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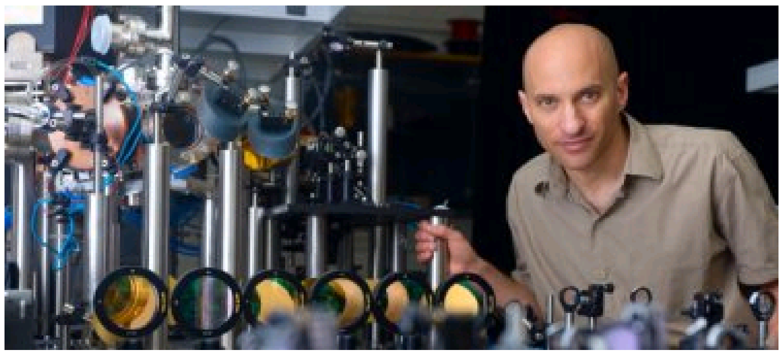
NEWS

Jun 16, 2009

Black-hole analogue traps sound



Jeff Steinhauer hopes to detect Hawking radiation in the lab

Physicists in Israel have created a black-hole analogue that can trap sound in the same way an astrophysical black hole can trap light. The system, which comprises a “density-inverted Bose–Einstein condensate”, may present one of the best chances yet to detect elusive Hawking radiation.

In an astrophysical sense, a black hole is a region of space so dense that the gravity at its centre approaches infinity. Surrounding this region is the so-called event horizon, beyond which nothing — not even light — can escape.

For a long time, the notion that black holes are totally black led scientists to think the objects could not be observed directly. But in the early 1970s, Stephen Hawking, building on work by Jacob Bekenstein of the Hebrew University of Jerusalem, showed that this need not be the case. Hawking’s calculations indicated that if a particle–antiparticle pair came into existence straddling the event horizon, the one closest to the black hole would fall inwards while the other would escape. The sum of escaped particles would constitute Hawking radiation, and could reveal the black hole’s presence.

The trouble is that the temperature of Hawking radiation would be much lower than the universe’s background radiation, and therefore would be difficult to make out. For this reason, several research groups have attempted to create analogues of black holes in the lab, where they can decrease the background temperature. However, so far none of these systems — which include optical fibres and quantum fluids — have yielded Hawking radiation that could be detected.

Two potentials

Jeff Steinhauer and colleagues of the Israel Institute of Technology "Technion" in Haifa have perhaps got a step further with their sonic black hole. Their system comprises a Bose–Einstein condensate (BEC), or a collection of cold atoms that move coherently in the same quantum state.

The BEC contains two potentials: one crater-shaped "harmonic" potential, which is formed via magnetic fields, and a deeper, superimposed "Gaussian" potential, which is formed with a laser beam. By shifting the potential sideways, the researchers found that atoms fell in and climbed out of the potential at a speed faster than sound in the medium, or about 1 mm/s.

This supersonic travel is key to the success of the system. If a sound wave approaches the atoms in the opposite direction as their movement, it will reach the atoms but will never be able to leave. In this instance, the moving atoms act as a sonic "black hole", from which no sound can leave. Conversely, if the atomic flow "velocity gradient" is altered, the sound wave will never reach the atoms, in which case they act as a sonic "white hole"..

The Israeli group's evidence for this effect came by mapping the density of the atomic clouds in and around the Gaussian potential minimum. Although they do not yet have evidence for Hawking radiation — which in this type of system would constitute packets of sound energy or "phonons" — they predict the Hawking temperature to be at a temperature in the region of 0.3 nK. Just an order-of-magnitude increase in this temperature should be enough to make the Hawking radiation visible, they say.

Good system

Renaud Parentani, a theorist at the University Paris-Sud in France who studies black-hole analogues, thinks the Israeli group's experiment marks "a new step" towards seeing Hawking radiation in a condensed-matter environment. In particular, he has done calculations to show that this type of quantum-fluid system should suffer less from dispersion — which limits the production of particle-antiparticle pairs at the event horizon — than other recently tried systems, such as fibre optics.

Parentani says that if the researchers can achieve an order-of-magnitude increase in temperature, it could become easier to detect Hawking radiation. However, he points out — as do the researchers themselves — that they may still see it without such an increase if the black- and white-hole analogues work together to amplify the signal. In this theory, which was devised by Steven Corely of the University of Alberta, Canada, and Ted Jacobson of the University of Maryland, US, in 1999, the system behaves like a laser, so that the Hawking radiation becomes more intense than the temperature alone would imply.

The research is described in detail at *arXiv*: 0905.0777.

About the author
Jon Cartwright is a freelance journalist based in Bristol, UK

12 COMMENTS

Add your comments on this article

Oliver K. Manuel
Jun 16, 2009 10:03 PM
United States

1

INTRIGUING!
The only question is whether the public will appreciate the study of black hole sound traps.

Oliver K. Manuel
www.omatumr.com...

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Neeyik
Jun 17, 2009 9:15 AM
Workington, United Kingdom

2

A good portion of scientific research won't be appreciated/understood by, or of interest to, the general public, so why point this out?

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jmcaneney
Jun 17, 2009 9:25 AM
BANGOR, United Kingdom

3

Quote:

> Originally posted by Neeyik
> A good portion of scientific research won't be appreciated/understood by, or of interest to, the general public, so why point this out?

Indeed, most scientific research is not even reported to the general public unless it comes with a specific sensationalist view point that captures the attention of the Tabloids. The recent concerns of the LHC in the demise of the planet springs to mind, which may as well have read "LHC ate my hamster" for some of the papers.

As you say, much of it is not of interest to Joe Public, so why should newspapers for example use it to sell newspapers, when scantily clad pictures of popstars do it better.

Reply to this comment ▸ Offensive? Unsuitable? Notify Editor ▸

Neeyik
Jun 17, 2009 1:05 PM
Workington, United Kingdom

4

At least we haven't reached the stage where scantily clad physicists are denying that the LHC will induce hamster-eating black holes...

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steffen.schaefer
Jun 17, 2009 4:16 PM
Marseille, France

5

black hole trapping comments
I am probably not the only member of the general public of physicsworld who would be interested by a black hole trapping comments by Oliver K Manuel :-)

Reply to this comment ▸ Offensive? Unsuitable? Notify Editor ▸

unitygain
Jun 19, 2009 11:45 PM
United States

6

Quote:
> Originally posted by steffen.schaefer
> I am probably not the only member of the general public of physicsworld who would be interested by a black hole trapping comments by Oliver K Manuel :-)

That ain't what he talked about, though. He talked about the interest of the public in the research, which is a social question. And an irrelevant one. Hell, most folks are oblivious to the art of using their bodies, a much more 'tangible' experience. Next.

Reply to this comment ▸ Offensive? Unsuitable? Notify Editor ▸

Wizards Eye
Jun 20, 2009 11:00 PM
Palm Beach Gardens, United States

7

"Manuel Radiation"
Obviously intelligent, Mr. Manuel's comments, at times, can seem a little "holier than thou". I think Mr. Schaefer's comment, while somewhat sarcastic, was not completely uncalled for. Anyway, I agree with "Muggz's" comment. This may be a case of invention preceding necessity. Along the lines of silica being formed into glass a "few days" before anyone ever needed a fiber optic cable. After all is said and done it's up to the scientific community to decide what to do with the technology, public interest aside.

On a lighter note, I seem to recall a story about not a hamster, but a gerbile being captured by a black hole. Not by a scantilly clad popstar, but a well-to-do Hollywood actor. Who I'm sure needs not be named here. Point being that the media wouldn't touch that story with a ten foot pole. So, while we still have it, let's enjoy the seperation of science and news while we can. Those interested can find what they need when they want it. Or haven't you heard that a little information can be dangerous?

Quote:
> Originally posted by unitygain
>
> Quote:
> > Originally posted by steffen.schaefer
> > I am probably not the only member of the general public of physicsworld who would be interested by a black hole trapping comments by Oliver K Manuel :-)

> That ain't what he talked about, though. He talked about the interest of the public in the research, which is a social question. And an irrelevant one. Hell, most folks are oblivious to the art of using their bodies, a much more 'tangible' experience. Next.

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rlockyer
Jun 17, 2009 4:58 PM
South Wonston, United Kingdom

8

mmmmm, an application that traps sound waves. I can see a domestic application already.

Just patenting the Naginator

;-)

Edited by rlockyer on Jun 17, 2009 5:00 PM.

Reply to this comment ▶ Offensive? Unsuitable? Notify Editor ▶

Muggz
Jun 18, 2009 2:18 PM
Canada

9

I'm probably jumping ahead here, but wouldn't the public be interested if this technology could somehow create the first truly silent aircraft? Of course it would be a long way away, but it would be interesting to see this research applied to engine design.

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andy.kelt
Jun 19, 2009 9:42 AM
Chelmsford, United Kingdom

10

I find all this very baffling. Presumably this Hawkins Pair, to start with, is entangled. Do they ever become disentangled, and if so, at which point? We have one spiralling off towards an infinite gravity well, but never quite getting there because of no passage of time , whilst the other, in a completely different temporal state, (or is it, I mean is it still entangled or not?). What's going on?

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dratman
Jun 19, 2009 10:07 AM
cherry Hill, United States

11

This line of inquiry suggests that the "black hole" puzzle -- or paradox, as one might be inclined to view it -- comes into being because there exist both particles with mass as well as those lacking mass. This "ultimate difference" seems to create a kind of Michaelson-Morely experiment, but with a positive outcome, detecting a sort of absolute threshold beyond which the usual no-preferred-frame-of-reference rules seem to fail. Such a threshold shows itself only under edge conditions such as those created by a fathomless gravity well or a non-causal fluid.

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ASTRON551
Jun 19, 2009 2:08 PM
okc, United States

12

blackhole and or x ray source
look at the possiblies of a blackhole even formulating down on this planet of what we call earth, is it really possible. not really that big but do you think that we could have created a blackhole. please explain?

Reply to this comment ▶ Offensive? Unsuitable? Notify Editor ▶

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