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Physics

Wanted: Einstein Jr

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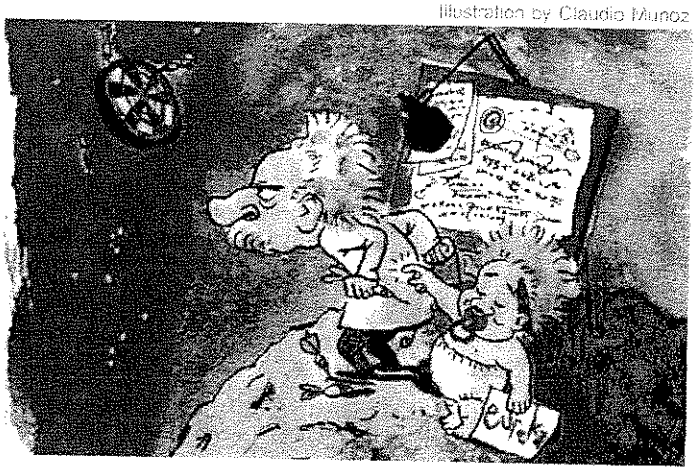

Something seems wrong with the laws of physics. Spacecraft are not behaving in the way that they should

MIGHTY oaks from little acorns grow. In the 1840s an astronomer called Urbain Le Verrier noticed there was something wrong with the orbit of Mercury. The main axis of the planet's orbital ellipse shifts each time it goes round the sun. That was well known, and is caused by the gravitational pull of Venus. Le Verrier, however, realised that the orbit was shifting too fast. The excess was a tiny fraction of a degree. But it was a disturbing departure from the purity of Newton's majestic clockwork—a departure that was explained only 70 years later, when Einstein's general theory of relativity swept Newton away by showing that gravity operates by distorting space itself.

Even Einstein, however, may not have got it right. Modern instruments have shown a departure from his predictions, too. In 1990 mission controllers at the Jet Propulsion Laboratory (JPL) in Pasadena, California, which operates America's unmanned interplanetary space probes, noticed something odd happen to a Jupiter-bound craft, called *Galileo*. As it was flung around the Earth in what is known as a slingshot manoeuvre (designed to speed it on its way to the outer solar system), *Galileo* picked up more velocity than expected. Not much. Four millimetres a second, to be precise. But well within the range that can reliably be detected.

Once might be happenstance. But this strange extra acceleration was seen subsequently with two other craft. That, as Goldfinger would have put it, looks like enemy action. So a team from JPL has got together to analyse all of the slingshot manoeuvres that have been carried out over the years, to see if they really do involve a small but systematic extra boost. The answer is that they do.

Altogether, John Anderson and his colleagues analysed six slingshots involving five different spacecraft. Their paper on the matter is about to be published in *Physical Review Letters*. Crucially for the idea that there really is

a systematic flaw in the laws of physics as they are understood today, their data can be described by a simple formula. It is therefore possible to predict what should happen on future occasions.

Gravity's rainbow

That is what Dr Anderson and his team have now done. They have worked out the exact amount of extra speed that should be observed when they analyse the data from a slingshot last November, which involved a craft called *Rosetta*. If their prediction is correct, it will confirm that the phenomenon is real and that their formula is capturing its essence. Although the cause would remain unknown, a likely explanation is that something in the laws of gravity needs radical revision.

Dr Anderson and his team have, of course, gone through painstaking efforts to rule out conventional physical explanations and systematic errors. Their model takes into account both general relativity and all known gravitational effects of the sun, the moon, the planets and large asteroids. Effects stemming from the Earth's atmosphere, from ocean tides and from the solar wind of charged particles were all found to be too small to explain the spacecrafts' extra velocity. And to rule out computer bugs, independent groups verified the calculations using several different versions of the modelling software.

Furthermore, because the effect is present in data from five vehicles—*Galileo*, the *Cassini* mission to Saturn, the *MESSENGER* craft sent to Mercury, and the *NEAR* and *Rosetta* missions to study asteroids and comets—the team thinks it is unlikely to be caused by the spacecraft themselves. Each has a unique design, so a systematic machine-related error is unlikely.

Dr Anderson is no stranger to anomalous behaviour by spacecraft. In the early 1970s *Pioneer 10* and *Pioneer 11* were sent to fly past Jupiter and Saturn. Once their missions were accomplished, they carried on into the outer reaches of the solar system. He and his colleagues noticed soon afterwards that the sibling crafts' trajectories were deviating from those predicted by Einstein. Both *Pioneers* act as though an extra force beyond mere gravity is tugging at them from the direction of the sun.

Thirty years later, no explanation for this has been found. Each year the *Pioneers* fall a further 5,000km behind their projected paths. Hundreds of scientific papers have been written on the *Pioneer* anomalies, many of them trying to find explanations beyond the current laws of gravity.

Dr Anderson himself points out that several features of the *Pioneer* anomalies and the slingshot anomalies suggest they may have a common explanation. Both, for example, involve small objects. By contrast, the data on which Newton and Einstein built their theories were from stars, planets and moons. In addition, the spacecraft in question are all travelling in types of orbit not usually seen in natural systems. Not for them the closed ellipses of Mercury and the other planets; at the whim of their masters in Pasadena they are following much more unusual hyperbolic curves.

What it all means is not yet clear. Perhaps there is some overlooked explanation within the laws of physics. But Le Verrier thought that must be so for his discovery, too. He and later astronomers spent decades looking for the missing planet within the orbit of Mercury which, they were convinced, explained what was going on. They even gave it a name: Vulcan. But it wasn't there.

There is a good chance that modern physics is in a similar situation. It would be nice, therefore, to believe that somewhere, the contemporary equivalent of a bored patent clerk is thinking about the problem, and that when he has thought hard enough, a new reality will emerge.