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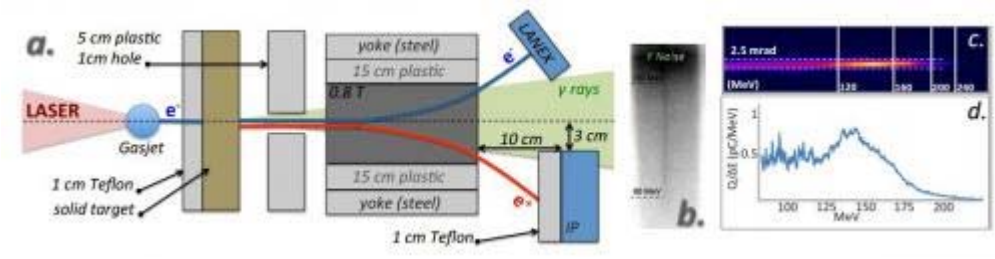
Physicists create tabletop antimatter 'gun'

Jun 25, 2013 by Bob Yirka



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a. Top-view of the experimental setup. Plastic and Tefon shielding was inserted to reduce the noise due to low energy divergent particles and x-rays. b. Typical positron signal as recorded by the Image Plate. The region labelled with gamma noise is predominantly exposed by the gamma-rays escaping the solid target. c. Typical signal of the electron beam as recorded on the LANEX screen, without a solid target and d. extracted spectrum. Credit: arxiv.org/abs/1304.5379

(Phys.org) —An international team of physicists working at the University of Michigan has succeeded in building a tabletop antimatter "gun" capable of spewing short bursts of positrons. In their paper published in the journal *Physical Review Letters*, the team describes how they created the gun, what it's capable of doing, and to what use it may be put.

Positrons are anti-particles, the opposite twin of electrons. Besides being created in physics labs, they are also found in jets emitted by black holes and pulsars. To date, the creation of positrons for study has involved very big and expensive machines. One of those is the particle accelerator at CERN. Another is a device built by scientists at Lawrence Livermore National Laboratory that created positrons by firing a hugely powerful laser at a tiny disc made of gold. Other recent work by researchers at the University of Texas has involved building a desktop sized accelerator. This new effort builds on that work—this team has built a device not more than a meter long that is capable of generating short bursts of both electrons and positrons, very similar they report, to what is emitted by black holes and pulsars.

To achieve this feat, the team fired a petawatt laser at a sample of inert helium gas. Doing so caused the creation of a stream of electrons moving at very high speed. Those electrons were directed at a very thin sheet of metal foil which caused them to smash into individual metal atoms. Those collisions resulted in a stream of electron and positron emissions—the two were then separated using magnets.

The researchers report that each blast of their gun lasts just 30 femtoseconds, but each firing results in the production of quadrillions of positrons—a density level comparable to those produced at CERN. The researchers suggest their device could be used to mimic the jet streams from black holes and/or pulsars, hopefully offering some answers to questions such as, what sort of proportion of particles are present in such streams, how much energy is in them, and in what ways do the particles in them interact with the environment into which they are spewed.

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More information: Table-Top Laser-Based Source of Femtosecond, Collimated, Ultrarelativistic Positron Beams, *Phys. Rev. Lett.* 110, 255002 (2013). prl.aps.org/abstract/PRL/v110/i25/e255002 . On Arxiv: arxiv.org/abs/1304.5379

Abstract

The generation of ultrarelativistic positron beams with short duration ($\tau_{e^+} \simeq 30$ fs), small divergence ($\theta_{e^+} \simeq 3$ mrad), and high density ($n_{e^+} \simeq 10^{14}$–10^{15} cm^{-3}) from a fully optical setup is reported. The detected positron beam propagates with a high-density electron beam and γ rays of similar spectral shape and peak energy, thus closely resembling the structure of an astrophysical leptonic jet. It is envisaged that this experimental evidence, besides the intrinsic relevance to laser-driven particle acceleration, may open the pathway for the small-scale study of astrophysical leptonic jets in the laboratory.

via Synopsis

Journal reference: Physical Review Letters

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hemitite

-

1 / 5 (2) Jun 25, 2013
Perhaps something like this gizmo could drive a gamma ray laser.

I wonder if such a device could see into the workings of nuclei like x-ray lasers can "freeze frame" chemical reactions?

JamesG

-

2 / 5 (4) Jun 25, 2013
Haha. Someone please tell me this doesn't do EVERYTHING those big multi-billion dollar units do. If so, someone is going to be really embarrassed.

I know that sounds ignorant but, hey, ignorant is as ignorant does. My total physics training comes from reading this site.

shavera

-

5 / 5 (2) Jun 25, 2013
JamesG, no it doesn't necessarily do everything, it only generates positrons. Furthermore, it's a Petawatt laser, a big multi-million/billion dollar unit as well. This is just a novel way of using such a laser to produce positrons.

WernerC

-

4.2 / 5 (5) Jun 25, 2013
Tell me when they make one small enough to attach to the freakin head of a freakin shark... I'll buy 5 then.

PosterusNeticus

-

4 / 5 (4) Jun 25, 2013
"Tabletop" is a tad misleading as the entire setup involved a great big laser and a supersonic jet of high-pressure helium and the equipment that goes along with it. Altogether that makes for one heck of a table.

Don't get me wrong; I don't mean to take anything away from this remarkable experiment. And the apparatus itself did fit on the benchtop so the headline isn't completely wrong.

eshaw

-

3.5 / 5 (2) Jun 25, 2013
They said it produces both electrons and positrons. Does it produce both at the same rate? If so this could possibly generate a lot of energy. Say they made a quadrillion pairs annihilate that would be roughly 160 J to the 30 J used by the petawatt laser over 30 fs. (annihilation energy ~ 1 MeV, multiplied by quadrillion and converted to joules is 160 J)

winthrom

-

5 / 5 (1) Jun 25, 2013
There is a good discussion of the Hercules device here:

http://www.engine...tt-Laser

Regards the Laser source for this experiment, this video is 3 years old. Apparently the increase in power described in the video has been achieved.

Kudos to U of M Physics Department.

The unit shown is a large room sized device (see video). The video says they might be able to reduce the size, and/or increase the power.

antialias_physorg

3.7 / 5 (6) Jun 25, 2013

> If so this could possibly generate a lot of energy.

Orders of magnitude less than it takes to make the laser light. Making laser light for high intensity lasers is a very inefficient process.
The HERCULES laser system used here is a Titan-Spahire laser which itself is 5-10% efficient (i.e. 90-95% of input energy is lost as heat and not converted into laser light in the last stage)
Ti-Sa lasers are usually pumped via neodym-yag lasers (which have themselves an efficiency of 3-5%.). So we're looking at a compound efficiency of 0.15% to 0.5% tops (not counting losses in other systems).

Read: Under most optimistic assumptions 30J laser light cost you (at least) 6000J to make.

No free lunch (i.e.no perpetuum mobile), here.

rebelclause

2.3 / 5 (3) Jun 25, 2013
If two or more of these converged annihilation at a point in space would the mass/gravity at that point be altered, and what speculation as to energy requirements to make pulsed gravity useful in space -- for travel or diverting objects -- if at all possible?

LarryD

1 / 5 (2) Jun 25, 2013

> Haha. Someone please tell me this doesn't do EVERYTHING those big multi-billion dollar units do. If so, someone is going to be really embarrassed.
>
> I know that sounds ignorant but, hey, ignorant is as ignorant does. My total physics training comes from reading this site.

Yes I understand being a layman myself. A little while back I posted a very similar remark about a lab size 'collider'. Even though they may less energy efficient I think these mark the beginning of the end for those multi kilometer machines. Scientists will gradually improve the performance. There is just one thing that bothers me...the military. While LHC etc are massive they can't be built into Naval and Airforce tactical craft but once the size is reduced... But then this happens anyway so carry on chaps, all great stuff as far as I'm concerned.

Osiris1

1.7 / 5 (6) Jun 26, 2013
Now if we could store those positrons in a stable manner and use them later on.....Store enough of them and we could have a propulsion system. But if anything goes wrong, then we have a large bang. Earthbound generation not a problem if we use some kind of renewable energy source to make them, like photovoltaic solar. It is the storage that is the rub... comments?!

ROBTHEGOB

-

1.8 / 5 (5) Jun 26, 2013
Arm the photon torpedoes.

vidyunmaya

-

1 / 5 (7) Jun 26, 2013
old wine in new bottle-why all this fuss?

nkalanaga

-

1 / 5 (1) Jun 26, 2013
For use on Earth it's likely to be too dangerous. For space propulsion AM is a great energy storage/transport system. It also has the advantage that solar energy is readily available in space, so one could make and store the AM "out there". If something goes wrong all you lose is the space station, not a chunk of your country.

adam_russell_9615

-

1 / 5 (3) Jun 29, 2013
Congrats. I think this is an awesome achievement.

Humpty

-

1 / 5 (5) Jul 01, 2013
We should be careful, as it might set the atmosphere on fire.

antialias_physorg

-

3 / 5 (2) Jul 01, 2013

> ..Store enough of them and we could have a propulsion system.

That's a bit of a problem, as storage of antimatter takes energy (you must confine it in a magentic trap. It must not touch any walls)

So you can do the math on when antimatter storage will not be worth it. I.e. if you have very long travel times (say to the next solar system) then the amount of energy needed to confine the antimatter until it is used will at some point be greater than the energy delivered by the antimatter itself.

Positrons are also all electrically positively charged, so they repel each other with an enormous force. This makes storage increasingly difficult (read: energy intensive) the more you wish to store.

That said, if you could capture 100% of all created positrons then you'd need a billion (10^12) shots of this apparatus to create 1 gram of positrons (which is about enough to get a smallish probe to Mars according to NASA).

antialias_physorg

-

2.3 / 5 (3) Jul 01, 2013
Just fo completness sake a NASA estimate (from 1999) quotes the cost of producing 1 gram of antimatter in excess of 60 trillion dollars. Certainly that figure has come down somewhat but I'd still guess it's not an inexpensive fuel to make.

> The mass energy conversion during cold fusion is of the same order

No it is not. If cold fusion is (better: if it were) a fusion process then the conversion efficiency is more than 2 orders of magnitude lower than an antimatter process (3 orders for fission and 10 orders for chemical fuels).

In fission and fusion only bonding energies (electromagnetic and strong nuclear forces respectively) contribute to released energy. In antimatter you have a total annihilation.

> because during its reaction with matter many pions and another unstable particles are generated

You get gammas if you mix positrons and electrons. Why would you mix positrons with anything else for fuel?

Doc Brown

-

2.3 / 5 (6) Jul 01, 2013

> So I would guess, the effective conversion of cold fusion to energy is already higher.

Mr. Natello,

I have asked previously that you and Mr. Valeria desist infringing on the patent protected cold fusion methods used to

power my flux capacitor drive Delorean time machine. This will be your last desist notice. I will seek legal remedy if you continue to infringe on my intellectual property.

Sincerely,

Emmett Brown, Scientist
Hill Valley, U.S.A.

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