Does antimatter weigh more than matter? Lab experiment to find out the answer

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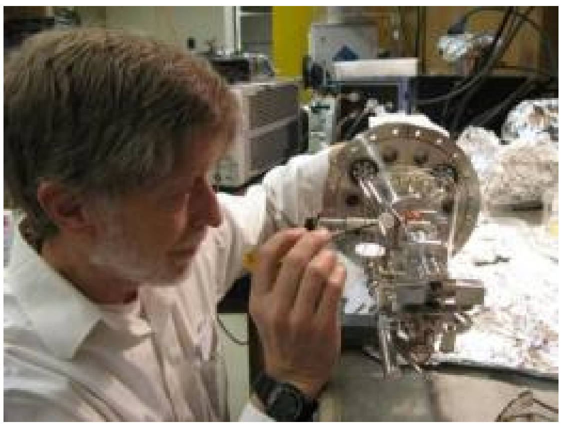

This photo shows Allen Mills, a professor of physics and astronomy at the University of California, Riverside, in the lab. Credit: Mills lab, UC Riverside.

Does antimatter behave differently in gravity than matter? Physicists at the University of California, Riverside have set out to determine the answer. Should they find it, it could explain why the universe seems to have no antimatter and why it is expanding at an ever increasing rate.

In the lab, the researchers took the first step towards measuring the free fall of "positronium" – a bound state between a positron and an electron. The positron is the antimatter version of the electron. It has identical mass to the electron, but a positive charge. If a positron and electron encounter each other, they annihilate to produce two gamma rays.

Physicists David Cassidy and Allen Mills first separated the positron from the electron in positronium so that this unstable system would resist annihilation long enough for the physicists to measure the effect of gravity on it.

"Using lasers we excited positronium to what is called a Rydberg state, which renders the atom very weakly bound, with the electron and positron being far away from each other," said Cassidy, an assistant project scientist in the Department of Physics and Astronomy, who works in Mills's lab. "This stops them from destroying each other for a while, which means you can do experiments with them."

Rydberg atoms are highly excited atoms. They are interesting to physicists because many of the atoms' properties become exaggerated.

In the case of positronium, Cassidy and Mills, a professor of physics and astronomy, were interested in achieving a long lifetime for the atom in their experiment. At the Rydberg level, positronium's lifetime increases by a factor of 10 to 100.

"But that's not enough for what we're trying to do," Cassidy said. "In the near future we will use a technique that imparts a high angular momentum to Rydberg atoms," Cassidy said. "This makes it more difficult for the atoms to decay, and they might live for up to 10 milliseconds – an increase by a factor of 10,000 – and offer themselves up for closer study."

Cassidy and Mills already have made Rydberg positronium in large numbers in the lab. Next, they will excite them further to achieve lifetimes of a few milliseconds. They will then make a beam of these super-excited atoms to study its deflection due to gravity.

"We will look at the deflection of the beam as a function of flight time to see if gravity is bending it," Cassidy explained. "If we find that antimatter and matter don't behave in the same way, it would be very shocking to the physics world. Currently there is an assumption that matter and antimatter are exactly the same – other than a few properties like charge. This assumption leads to the expectation that they should both have been created in equal amounts in the Big Bang. But we do not see much antimatter in the universe, so physicists are searching for differences between matter and antimatter to explain this."

Study results appear in the Jan. 27 issue of *Physical Review Letters*.

Cassidy and Mills expect to attempt the next step in their gravity experiments this summer.

Provided by University of California - Riverside