

BLACK HOLES

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INTRODUCTION

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How To Erase hard disks

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NEWTONS LAW OF GRAVITATION

Remember Newtons formula of gravitation:

$$F_G = G \cdot \frac{m_1 \cdot m_2}{r^2}$$

Now, let's calculate how much energy you need, to exit the gravitation:

$$E = \int F_G ds = \int G \cdot \frac{m_1 \cdot m_2}{r^2} dr = -G \cdot \frac{m_1 \cdot m_2}{r}$$

THE EVENT HORIZON

$$E = m \cdot c^2$$

The most famous formula of Einsteins theory of relativity means, that every energy has got a mass.

If you need more energy, to exit the gravitation, than you got through the equation on top, you can not.

When does this case become true?

$$m_2 \cdot c^2 = G \cdot \frac{m_1 \cdot m_2}{r} \Leftrightarrow c^2 = G \cdot \frac{m_1}{r} \Leftrightarrow r = m_1 \cdot \frac{G}{c^2}$$

The radian r is called **event horizon** and propotional to the mass of the object in it.

If the objects are smaller than the event horizon we call it **black hole**.

THE EVENT HORIZON

$$G = 6.674\ 28(67) \cdot 10^{-11} \text{ m}^3 / (\text{kg s}^2) \text{ (CODATA)}$$

$$G / c^2 = 7,42613(74) \cdot 10^{-28} \text{ m} / \text{kg}$$

Typical radii of event horizons:

object	mass	event horizon	radian
Proton	$1,672 \cdot 10^{-27} \text{ kg}$	$1,242 \cdot 10^{-54} \text{ m}$	$1,4 \cdot 10^{-15} \text{ m}$
Atom (U)	$3,953 \cdot 10^{-25} \text{ kg}$	$2,936 \cdot 10^{-52} \text{ m}$	10^{-10} m
Human	80 kg	$5,941 \cdot 10^{-26} \text{ m}$	2 m
Moon	$7,348 \cdot 10^{22} \text{ kg}$	$5,483 \cdot 10^{-5} \text{ m}$	$1,737 \cdot 10^6 \text{ m}$
Earth	$5,974 \cdot 10^{24} \text{ kg}$	$4,436 \cdot 10^{-3} \text{ m}$	$6,371 \cdot 10^6 \text{ m}$
Sun	$1,989 \cdot 10^{30} \text{ kg}$	1477 m	$6,955 \cdot 10^8 \text{ m}$

ACCRETION DISKS

If something falls into a black hole (the favorite food of black holes are stars, but they will eat everything), the kinetic friction will warm it. So we can see this. We call this scream of death, because it seems sure, it falls into the black hole and never will come back. There're many pictures in false colors of this event.

I got someone for you:

You will also see jets. Cause of the magnetic field, some materia is ripped of the accretition disk and accelerated nearly to light speed.

TIME DILATION

One consequence of Einsteins relativity is the time dilation in a gravitational field like for example one of a black hole. This means an observer out of the gravitational field sees all action in it in slow motion.

You get closer to the event horizon => The time passes slower

You are at the event horizon => The time halts

What can we do with this?

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Today: Seq 1 - How to travel in time?

What we need:

- A black hole (at close quarters)
- A spaceship (full of fuel)

What we do:

1. Fly to the black hole
2. Stay there (in the gravitational field)
3. Be careful not to slip into the black hole
4. Get out
5. Watch the future

WARNING !!!

The time traveling is only one way and you will never come back. So be sure, if you really want this !!!

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Today: Seq 2 - How to find a black hole?

The problem:

- We can't see black holes, because the universe is black, too.
- How can we find them?

The solution:

- Buy a spyglass (a satellite gamma-detector will work better, but it's very expensive).
- Watch out for accretion disks. They emit bright gamma radiation.
- Watch out for jets

Problem:

- Other objects can look like this, too.

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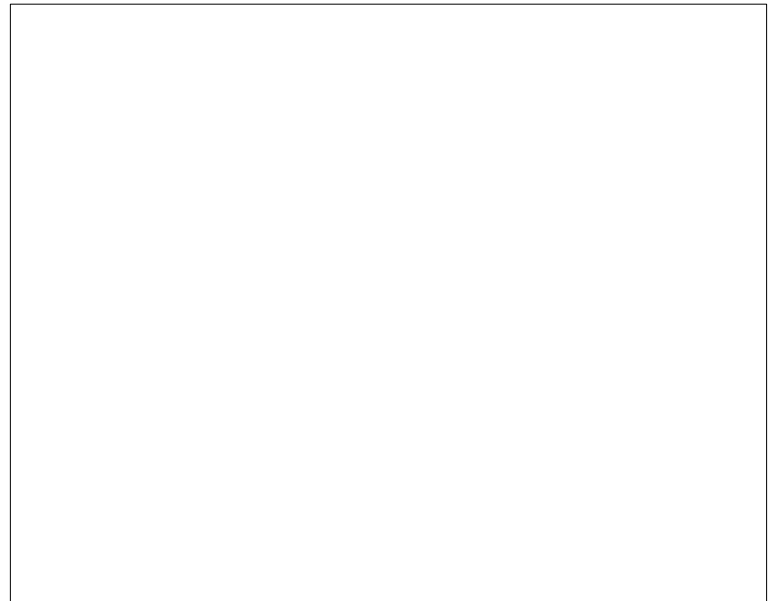
Today: Seq 2 - How to find a black hole?

The problem:

- We can't see black holes, because the universe is black, too.
- How can we find them?

The ultimate solution:

- Take several pictures
- Watch out for gravitation lensing



HAWKING RADIATION

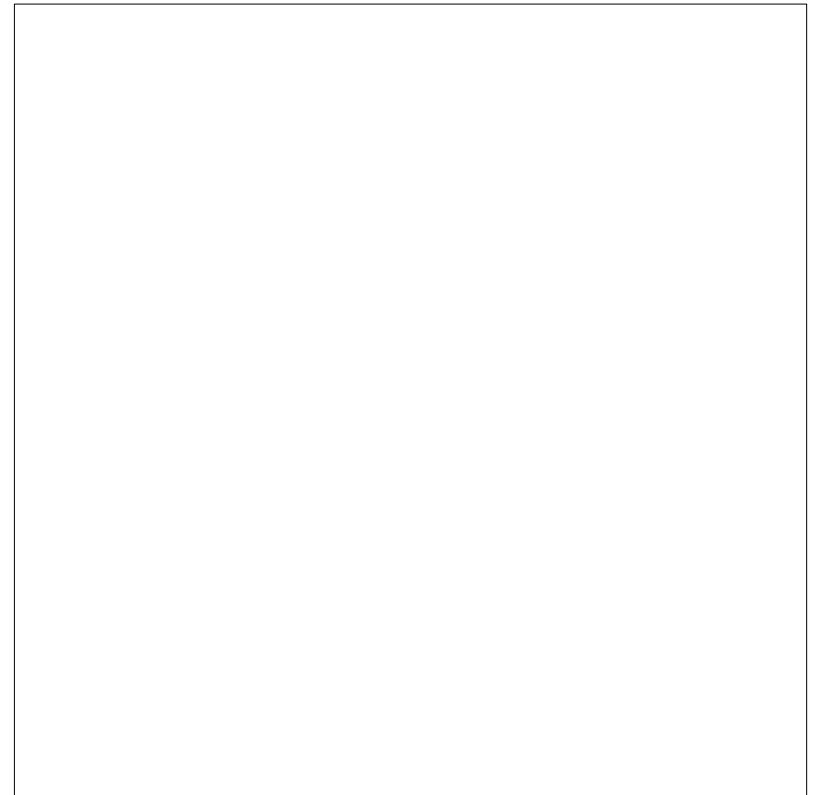
Steven Hawking was the first one, who forecasted black holes radiating.

Imagine the following:

A new pair of particle and antiparticle is created from vacuum near the event horizon. This can happen for a short time.

One particle falls into the black hole, the other flies away.

Usually the two particles would delete themselves, but now the remaining particle has no partner to delete and can fly away.



HAWKING RADIATION

As we have radiation, thermodynamics allows us to assign a temperature to the black hole. It is only dependend on the mass of the black hole:

$$T = \frac{\hbar c^3}{8 \pi k G} \cdot \frac{1}{M} = \frac{1,227 \cdot 10^{23} \text{ K kg}}{M}$$

You see: The smaller the black hole, the higher the temperature and the more radiation.

Maybe you think, if it radiates, it must loose energy and get smaller because of energy conservation and $E=mc^2$.

You are right. Some people calculated when a black hole lost all energy and dissappears:

$$t = c_{onst} \cdot M^3, \quad c_{onst} = 8,4 \cdot 10^{23} \frac{s}{kg^3}$$

HAWKING RADIATION

Let's have a look on our black-hole-objects. What is their temperature and life time?

object	mass	temperature	life time
Proton	$1,672 \cdot 10^{-27}$ kg	$7,339 \cdot 10^{49}$ K	$3,927 \cdot 10^{-57}$ s
Atom (U)	$3,953 \cdot 10^{-25}$ kg	$3,104 \cdot 10^{47}$ K	$5,189 \cdot 10^{-50}$ s
Human	80 kg	$1,534 \cdot 10^{21}$ K	$1,363 \cdot 10^{22}$ Y
Moon	$7,348 \cdot 10^{22}$ kg	1,67 K	$1,056 \cdot 10^{85}$ Y
Earth	$5,974 \cdot 10^{24}$ kg	0,020545 K	$5,599 \cdot 10^{90}$ Y
Sun	$1,989 \cdot 10^{30}$ kg	$6,169 \cdot 10^{-8}$ K	$2,095 \cdot 10^{107}$ Y

Some people think, a black hole with a size of a proton can eat up the whole earth. But if you have a look at the life time, there's no danger.

ENTROPY

Entropy is the gauge of untidiness and the opposite of information.

John Wheeler, an American theoretical physicist, said: „Black holes have no hair.” What does this mean?

A black hole has no information of either mass, electric charge or angular momentum.

A black hole has no information of either mass, electric charge or angular momentum.

This means, you can't look inside a black hole, because there's nothing to see. Every structured material will lose its structure if it falls in one.

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Today: Seq 3 - How to erase hard disks?

The problem:

- A friend calls us the police, FBI, CIA, mafia or George W. Bush in person will arrive in 5 minutes and want's to have the data on our hard disk.

The solution:

Erase all data with a file-shredder program like „Eraser“ or „Tune up shredder“.

Good idea if you do it before, but 5 minutes is not enough.

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The better solution:

Burn up the hard disk, shredder it with an axe or electromagnet.

Very good idea, it should help in most practical cases, but what if you want to erase it theoretically.

So that no one will ever be able to get the data?

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The ultimate solution:

Start your spaceship full of fuel for timetraveling and put the hard disk into a black hole. All structure and all data is lost forever.

If it's Gorge W. Bush you can alternate start internet tv an say, that this is no computer - he will belive it.

DATA SOURCES

Constants: CODATA 2006

Uranmass:

http://www.dsemmler.de/Schule/Hausaufgabenforum/Data/CH_11_Periodensystem.pdf

Moondata: <http://en.wikipedia.org/wiki/Moon>

Earthdata: <http://en.wikipedia.org/wiki/Earth>

Sundata: <http://en.wikipedia.org/wiki/Sun>

Gravitation time dilation formula:

http://www.quantenwiki.de/Gravitationspotenzial_der_Sonne#gravitative_Zeitdilatation

Temperature and life time formula and constants:

http://de.wikipedia.org/wiki/Schwarze_L%C3%B6cher#Entropie_und_Temperatur
and the 42 :-)

PICTURE SOURCES

<http://www.nobelpreis.org/physik/images/pauli.jpg>

http://www.mopo.de/bilder/mopo/basic/st_pauli.gif

http://www.lsw.uni-heidelberg.de/users/mcamenzi/BH_storm.jpg

http://www.mpa-garching.mpg.de/HIGHLIGHT/2002/fig0207_1.jpg

<http://www.astrofoto.de/german/highlite/blackhol.htm>

http://de.wikipedia.org/wiki/Bild:Black_hole_lensing_web.gif

FUTHER SOURCES

http://en.wikipedia.org/wiki/Black_Holes

http://de.wikipedia.org/wiki/Zeitdilatation#Zeitdilatation_durch_Gravitation

Prof. Metags Exphy-Script

Vocabulary: Wikipedia, Google and <http://www.student-online.net/woerterbuch.shtml>

DOWNLOAD

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