Abstractions

LAST AUTHOR
Migrating birds don't use the Global Positioning System, so how do they know where they're going? Biologists had two theories, both based on birds' ability to sense Earth's magnetic field and use it as a compass. One theory held that clusters of iron-mineral crystals in the birds' upper beaks detect magnetic information and relay it through the trigeminal nerve to the brain. The other theory proposed that the magnetic field is detected by light-sensitive molecules in birds' eyes that communicate the information to a specialized brain region by means of a visual signal. Working with European robins (*Erithacus rubecula*), Henrik Mouritsen at the University of Oldenburg in Germany and his colleagues have found evidence that favours the second theory, and simultaneously disproved the first (see page 1274). Mouritsen tells *Nature* more.

How did you prove the second theory?
We proposed that if we inactivated cluster N — the specialized forebrain region that we believed processes signals from light-sensitive magnetosensory molecules in birds' eyes — then the magnetic compass would fail. We inactivated the region by injecting a neurotoxin, then tested the birds in small wooden huts on campus that were fitted out with magnetic coils. We observed the birds' behaviour in Earth's normal magnetic field as well as in two experimental conditions, one with the geomagnetic field turned 120 degrees anticlockwise and the other with a vertical component of the magnetic field inverted. The birds didn't orient at all.

And how did you disprove the first theory?
We cut the nerve connecting the crystal clusters in the birds' upper beak to the brain. We then put them through the same tests. They oriented perfectly in all cases.

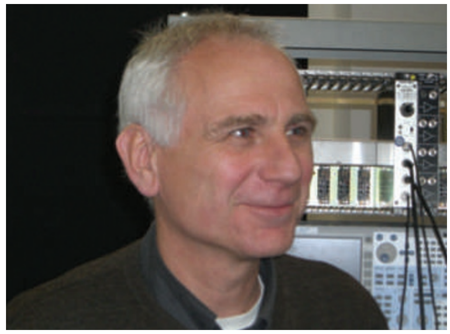
How did you know that the neurotoxin you used to inactivate cluster N didn't cause more extensive brain damage?
Birds can use the Sun and the stars as a compass, so we tested them outside at sunset and in a planetarium set to simulate local stars. They oriented wonderfully in both situations.

Why are your findings significant?
If a migratory bird species is facing extinction, conservationists might move it to a new breeding or wintering ground. The birds are shipped to a new area, but once they're released, they go straight back 'home'. For such endeavours to succeed, we need to understand the birds' navigational system to manipulate it during transportation or know how their sensory system develops and move them before they can imprint on where they were born. ■

MAKING THE PAPER

Ulli Eichmann

Physicists push excited neutral atoms to ultrafast speeds.



In working to resolve a twenty-year-old debate about what fate holds for neutral atoms blasted by a powerful laser, researchers have revealed a surprising twist. A four-strong team led by Ulli Eichmann at Berlin's Max Born Institute used lasers to accelerate neutral atoms to one of the fastest rates known in the Universe — without tearing the atoms apart.

Physicists often apply laser pulses lasting just a split second to tiny objects such as atoms. The laser's energy is transferred to the atoms, which typically become ionized, forming ions and electrons. These charged particles shoot away from the position of the laser beam. Laser-accelerated ions and electrons have already found various important applications in biology and physics, for example as optical tweasers. But the hunt is still on for techniques that can accelerate neutral particles in powerful and precise ways.

The idea that a neutral atom — so named because its equal positive and negative charges cancel each other out — might be able to survive a strong laser field intact was first mooted in the 1980s. However, it was not until 2008 that a paper provided evidence of how this might actually happen. The work suggested that the neutral atom would survive in an excited state, leading Eichmann and his colleagues to wonder whether it might be possible to accelerate neutral atoms by applying a strong laser pulse to them. "I was curious to see if we could detect this acceleration in excited states", says Eichmann.

The researchers decided to pursue the experiment using helium atoms. As an atomic featherweight, helium is easy to 'push around' with the forces supplied by the lasers. In the particle accelerator, "you apply hell to these atoms, and then you see the details", explains Eichmann. These details — revealed by a detector that measures the positions of accelerated particles — showed that excited neutral atoms had indeed survived the laser (see page 1261). Even more surprisingly, the acceleration on these particles had been ultra-strong — much higher than anything previously observed in the laboratory.

So why was this? Using a quantitative theoretical model, Eichmann and his team explain that helium's electron, which oscillates vigorously near its ionic core in response to the laser field, still lacks enough energy after the pulse to escape the core. As a result, the electron is recaptured by the core in a bound excited state. During the oscillation, however, the strongly focused laser beam induces a specific nonlinear force, or ponderomotive force, on the electron, pushing it towards areas of lower laser intensity. Caught in a tug-of-war between the atom's core and the ponderomotive force, the electron drags the core with it, accelerating the whole atom at an ultra-high rate.

According to Eichmann, examples of how such super-acceleration could be used include more precise manipulation of atom motion — much like the way in which light can be manipulated with lenses — and the deposition of atoms on the surfaces of nanostructures.

Eichmann remains most excited about the fundamental insight into strong-field and particle physics. "Twenty years ago, there was a big discussion on the stabilization of atoms in strong laser fields — but there was only indirect evidence that this was true," he says. "Our study is a strong indication that this type of configuration is as was predicted. All the people who saw this result were astonished that this worked." ■

FROM THE BLOGOSPHERE

On the Climate Feedback blog, freelance science writer Keith Kloor teases apart debates stirred up by Stephen Dubner and Steven Levitt's *Superfreakonomics*, a book that is decidedly cool on global warming (http://go.nature.com/HwNoR6).

Several rounds of blog posts between the book's authors and their critics have escalated into smear campaigns, with some calling the authors global-warming deniers. But many have focused on scientific issues. "Real Climate's Gavin Schmidt has scolded the ... authors for embracing geoengineering, which Schmidt asserted: 'is neither cheap, nor a fix ... [with] still-uncertain scientific merits'," writes Kloor. And Dubner has not yet replied to charges of huge scientific errors in the book's logic, summarized by a previous post (http://go.nature.com/Z87xTn).

You can follow the whiplashing exchanges on the topic through Kloor's post, which also includes links to unusual climate-related news, such as the decision by computer company Apple to drop its US Chamber of Commerce membership in response to "the latter's hostility to regulatory action on global warming". ■

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