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Lightning is only the most visible product of clouds' intense electric fields.

PHYSICS

Rogue antimatter found in clouds

Aeroplane detects signature spike in thundercloud photons that does not fit any known source of antiparticles.

BY DAVIDE CASTELVECCHI

When Joseph Dwyer's aeroplane took a wrong turn into a thundercloud, the mistake paid off: the atmospheric physicist flew not only through a frightening storm but also into an unexpected — and mysterious — haze of antimatter.

Although powerful storms have been known to produce positrons — the antimatter versions of electrons — the antimatter observed by Dwyer and his team cannot be explained by any known processes, they say. "This was so strange that we sat on this observation for several years," says Dwyer, who is at the University of New Hampshire in Durham.

The flight took place six years ago, but the team is only now reporting the result (J. R. Dwyer *et al. J. Plasma Phys.*; in the press). "The observation is a puzzle," says Michael Briggs, a physicist at the NASA Marshall Space Flight Center in Huntsville, Alabama, who was not involved in the report.

A key feature of antimatter is that when a particle of it makes contact with its ordinary-matter counterpart, both are instantly transformed into other particles in a process known as annihilation. This makes antimatter exceedingly rare. However, it has long been known that positrons are produced by the decay of radioactive atoms and by astrophysical phenomena, such as cosmic rays plunging into the atmosphere from outer space. In the past decade, research by Dwyer and others has shown that storms also produce positrons, as well as highly energetic photons, or γ-rays.

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It was to study such atmospheric γ-rays that Dwyer, then at the Florida Institute of Technology in Melbourne, fitted a particle detector on a Gulfstream V, a type of jet plane typically used by business executives. On 21 August 2009, the pilots turned towards what looked, from its radar profile, to be the Georgia coast. "Instead, it was a line of thunderstorms — and we were flying right through it," Dwyer says. The plane rolled violently back and forth and plunged suddenly downwards. "I really thought I was going to die."

During those frightening minutes, the detector picked up three spikes in γ-rays at an energy of 511 kiloelectronvolts, the signature of a positron annihilating with an electron.

Each γ-ray spike lasted about one-fifth of a second, Dwyer and his collaborators say, and was accompanied by some γ-rays of slightly lower energy. The team concluded that those γ-rays had lost energy as a result of travelling some distance and calculated that a short-lived cloud of positrons, 1–2 kilometres across, had surrounded the aircraft. But working out what could have produced such a cloud has proved hard. "We tried for five years to model the production of the positrons," says Dwyer.

Electrons discharging from charged clouds accelerate to close to the speed of light, and can produce highly energetic γ-rays, which in turn can generate an electron–positron pair when they hit an atomic nucleus. But the team did not detect enough γ-rays with sufficient energy to do this.

Another possible explanation is that the positrons originated from cosmic rays, particles from outer space that collide with atoms in the upper atmosphere to produce short-lived showers of highly energetic particles, including γ-rays. "There's always like a light drizzle of positrons," says Dwyer. In principle, there could be some mechanism that steered the positrons towards the plane, he says. But the motion of positrons would have created other types of radiation, which the team did not see.

The team's data are a "cast-iron signature" of positrons, says Jasper Kirkby, a particle physicist who heads an experiment investigating a possible link between cosmic rays and cloud formation at the CERN particle-physics laboratory near Geneva, Switzerland. But "the interpretation needs to be nailed down". In particular, he says, the team's estimate of the size of the positron cloud is not convincing.

If Kirkby is right, and the cloud was smaller than Dwyer's team estimates, that could imply that the positrons were annihilating only in the immediate vicinity of the aircraft, or even on the craft itself. The wings could have become charged, producing extremely intense electric fields around them and initiating positron production, says Aleksandr Gurevich, an atmospheric physicist at the Lebedev Physical Institute in Moscow.

To answer these and other questions, Dwyer needs fresh observations of the innards of thunderclouds. To that end, he and others are sending balloons straight into the most violent storms, and the US National Science Foundation even plans to fly a particle detector on an A-10 'Warthog' — an armoured anti-tank plane that could withstand the extreme environment. "The insides of thunderstorms are like bizarre landscapes that we have barely begun to explore," says Dwyer. ■