50 Years Ago

The Prehistoric Chamber Tombs of France. By Glyn Daniel — To win appreciation for some phase of antiquity on the strength of modern excavations is far easier than what has been undertaken here — where the antiquities concerned have been known for centuries, until only yesterday often excavated badly, and celebrated in a literature in which perverse and obsolete terminologies have run riot. Dr. Daniel, supported by his wife, and with backing from many quarters as well as friendly French co-operation, has for long been working towards a systematic account of the megalithic and related stone tombs of France, their form and contents, and their placing in the frame of European prehistory in the third and second millennia B.C., to which in general they belong. This book, by no means his first study of megalithic structures, is his best so far. It is not too hard to read.
From *Nature* 12 August 1961

100 Years Ago

In the July number of *The American Naturalist* Dr. O. P. Hay reopens the discussion with regard to the position of the limbs in Diplodocus and other sauropod dinosaurs, criticising the views of those who assert that these reptiles carried themselves in elephantine fashion, and maintaining his own opinion that the general pose was more after the crocodilian style … Mr. Hay expresses doubts as to whether the erect bird-like posture attributed to the carnivorous dinosaurs of the Jurassic is really true to nature … In reference to the opinion of Dr. Matthew that Sauropods were too bulky to have lived on land, it is added that "the law to which he gives expression does, of course, prescribe a limit to the size an animal can attain, but who has yet determined what that limit is?"
From *Nature* 10 August 1911

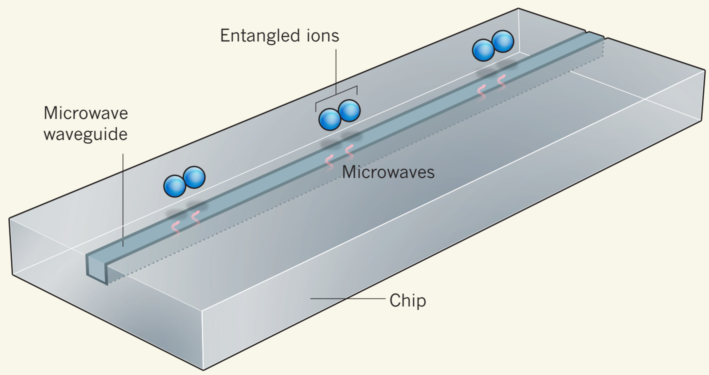

Figure 1 | Microwave ion-trap chip. Ospelkaus and colleagues' approach[4] to entangling pairs of ions and generating a quantum gate involves launching microwaves into a waveguide incorporated on a chip.

breaking advances in quantum-information processing using trapped ions, including the entanglement of up to 14 ions[6], and the development of other entanglement-based protocols, such as the realization of a number of quantum algorithms[3] and of teleportation[7,8]. These advances have been made in experiments in which laser beams are used to perform entanglemewnt operations. In 2001, Mintert and Wunderlich had the visionary idea[9] of implementing quantum gates using long-wavelength radiation, such as microwaves or radio waves. Whereas laser beams must be carefully aligned to interact with the trapped ions that are to be entangled, microwaves can be applied via waveguides (structures that can guide radiation) that are part of the chip on which the ion trap is integrated[10], and so do not require alignment.

What's more, it is much easier and less costly to generate microwave radiation than it is to use the complicated laser systems currently employed, and highly stable microwave sources are readily available. Large-scale quantum computers may require many millions of individually trapped ions, each constituting a single quantum bit (the basic unit of information storage in a quantum computer). As a result, creating the required number of laser beams to entangle the ions may entail significant engineering and come at a considerable cost. By contrast, the use of microwave radiation for the same purpose would be much easier and would make the construction of a large-scale ion-trap quantum-information processor much simpler.

Based on their proposal[11] to make use of the oscillating magnetic fields that are inherent to microwave radiation (the original proposal by Mintert and Wunderlich[9] requires static magnetic fields in addition to microwaves), Ospelkaus *et al.*[4] have realized the first microwave quantum gate. They achieved this by using a waveguide integrated into a microchip (Fig. 1) that holds the ion-trap structure. The microchip contains electrodes that produce electric fields capable of trapping two ions just above the chip's surface. Multiple pulses of microwave radiation are then applied to the trapped ions through the waveguide, effectively entangling the two ions and successfully executing a quantum gate.

Meanwhile, Timoney *et al.*[5] trapped individual ions and applied a number of microwave pulses to them. This approach sets the ions to a state in which they are decoupled from outside noise. An easy way to visualize this is by considering the suspension of a common car. Springs in the car's suspension system decouple the car frame from the wheels, largely isolating the driver from vibrations caused by uneven road surfaces. In a similar way, Timoney and colleagues' scheme allows trapped ions to be isolated from external disturbances that would otherwise have the potential to disturb the operation of a microwave trapped-ion quantum processor.

The achievements of Ospelkaus *et al.*[4] and Timoney *et al.*[5] constitute step-changing innovations for quantum computing with trapped ions because they will probably aid the production of large-scale ion-trap quantum computers on foreseeable timescales. Quantum computing is likely to revolutionize many areas of science, and we have only just started to appreciate its true potential. ■

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1. Cirac, J. I. & Zoller, P. *Phys. Rev. Lett.* **74,** 4091–4094 (1995).
2. Wineland, D. J. *et al. J. Res. Natl Inst. Stand. Technol.* **103,** 259–328 (1998).
3. Häffner, H., Roos, C. F. & Blatt, R. *Phys. Rep.* **469,** 155–203 (2008).
4. Ospelkaus, C. *et al. Nature* **476,** 181–184 (2011).
5. Timoney, N. *et al. Nature* **476,** 185–188 (2011).
6. Monz, T. *et al. Phys. Rev. Lett.* **106,** 130506 (2011).
7. Leibfried, D. *et al. Nature* **422,** 412–415 (2003).
8. Schmidt-Kaler, F. *et al. Nature* **422,** 408–411 (2003).
9. Mintert, F. & Wunderlich, C. *Phys. Rev. Lett.* **87,** 257904 (2001).
10. Hughes, M. D., Lekitsch, B., Broersma, J. A. & Hensinger, W. K. *Contemp. Phys.* http://dx.doi.org/10.1080/00107514.2011.601918; preprint available at arXiv:1101.3207v2 [quant-ph] (2011).
11. Ospelkaus, C. *et al. Phys. Rev. Lett.* **101,** 090502 (2008).