few 'e-folds' (each being the time taken for a volume increase by a factor of e) of superinflation are necessary — countering the criticisms made of earlier approaches.

Lessons from afar



Europhys. Lett. **81,** 48006 (2008)

From a few dozen initial settlers in 400 AD, the population of Easter Island reached a maximum of several thousand. By 1600, the highly evolved civilization — known for its giant statues, or *moai* — had collapsed. To model the population dynamics of any society is a complex task, but, owing to its isolation, Easter Island was a good starting point for M. Bologna and J. C. Flores.

It's a classic case of overexploitation of resources. For the Easterners, palm trees were the main resource; they once covered the entire island but went extinct around the same time as the human population collapsed. The palms provided cooking fuel and raw material for tools — including those necessary for moving the heavy statues — and fishing boats, as well as a barrier to soil erosion.

The authors' simple model captures the essence of the dynamics. Their calculations of number of inhabitants and amount of resources over time agree with archaeological data. Moreover, their model also gives a precise time of collapse for the Mayan civilization at Copán, in Honduras.

Force-fed bacteria

Nature Nanotech. **2,** 158–162 (2008)

Magnetotactic bacteria possess the remarkable ability to synthesize nanoparticles of magnetite, which enables them to respond to magnetic fields in their environment. It has been suggested that the purity, uniformity of size and shape, and inherent biocompatibility of these nanoparticles could prove useful in a range of applications from drug delivery to magnetic recording media. But to develop such an application, it would be good to be able to tailor their characteristics further.

To this end, Sarah Staniland and colleagues set out to dope these nanoparticles *in vivo*, by force feeding cobalt to three different strains of the bacterium *Magnetospirillum magnetotacticum*. Magnetite has the highest saturation field of all the iron oxides, but it is magnetically soft. By replacing iron quinate with cobalt quinate in the bacteria's growth media, Staniland *et al.* succeeded in increasing the coercive field — a measure of magnetic hardness — of the resulting nanoparticles by up to 45%.

Graphene nanoribbons

Science doi:10.1126/science.1150878 (2008)

The unusual properties of graphene present both great opportunities and great challenges. As a single layer, its charge carriers mimic the behaviour of massless relativistic particles — a potentially useful trait for making high-speed electronic devices. But as a two-dimensional sheet, graphene has no bandgap, making its carriers difficult to control.

Xiaolin Li and colleagues report a potential solution to this problem: they have developed a chemical means of producing graphene in well-defined ribbons down to a width of just 10 nm. In this 'nanoribbon' form, graphene develops a bandgap, which the authors exploit to make field-effect transistors with on–off ratios of up to 10^7 at room temperature.

Moreover, the work demonstrates a key advantage of graphene over carbon nanotubes — the consistency of its semiconducting nature. Nanotubes come in both semiconducting and metallic forms, but there is as yet no reliable means to grow one preferentially to the other. All the nanoribbons tested by the authors, in contrast, were uniformly semiconducting.

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