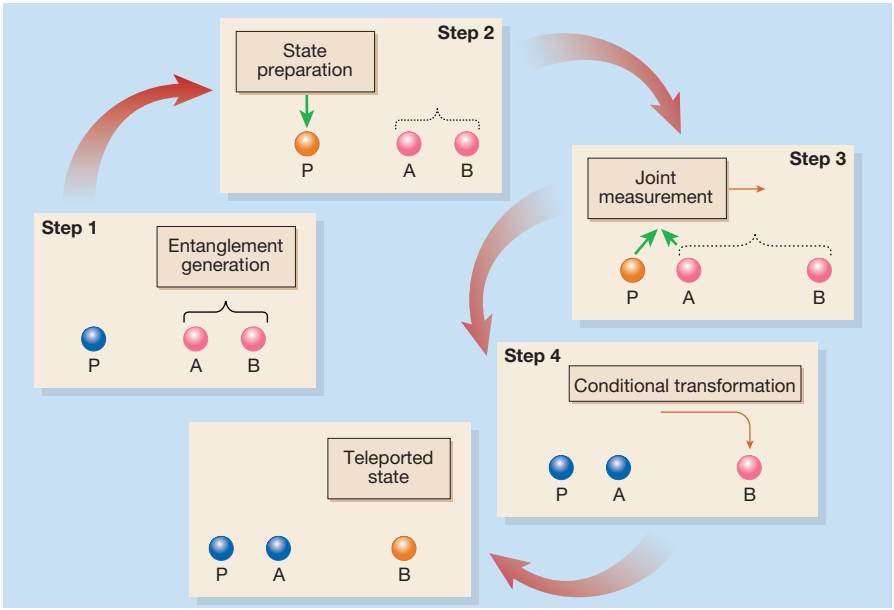

Figure 1 **Quantum teleportation, step by step. Although the details of their experiments differ, Riebe *et al.*[5] and Barrett *et al.*[6] have followed the protocol suggested by Bennett *et al.*[1] to achieve deterministic teleportation of a quantum state between trapped ions. First, an entangled state of ions A and B is generated, then the state to be teleported — a coherent superposition of internal states — is created in a third ion, P. The third step is a joint measurement of P and A, with the result sent to the location of ion B, where it is used to transform the state of ion B (step 4). The state created for P has then been teleported to B.**

et al. adopt a recently developed geometric method to perform two-qubit gating[9].

A second difference concerns how the authors addressed individual ions for manipulating quantum states, including projective measurements. Riebe *et al.* are able to address any specified target ion using tightly focused laser beams and have developed a technique to 'hide' the remaining ions from the target ion's fluorescence by changing their internal states so that they are insensitive to the fluorescent light. Barrett *et al.* have developed the capability to move groups of ions selectively to separate zones in a segmented trap, thereby isolating any target ion while still maintaining entanglement within the system.

The details of implementation aside, these two experiments represent a magnificent confluence of experimental advances, ranging from precision spectroscopy and laser cooling to new capabilities for controlled two-body interactions. The techniques developed and employed by these groups will no doubt prove important in the quest to build large-scale quantum computers based on trapped ions. Indeed, the fact that such diverse procedures performed so superbly in two separate laboratories attests to the flexibility and great potential of ion trapping for processing quantum information. ■

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Atmospheric chemistry

Fire and ice

Small air bubbles, trapped in glaciers and ice caps, have been a priceless source of information about the history of Earth's atmosphere: the record now goes back some 800,000 years. But, for a gas to be preserved in this frozen archive of atmospheric history, it must be chemically inert, and so there can be no direct record of the short-lived species, such as ozone (O_3) and the hydroxy radical (OH), that drive the key chemical processes in the atmosphere.

Writing in the *Journal of Geophysical Research* (doi:10.1029/2003JD004218; 2004), Becky Alexander *et al.* suggest that a little-known peculiarity of isotope chemistry, known as 'mass-independent fractionation', may offer a glimpse into the history of vegetation burning and its effects on oxidation reactions in the atmosphere.

The fractionation of isotopes that occurs during most chemical and physical processes is usually proportional to the mass difference between the isotopes. But a few reactions, notably the formation of ozone, also lead to isotope fractionations that are not proportional to the isotope mass. The resulting anomaly in the isotopic composition of atmospheric ozone is passed on to the sulphate and nitrate formed from aqueous-phase reactions between O_3 and SO_2 and NO_x respectively. Other processes that lead to sulphate and nitrate, such as gas-phase reactions involving the hydroxy radical, do not show this anomaly.

As a result, we can tell the relative contributions of liquid-phase oxidation by O_3 and gas-phase oxidation by OH from the isotopic composition of sulphate and nitrate trapped in the layers of ancient ice in Greenland and Antarctica. Alexander *et al.* have identified a large isotope anomaly in Greenland ice that dates from the period 1830–1900, and it turns out to correlate perfectly with indicators of biomass burning — formate and ammonium — in the same ice layers. They propose that this anomaly is the consequence of elevated levels of ozone that stemmed from air pollution from the fires that the pioneers used to clear North America for agriculture in the nineteenth century.

These data cannot yield quantitative conclusions about the amounts of oxidants in the pre-industrial atmosphere. They can, however, serve as constraints for models that integrate information about the emissions that are associated with different types of land use and their reactions in the atmosphere. Such models are used for analysing and predicting the human impact on atmospheric composition. In the tropics, high concentrations of water vapour and solar ultraviolet radiation combine to produce the highest OH concentrations worldwide, making this area the most important region for atmospheric oxidation. So, for further understanding of those processes, we might want to look with added urgency for isotopic clues in the few and rapidly vanishing ice caps on mountains in the tropics (pictured, Mount Huascarán in Peru, in 1978). **Meinrat O. Andreae**

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