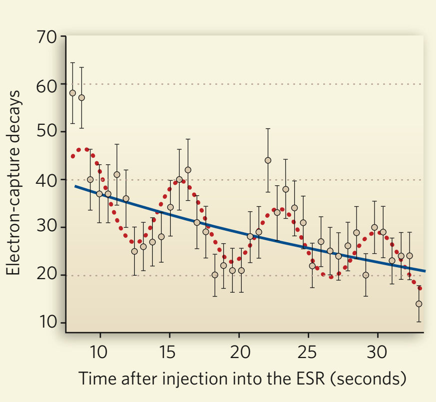

Figure 1 | Oscillating decay. **Litvinov and colleagues[1] observe decay-rate oscillations with a period of about 7 seconds, here for decays of promethium-142 through electron capture, but similarly for praesodymium-140 — a phenomenon they attribute to the effect of neutrino oscillations. There are no observations for the first few seconds after formation while the ions are cooled to reduce their velocity spread.**

ion's identity (mass) and decay (mass change) can be monitored.

The authors measured the process of electron capture on $^{140}Pr^{58+}$ and $^{142}Pm^{60+}$ — 'hydrogen-like' ions in which all but one of the electrons orbiting the nucleus have been removed. Electron capture is a kind of reverse β-decay in which a nucleus captures an electron from an atomic orbital, resulting in the conversion of a proton to a neutron in the nucleus and the emission of an electron neutrino. The decay products of ^{140}Pr and ^{142}Pm are thus the (stable) isotopes cerium-140 and neodymium-142; decays are signalled through a change in the ion's revolution frequency caused by a small drop in its mass. By observing many such individual decays, the decay rate is obtained, which should, as ever, fall over time as a simple exponential. What Litvinov *et al.*[1] discovered was an unexpected modulating oscillation with a period of about 7 seconds for both ions (Fig. 1).

This behaviour is perhaps all the more curious for popping up in an unusually 'clean' experimental environment. Because the radioactive ions being studied had only a single atomic electron, which went on to be captured during the decay, there are few confounding effects such as Coulomb interactions to take into account. By being confined to the high-vacuum storage ring, the ions were also effectively isolated from outside influences. In addition, only a very small number of ions — three or fewer — were allowed in the storage ring at any one time, limiting their interactions with each other.

So how are we to interpret these results? Litvinov *et al.* go to considerable lengths to rule out spurious causes such as a regular instability in the storage ring or the detection apparatus. They discuss several possible physical origins, such as the quantum-mechanical oscillation between two spin states, one of which is 'sterile', in that it is forbidden by angular-momentum conservation from decaying through electron capture. This possibility seems discounted by the fact that the overall decay rate agrees with the predictions that do not countenance a sterile state.

The authors thus argue by a process of elimination, and in agreement with a recent theoretical suggestion[3], that the modulations are due to the oscillation of neutrinos between two different mass states: that of an electron neutrino, emitted in the original decay; and that of a muon neutrino, which is observed in decays of the electron's 200-fold-heavier sibling, the muon. The generalized phenomenon of neutrino oscillation is now well documented in several contexts in which neutrinos arise — in radiation given off from the Sun, in cosmic rays, and in neutrinos produced in nuclear reactors for energy generation. In the case of heavy-ion experiments, a crucial feature is the minimal recoil energy of the ion as it decays emitting the neutrino, which should make the period of the interference oscillation dependent on the ion's mass — potentially an unequivocal experimental signature.

A back-of-the-envelope calculation shows that Litvinov and colleagues' conjecture[1] that what they see is the expression of neutrino oscillation could be well-founded — for values of the difference in neutrino masses in the middle of the presumed range, an oscillation period of the order of 10 seconds would be expected. If the conclusion did prove to be right, it could represent a sea change in neutrino physics. Neutrinos probably make up a substantial fraction of the mass of the Universe, so it is well worth our while getting to know them better. Yet they are notoriously aloof, generally passing straight through Earth without interacting. Vast underground detectors have to be built to stand a chance of detaining a few of them. One thing the ESR findings would produce would be a way of testing the properties of neutrinos purely through the decay characteristics of heavy ions that are much more amenable to investigation — without the bother of detecting neutrinos at all.

Caution is due, as it is far from simple to get to grips with the underlying cause of the decay-rate oscillations. Experimentally, the next step must be to study another example of electron capture involving a nuclide of substantially different mass that generates a different oscillation period. The authors are planning just such a test — it will be intriguing to see whether this putative new neutrino oscillation proves to be a robust phenomenon, or as elusive as the neutrinos themselves. ■

Philip M. Walker is in the Department of Physics, University of Surrey, Guildford GU2 7XH, UK.
e-mail: p.walker@surrey.ac.uk

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2. Jung, M. *et al. Phys. Rev. Lett.* **69,** 2164–2167 (1992).
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50 & 100 YEARS AGO

50 YEARS AGO

Prior to a recent television series on evolution, the producer asked the audience research department of the B. B. C. to equip him with information about the knowledgeability of potential viewers [and] their attitude towards evolution ... Viewers were asked whom they associated with evolution. One in three could give no name; the name given by far the most (by one-third of the total) was that of Darwin. A few mentioned Huxley — but as many named Einstein. Other suggestions ranged from Aristotle to Attenborough, or Marconi to Mortimer Wheeler ... About two-thirds of the sample of viewers said they themselves believed in evolution; just over a tenth disbelieved the theory, the remainder having no firm opinions. Of those who said they believed in evolution, almost half were unable to advance a reason for doing so ... Asked what would ultimately happen to man ...in descending order of frequency the forecasts were: (1) that man would suffer destruction at his own hands; (2) that he would increase his power and conquer space; (3) that there would be development of brain power, or that man would lose certain parts, such as his toes. A few thought man to be "at his peak" and not likely to change further.
From *Nature* 14 June 1958.

100 YEARS AGO

Thomas Alva Edison: Sixty Years of an Inventor's Life. By Francis Arthur Jones.— This biography should do much to disillusion the impressions which are so commonly formed about successful men, that they only have to invent something to make a fortune. It shows clearly that the only road to success is through failure. His career as a telegraph operator was most precarious, and one of his first inventions—a vote-recording machine for election purposes—was refused, really because it was too ingenious and perfect; in fact, it could not be tampered with.
From *Nature* 11 June 1908.