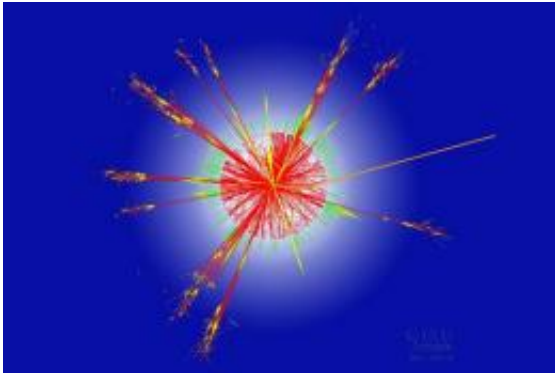


What are 'mini' black holes?

March 29 2010, by Pete Wilton



Simulated production of a black hole in ATLAS. This track is an example of simulated data modelled for the ATLAS detector on the LHC. These tracks would be produced if a miniature black hole was created in the proton-proton collision. Such a small black hole would decay instantly to various particles via a process known as Hawking radiation.

In films and books black holes capture unwary spaceships and planets, gobble up whole galaxies or offer portals to other parts of the Universe.

So the idea that, with the start of the [Large Hadron Collider](#) (LHC), physicists finally had a machine powerful enough to, potentially, create 'mini' black holes caused some alarm.

But what do we really know about black holes? And how would a 'mini' one be different from their giant cousins lurking out there in space?

'The simplest black holes are objects with a singularity in the centre and

that are surrounded by an ‘event horizon’,’ explains Cigdem Issever of Oxford University’s Department of Physics. ‘Once something comes closer to the black hole than the radius of the [event horizon](#), it is not able to leave: even light can’t escape and so the name ‘black hole’ was given to these objects by John Archibald Wheeler back in 1967.’

A hole in the Sun

Producing black holes turns out to be about mass (energy): squeeze mass into a sphere with a radius equal to what’s known as the ‘Schwarzschild radius’ - a threshold beyond which gravity causes an object of a certain density to collapse in on itself - and a black hole will form.

‘In fact the size of the Schwarzschild radius is directly proportional to the amount of mass that is squeezed in, as well as being directly proportional to the strength of gravity,’ Cigdem tells me.

‘For example, in order to form a black hole out of our Earth, you would need to squeeze its mass into a sphere about the size of a marble (radius 8.9 mm). By comparison the Schwarzschild radius of the sun is about 3 km.’

So what would happen if we swapped our Sun for a black hole?

‘If we replaced our Sun with a black hole of the same mass, surprisingly, not much would change in our solar system. The planets’ orbits would stay the same because the [gravitational field](#) that the black hole would produce would be exactly the same as that of the Sun. Although, admittedly, the [solar system](#) would be a bit dark and cold!’

But Cigdem’s interest in black holes isn’t theoretical, as a particle physicist she will be searching for signatures of ‘mini’ black holes in the LHC collisions:

‘I became interested in them as a particle physicist back in 2003 because extra dimension models predicted that they may be produced in high-energetic cosmic rays and, if so, even in particle accelerators. If we are really able to produce them, they could give us experimental insights into quantum gravitational effects.’

She hopes that studying them may lead to a formulation of a theory of quantum gravity: marrying Einstein’s theory of general relativity (which describes gravity on large scales) with quantum mechanics (which describes physics at very small distances).

The LHC is colliding protons on protons. These protons are made up of smaller constituents, the so called ‘partons’ which are actually the particles the LHC is colliding. The Schwarzschild radius of two colliding partons - quarks and gluons for example - at the LHC is at least fifteen orders of magnitudes below the Planck length - the smallest distance or size an object can achieve in our conventional universe.

‘This means that, in conventional models of physics, there is no way a black hole could be produced in a collision of two partons. However, there are models on the market suggesting that the strength of gravity could become significantly larger at very small distances, up to 10 to the 38th [10 with 38 zeroes] times stronger,’ she comments.

‘If this is true then the Schwarzschild radius of two colliding partons becomes large enough that, at the LHC centre-of-mass energy, two partons passing each other at their Schwarzschild radius is not so unlikely anymore. So, we may be able to produce microscopic black holes after all.’

Who's afraid of a 'mini' black hole?

So what would these tiny black holes be like? Should we be worried

about them?

Cigdem tells me: 'According to Stephen Hawking, they will not be that black in fact. They will evaporate with time approximately following a black body radiation spectrum. The evaporation rate will be inversely proportional to the black hole mass.'

'Astronomical black holes are so massive that their evaporation rate is negligible. In contrast, mini black holes are hot: unimaginably hot. The core of our Sun is at around 15,000,000 degrees Kelvin - to get close to the temperature of a mini black hole you would need to add another 42 zeroes.'

'What this incredible temperature means is that mini [black holes](#) of tiny mass 'evaporate' into the far, far colder space around them almost infinitely fast. Their expected lifetime is around one octillionth of a nanosecond - so that they pop out of existence again almost as soon as they are created.'

If they do appear they will almost instantaneously burst into many particles which the ATLAS detector should pick up.

'These particles will have very striking features. The total energy deposited in the detector will be of the order of a few TeVs [Tera electron volts] and the number of final state particles will be large. Black hole signatures can hardly be imitated by any other new physics so, if they are being produced, it will be hard to miss them,' Cigdem adds.

So the hunt begins: on 30 March the LHC is aiming for collision energies of 7 TeV that may enable us to see some quantum gravity effects for the first time.

At the beginning of this year Dr Cigdem Issever moved to CERN to

coordinate the efforts of the ATLAS Exotics physics group.

Read more about this topic in [What black holes can teach us](#) by Sabine Hossenfelder.

More information: ATLAS experiment -- atlasexperiment.org/
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