

# Lost in Los Angeles

I was driving around Los Angeles a few weeks ago, lost, and relying on a global positioning system receiver to guide me through the maze of freeways and unfamiliar streets. In the unending traffic jams, I had plenty of time to ponder and, surprisingly perhaps, my thoughts turned to Einstein.

2005 has been named World Year of Physics, to celebrate the centenary of Albert Einstein's 'miracle year', in which he wrote five seminal papers. The whole world is familiar with  $E = mc^2$ , but really it was Einstein's development of general relativity a decade later — and the dramatic confirmation in 1919 of the predicted bending of light, a consequence of interpreting gravity as a curvature of space — that catapulted him to the kind of superstar

status that warrants a whole year being named in his honour.

General relativity was perhaps the most objectively cerebral theoretical development in modern physics. It was not a response to an experimental problem (the precession of the perihelion of Mercury didn't seem to need a revolution in physics to explain it), and direct laboratory confirmation only took place over a quarter century after the theory was first written down.

But without that exotic theory of spacetime, I wouldn't have been able to find my way around LA. Global positioning systems rely on the timing of signals sent from several satellites located thousands of miles apart. However, the internal clocks of GPS satellites tick at rates that are shifted, according to gen-



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eral relativity, depending on their position in the Earth's gravitational field. Without correcting for that, GPS would not work properly.

Einstein didn't develop general relativity because he wanted to find a better way to track his own position, even if the technology had been available. But it is hard to think of a better example than this of the cross-germination between fundamental scientific investigation and technological innovation.

In this World Year of Physics, as economic pressures have led to cuts in funding for fundamental research in many industrialized countries, it is worth reflecting on this connection — at least the next time you're caught in traffic and looking for an alternative route.

**Lawrence M. Krauss**