

## Why we should learn to love anomalies

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AFP Anomalies and impossibilities are the crucial engines in bettering our understanding of the universe.

Anomalies can be annoying, they can niggle and cause discomfort. Some experimental measurement comes along that seems to be ignorant of the established order and breaks the rules. Perplexed by what is happening, people come up with conflicting accounts of what might be happening.

Ideas get knocked off pedestals, confidence is knocked. Frustrating, for sure, but necessary, too: anomalies and impossibilities are the crucial engines in bettering our understanding of the universe.

Take the recent question of whether neutrinos, a type of near-mass-less subatomic particle, can travel faster than light. Scientists at the Cern lab in Geneva fired a beam of these particles through 720km of rock towards detectors in the Gran Sasso lab in Italy. The neutrinos seemed to arrive a little earlier than expected. There was massive scientific scrutiny of the experiment, the results and the many new theories that might account for the anomaly.

The reason scientists are so exercised is that the Gran Sasso result seems to break Albert Einstein's special theory of relativity, a so-far unassailed set of rules that assumes nothing in the universe can travel faster than a value,  $c$ , equivalent to the speed of light in a vacuum.

The world would look very different to physicists if Einstein's ideas turn out to be flawed. Time travel would turn out to be possible, and causality would be challenged — effects could come before causes. Will the Gran Sasso result embarrass the know-it-all physicists, knock them off their pedestals by showing how wrong they have been all along? Well, no. As weird as it all sounds, anomalies are par for the course in physics. Special relativity itself came from trying to fix a big anomaly more than 100 years ago.

At the start of the 20th century, Einstein noticed a conflict between the recent work of Scottish physicist James Clerk Maxwell and the more established ideas of Isaac Newton. Maxwell showed that light was a vibration in the electromagnetic field, and that it travelled at a constant speed,  $c$ , in a vacuum.

Much earlier, Newton had come up with his laws of motion, which sensibly showed that the velocity of an object differed depending on who was measuring it and from where.

Try applying that to electromagnetic waves, though, and you run into a problem: nothing in Maxwell's work allowed electromagnetic waves, such as light, to change their speed depending on relative motion.

Whatever you did, however you moved the source of the waves, however you moved relative to them, the waves themselves would move at the same speed. Einstein started with this hanging thread, the invariance in the speed to light, and tugged at it to unravel Newton's description of the

universe. Crucially, he found a hitherto unnoticed flexibility in the measurement of space and time.

To make the equations of physics carry on working, Einstein showed that the length of any moving object must shrink in the direction of its travel. If the object reaches the speed of light, its length would disappear to zero.

Anyone moving with the object would not notice any change in size; only those observers in a different frame of reference would see the contraction in the object's length.

The anomaly noticed by Einstein kicked off one of the greatest revolutions in our understanding of the fabric of the universe. There is much checking, re-checking and repetition to do before the Gran Sasso anomaly is proved or disproved. If the results do turn out to be correct physicists will have to correct Einstein, in the way he corrected Newton. That's not embarrassing, worrying or pedestal-knocking, it's just progress. — © **Guardian Newspapers Limited, 2011**

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