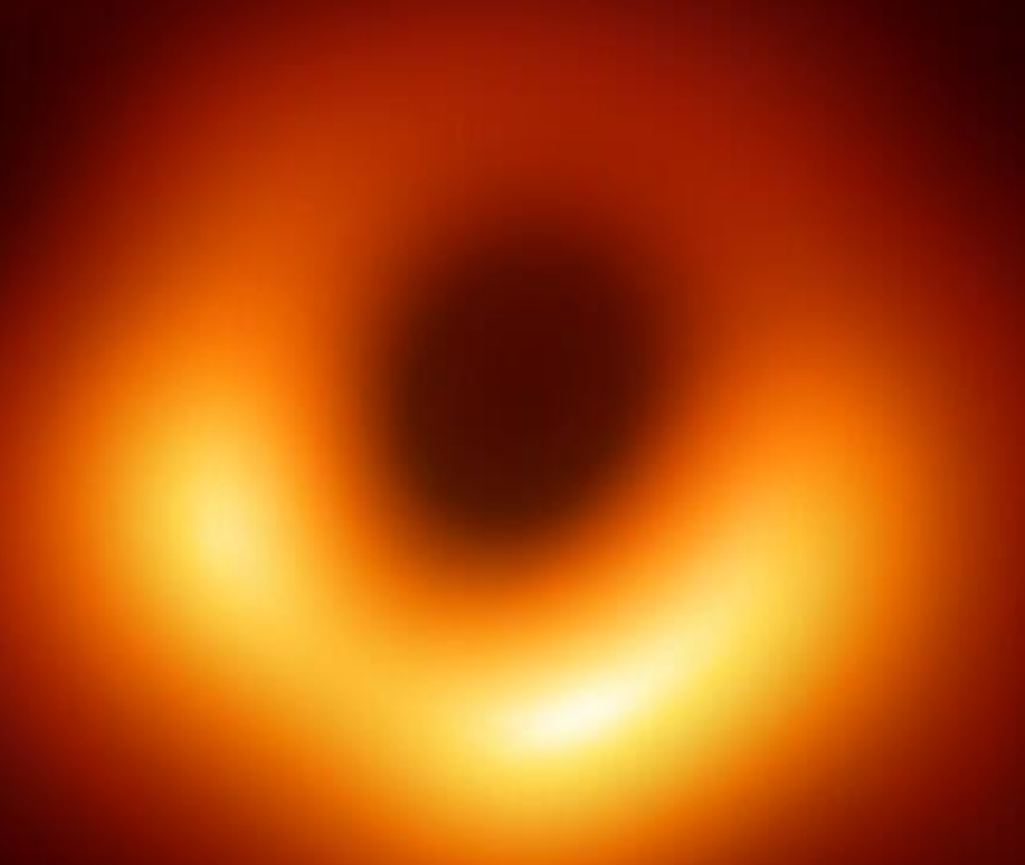




Svarthol fyrir almenning

Matthias Harksen

EÐLISFRÆÐI: Í DAGLEGU LÍFI

Hvernig eru svarthol á litinn?

EÐLISFRÆÐI: Í DAGLEGU LÍFI

Er svarthol endilega svart?

EÐLISFRÆÐI: Í DAGLEGU LÍFI

Hvað myndi gerast ef við myndum senda geimskip inn í svarthol?

EÐLISFRÆÐI: Í DAGLEGU LÍFI

Er hægt að búa til svarthol á tilraunastofu?

EÐLISFRÆÐI: Í DAGLEGU LÍFI

Hvernig komumst við að því að svarthol séu til?

EÐLISFRÆÐI: Í DAGLEGU LÍFI

Getur eitt svarthol gleypt annað svarthol?

Er rétt að hafa einhverjar áhyggjur af kenningunni sem nú er uppi að þegar vísindamennirnir sem kveikja á CERN þann 10. sept. nk. , sem á að líkja eftir miklahvell, myndist lítil svarthol sem að svo stigmagnast og gleypa á endanum jörðina?

Tækni & vísindi | AP | 29.6.2008 | 17:31

Ekki hætta á ragnarökum



EDLISFRÆÐI: Í DAGLEGU LÍFI

**Af hverju er alltaf verið að spá
heimsendi með svartholi? :(**

EÐLISFRÆÐI: Í DAGLEGU LÍFI

Hvað er svarthol?

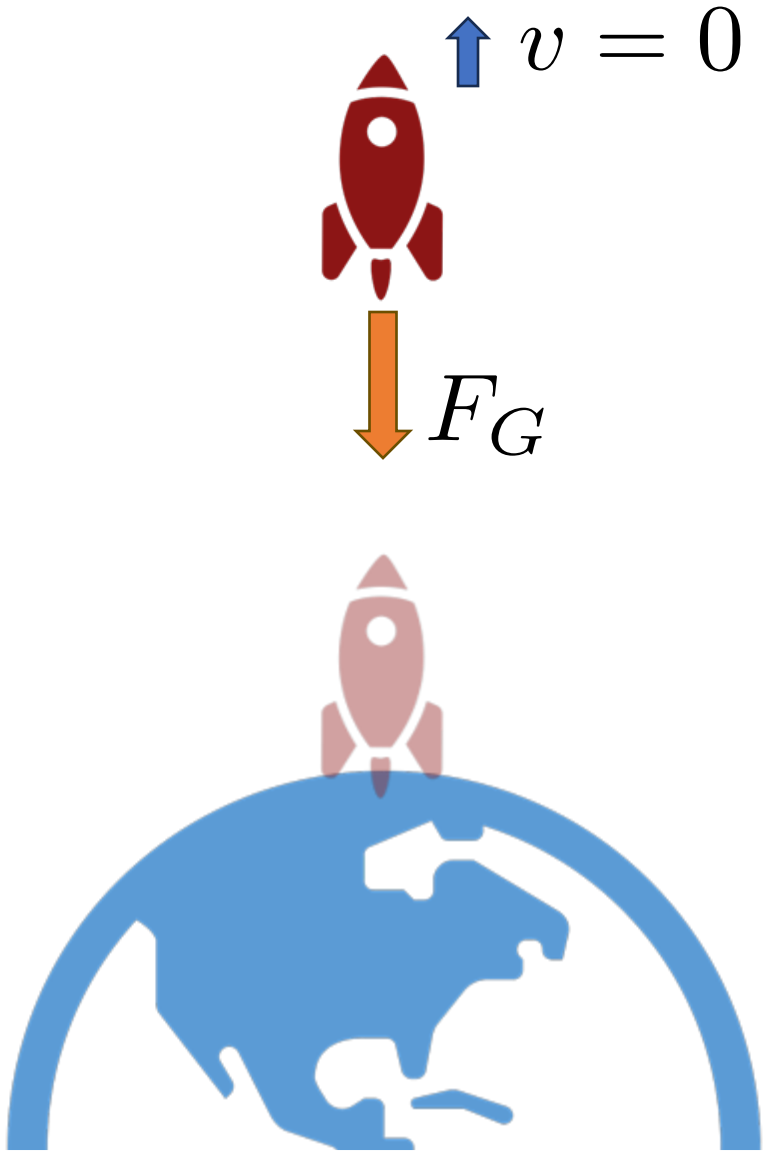


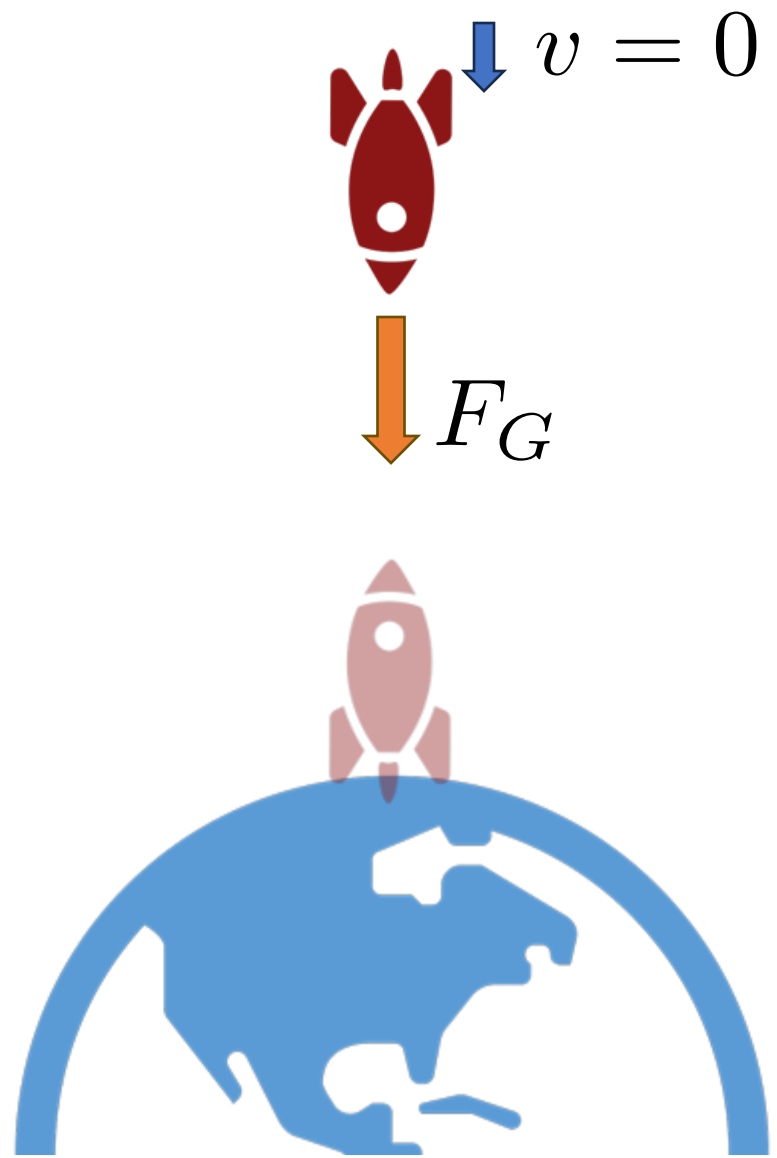
Laplace

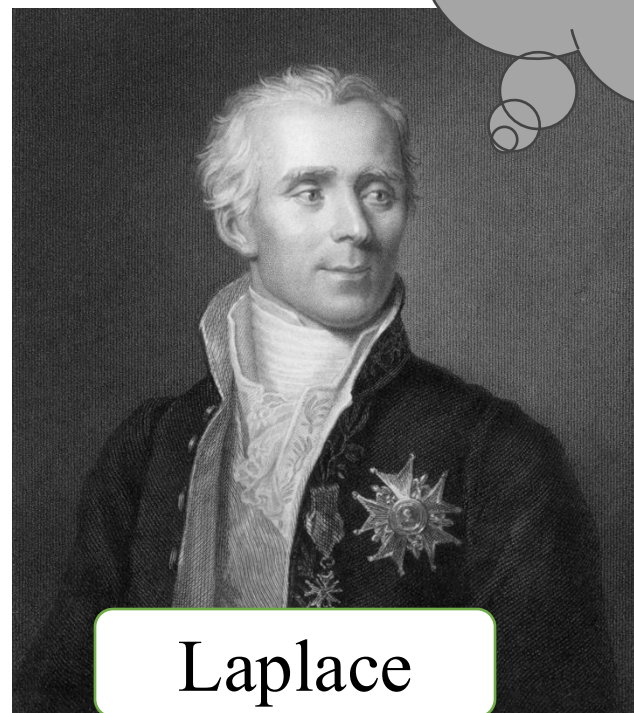
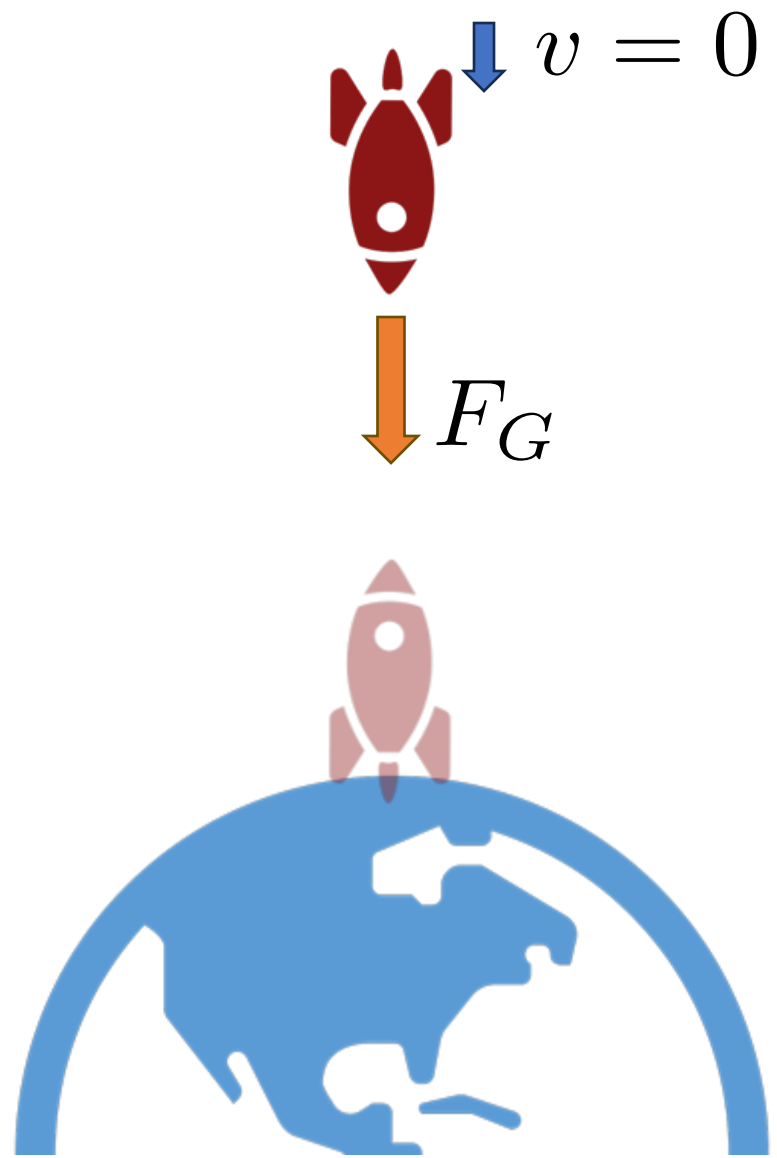
1789





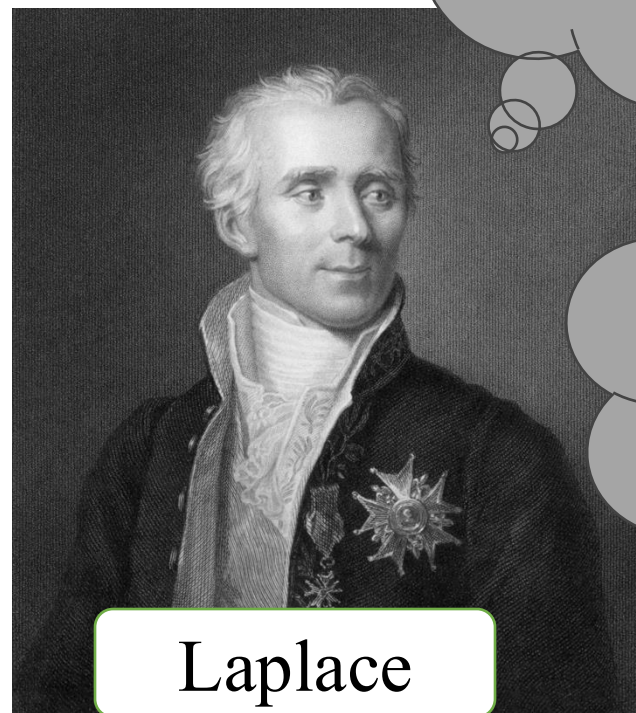
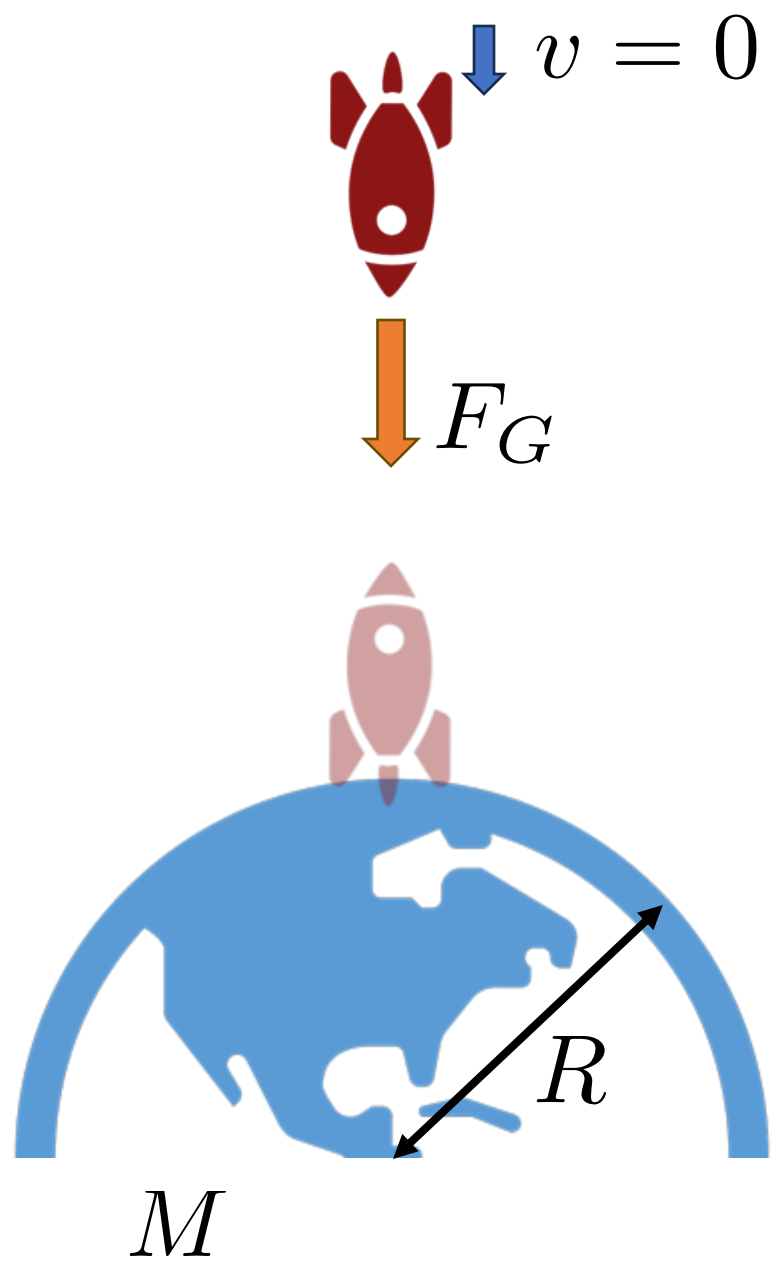






Laplace

Hvað ef hún
myndi aldrei
snúa við?



Hvað ef hún myndi aldrei snúa við?

Þá þyrfti:

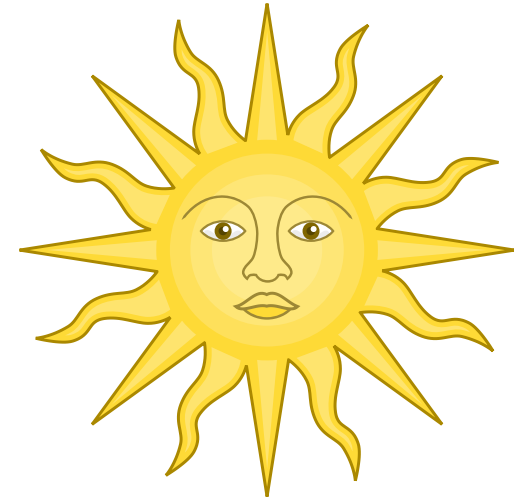
$$v_0 \geq \sqrt{\frac{2GM}{R}}$$



$$v_0 = 0,3 \text{ km/s}$$



$$v_0 = 11,2 \text{ km/s}$$



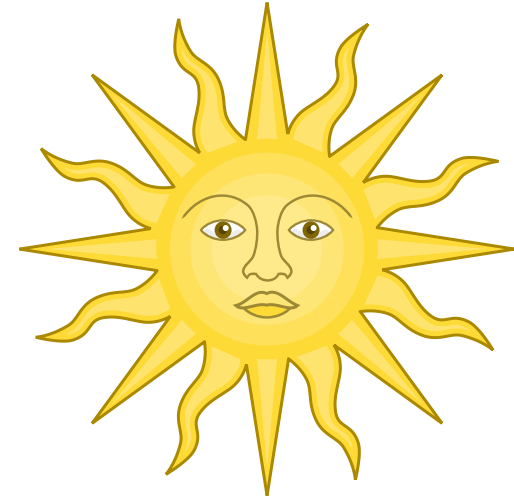
$$v_0 = 619 \text{ km/s}$$



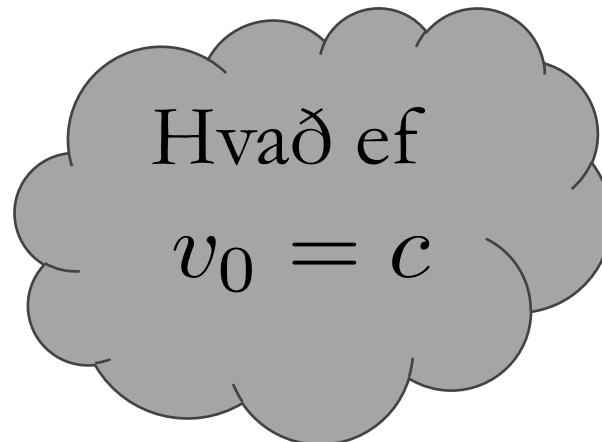
$$v_0 = 0,3 \text{ km/s}$$



$$v_0 = 11,2 \text{ km/s}$$

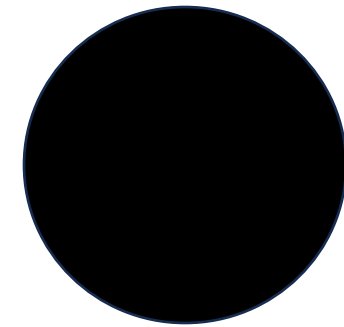


$$v_0 = 619 \text{ km/s}$$

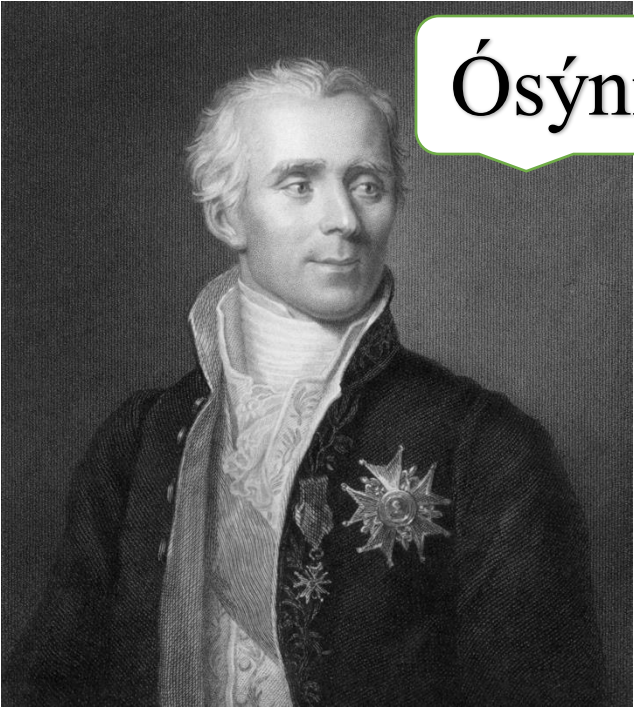


Hvað ef

$$v_0 = c$$



$$c = 300\,000 \text{ km/s}$$

A black and white engraving of Immanuel Kant, showing him from the chest up. He has white hair, is wearing a dark coat over a white cravat, and has a star-shaped medal on his left chest.

Ósýnileg

EDLISFRÆÐI: Í DAGLEGU LÍFI

Hvernig eru svarthol á litinn?

EDLISFRÆÐI: Í DAGLEGU LÍFI

Af hverju er erfitt að sjá svarthol?

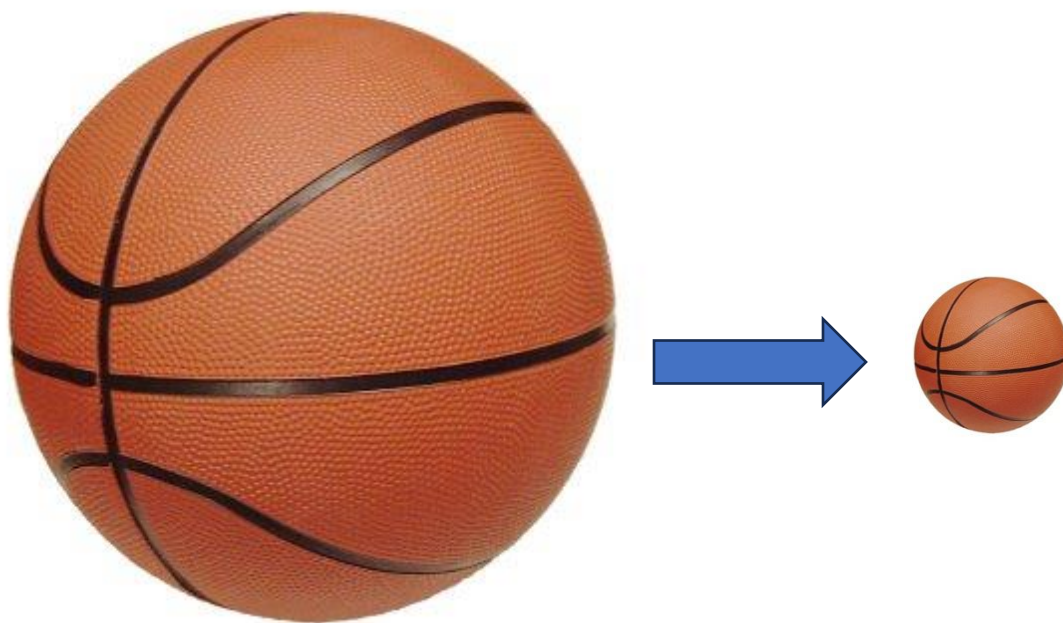
A color portrait of Albert Einstein, showing him from the chest up. He has his characteristic wild, dark hair, is wearing a dark suit and a white cravat, and has a serious expression.

Svört

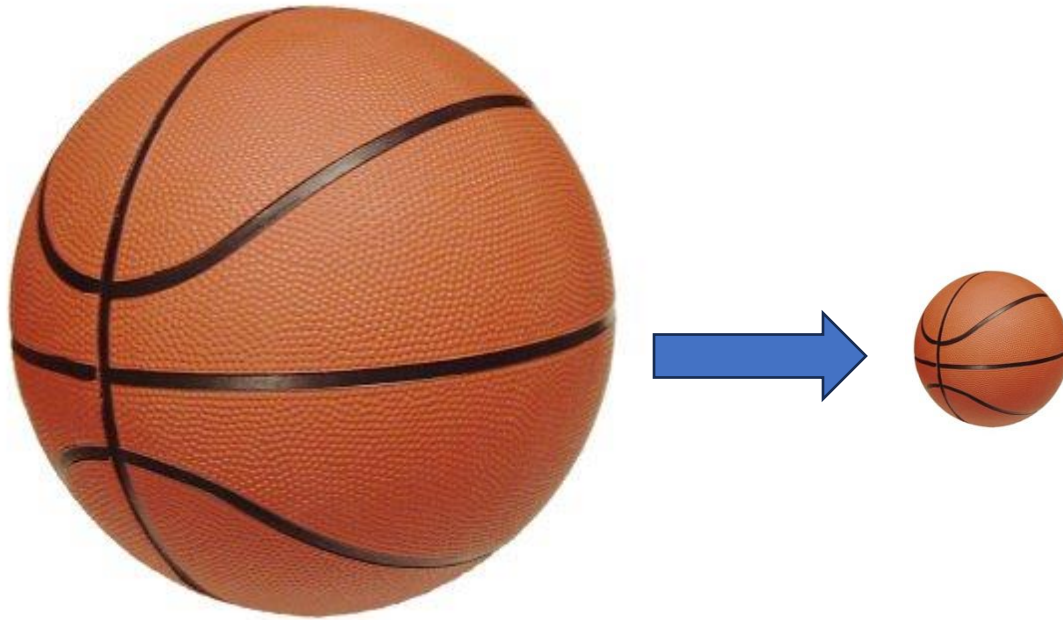
EDLISFRÆÐI: Í DAGLEGU LÍFI

**Er hægt að búa til svarthol á
tilraunastofu?**

**Er hægt að búa til svarthol á
tilraunastofu?**



Er hægt að búa til svarthol á tilraunastofu?



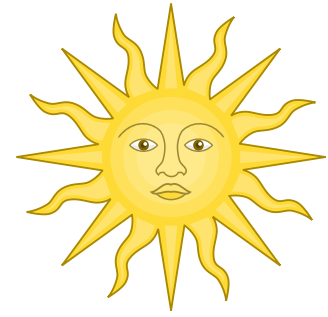
$$R = 12 \text{ cm}$$
$$M = 625 \text{ g}$$

$$R_S = 9,2 \cdot 10^{-28} \text{ m}$$
$$M = 625 \text{ g}$$

Er hægt að búa til svarthol á tilraunastofu?



$$R_S = 8,8 \text{ mm}$$



$$R_S = 3,0 \text{ km}$$



$$R = 12 \text{ cm}$$

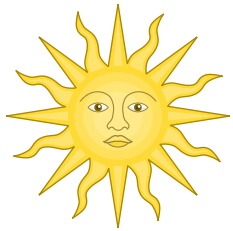
$$M = 625 \text{ g}$$



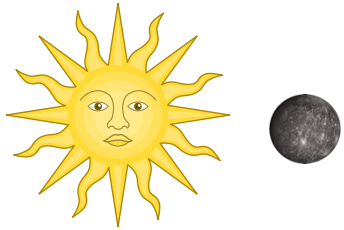
$$R_S = 9,2 \cdot 10^{-28} \text{ m}$$

$$M = 625 \text{ g}$$

Er hægt að búa til svarthol á tilraunastofu?



**Er hægt að búa til svarthol á
tilraunastofu?**

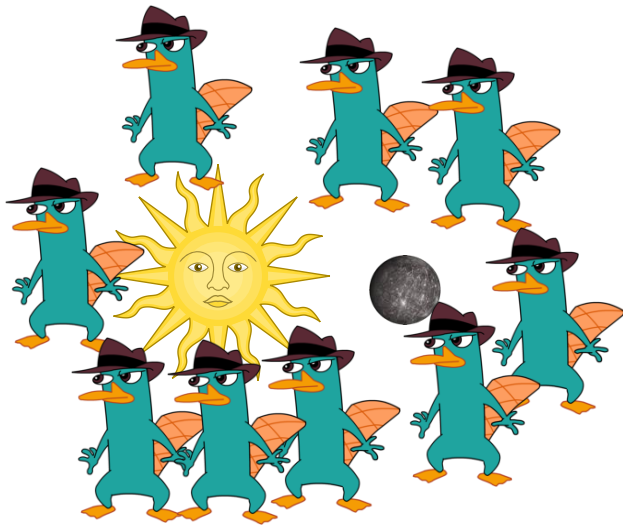


Pési Breiðnefur

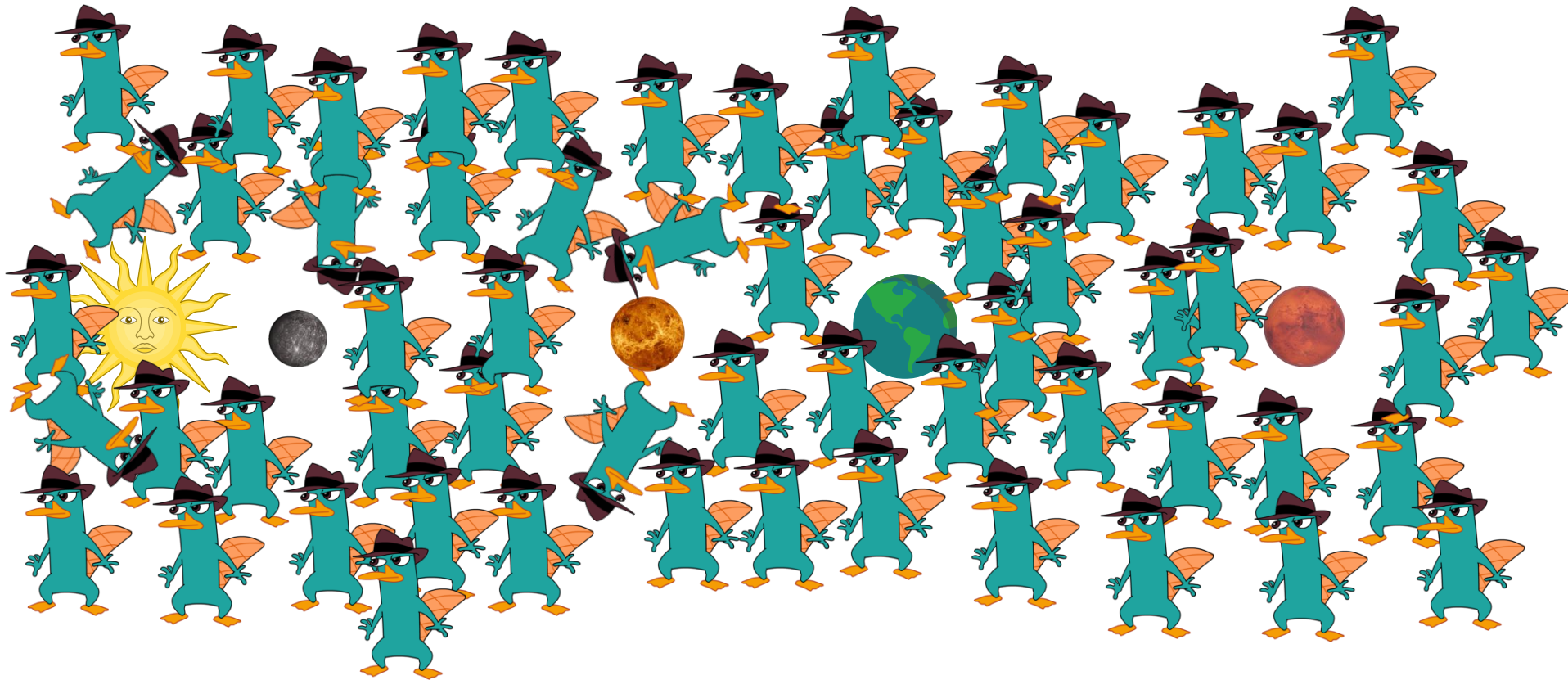


Doktor Hinrik Diðrik

Er hægt að búa til svarthol á tilraunastofu?



Er hægt að búa til svarthol á tilraunastofu?

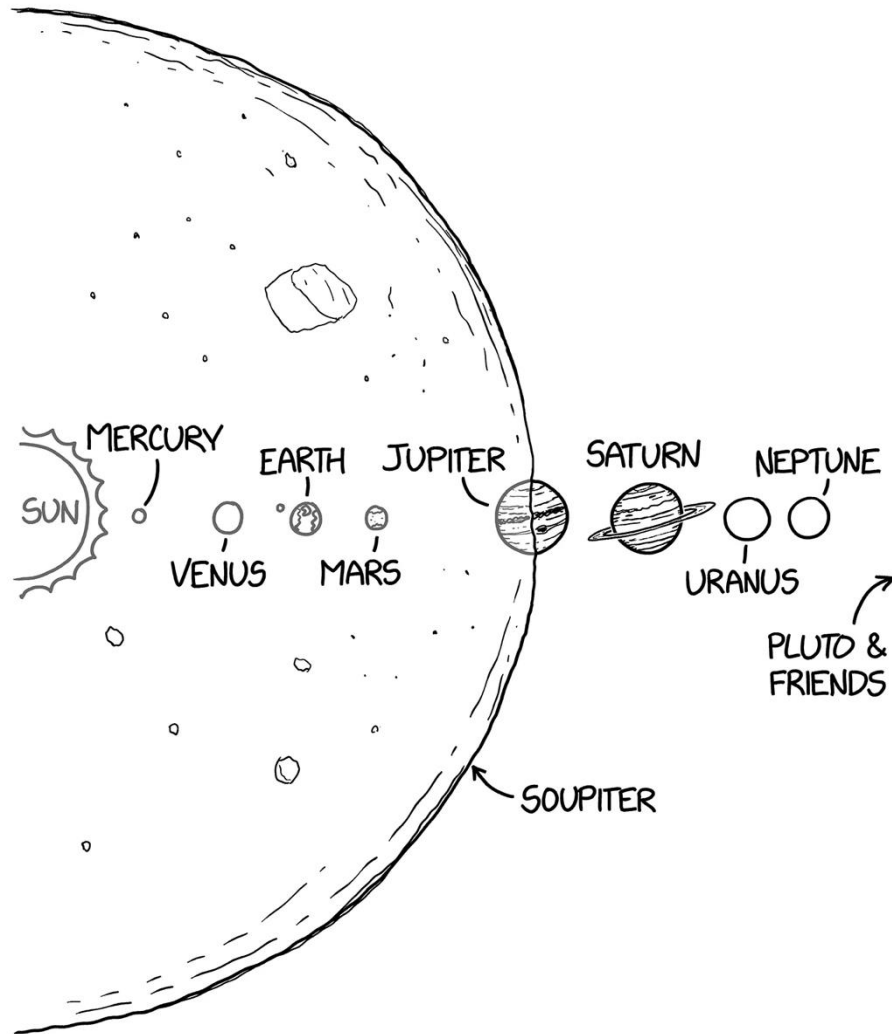


$$\rho = 1000 \text{ kg/m}^3$$

$$R_S = 2,7 \text{ AU}$$

What would happen if the Solar System was filled
with soup out to Jupiter?

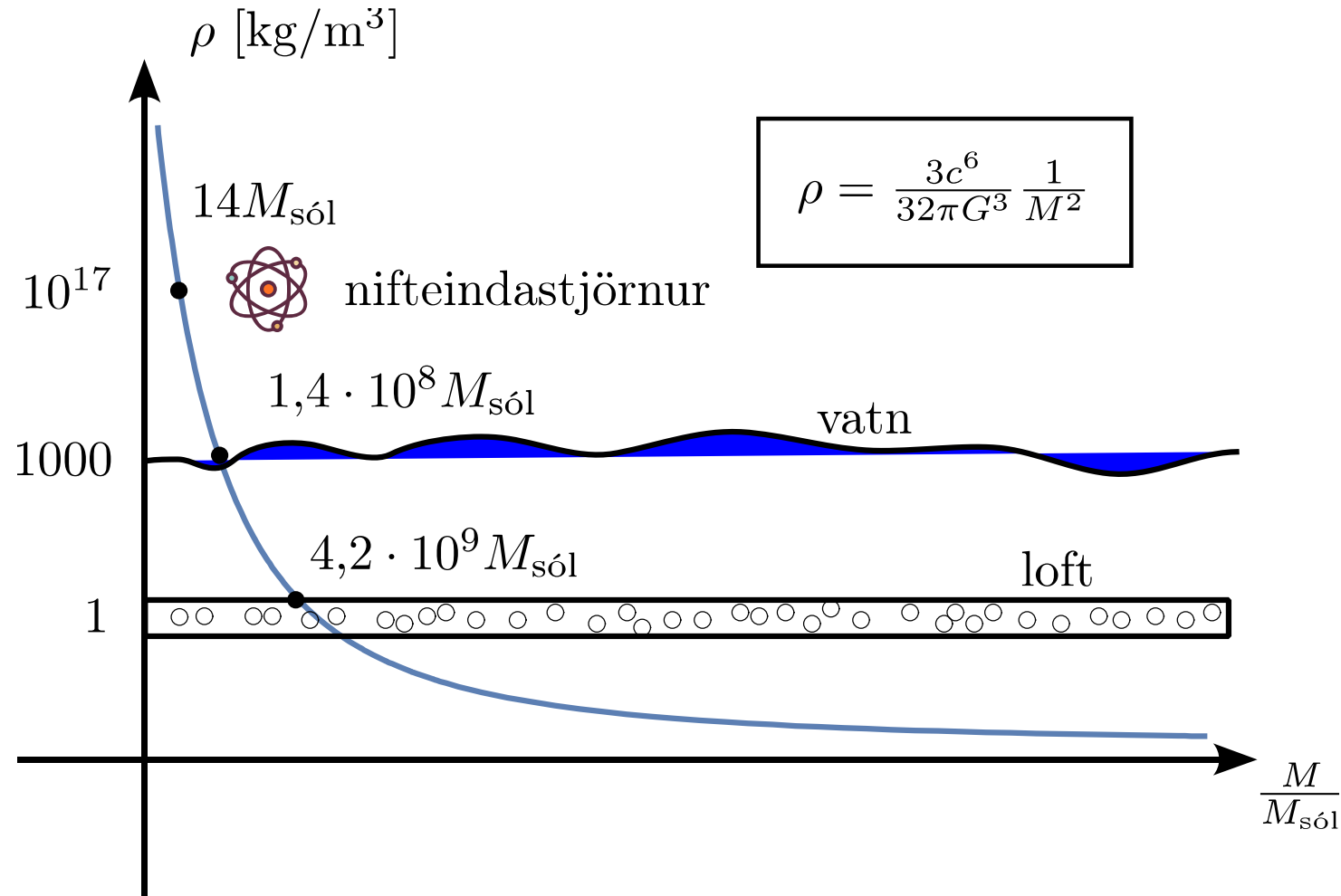
—Amelia, age 5



EDLISFRÆÐI: Í DAGLEGU LÍFI

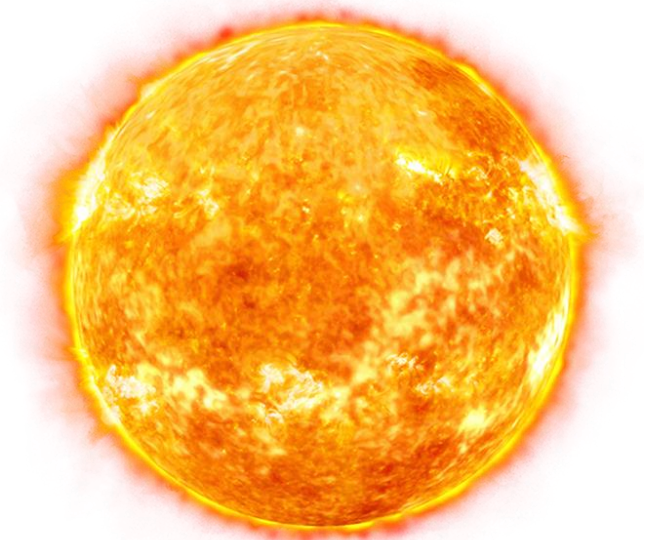
Hver er eðlismassi svarthols?

Hver er eðlismassi svarthols?



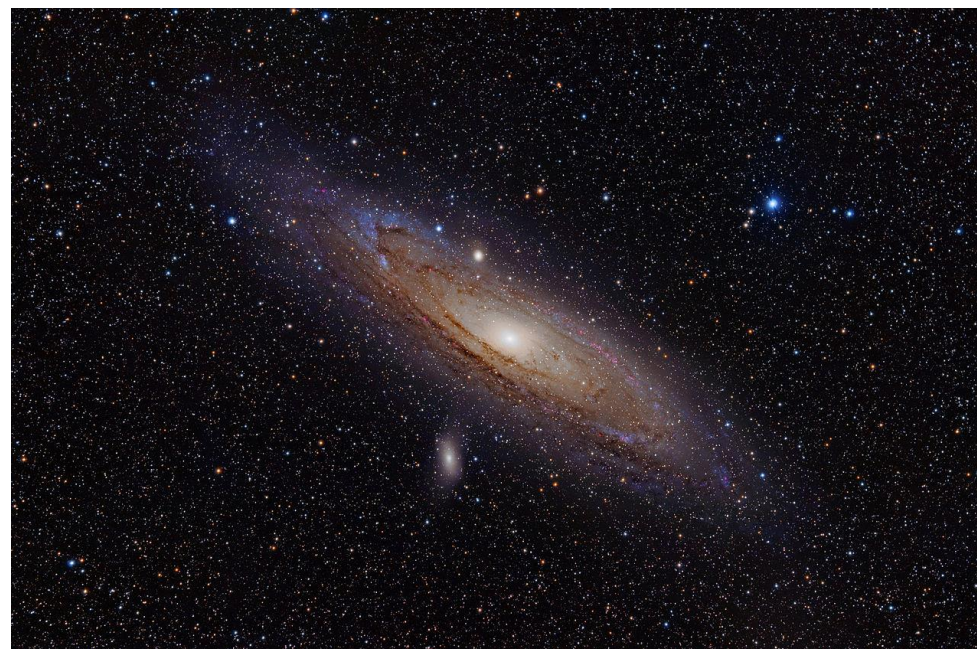
Tvær gerðir af svartholum

Dauðar stjörnur



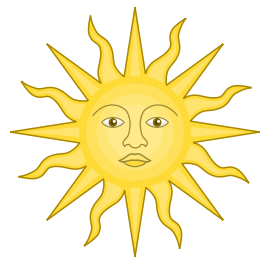
5-100 $M_{\text{sól}}$

Risasvarthol í miðjum vetrarbrauta

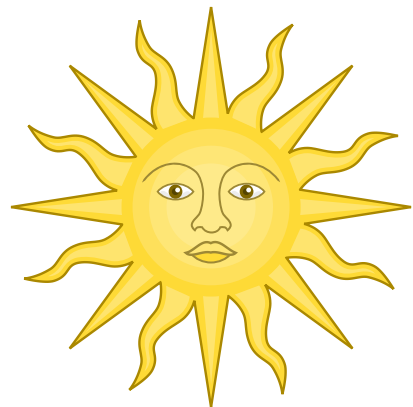


Milljón $M_{\text{sól}}$

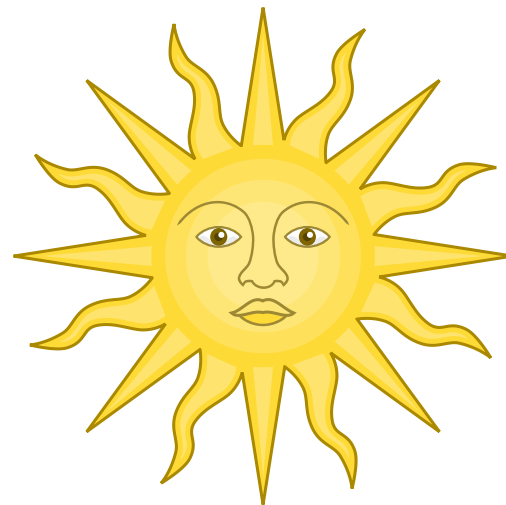
Chandrasekhar-mörk



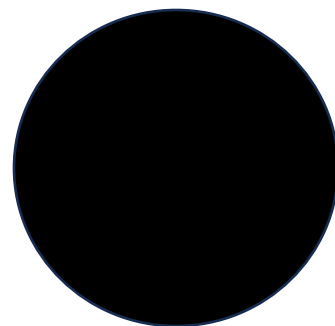
$< 10 M_{\text{sól}}$



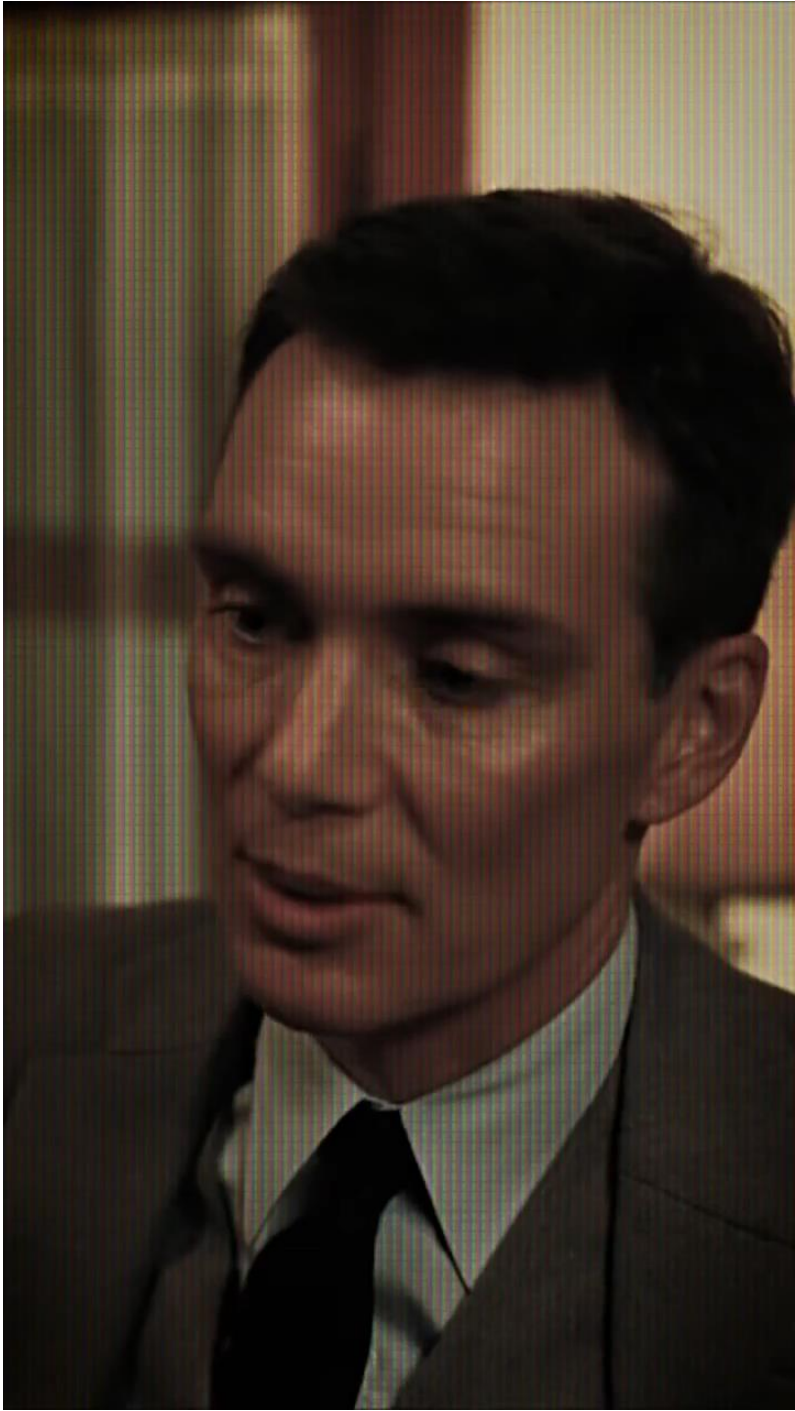
$< 30 M_{\text{sól}}$



$> 30 M_{\text{sól}}$



Tolman–Oppenheimer–Volkoff-mörk



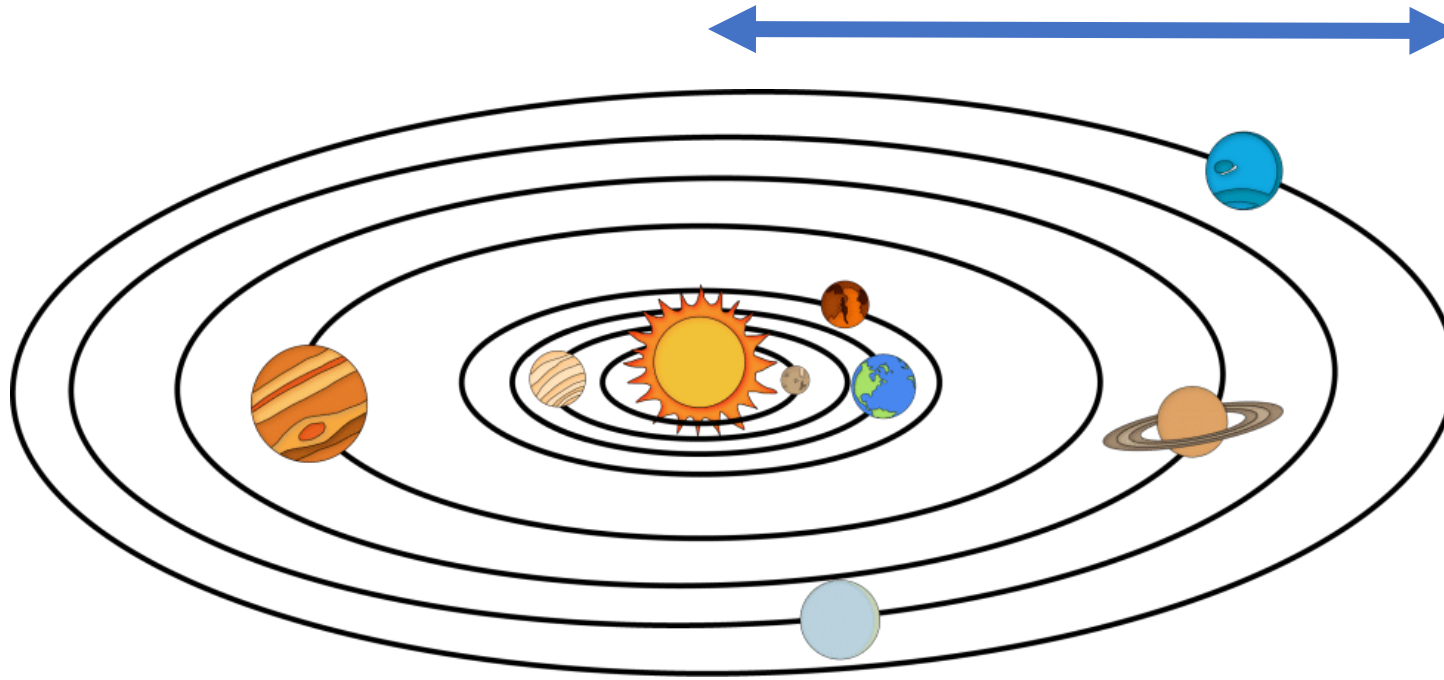
EDLISFRÆÐI: FRÆÐILEG

Hvaða svarthol er næst okkar sólkerfi?

Hvaða svarthol er næst okkar sólkerfi?

Sólkerfið okkar

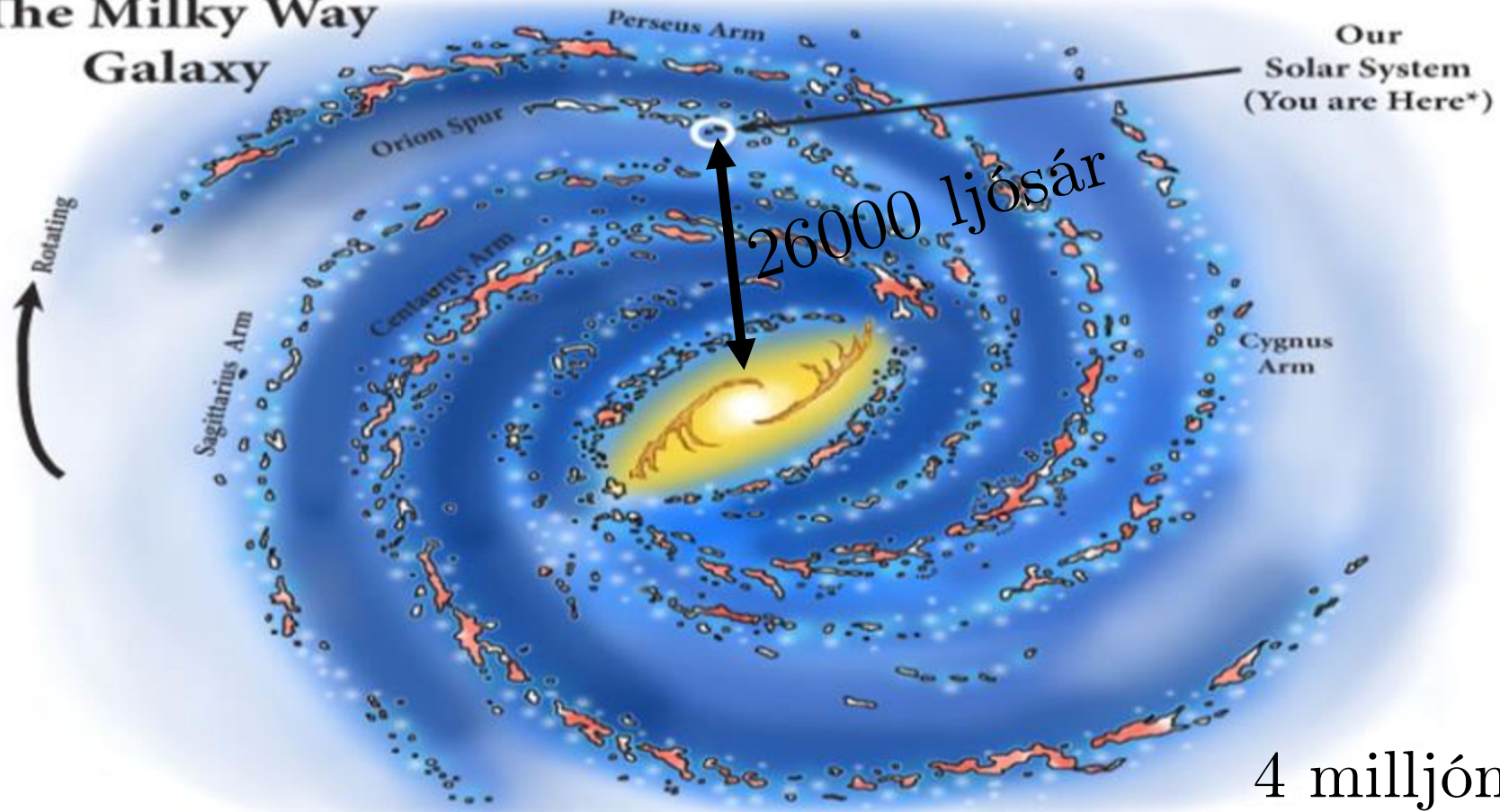
250 ljósmínútur



Hvaða svarthol er næst okkar sólkerfi?

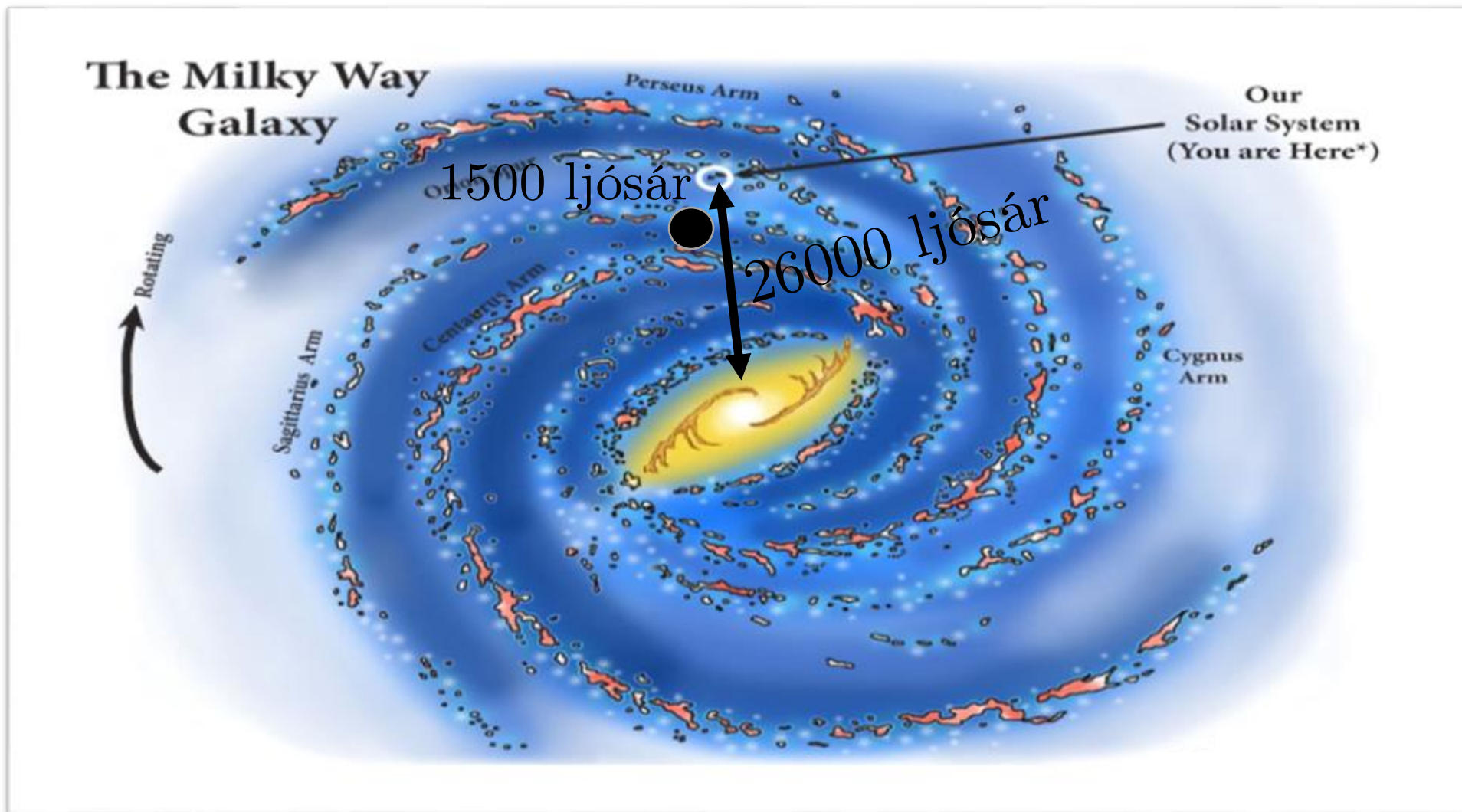
100 milljarðar stjarna

**The Milky Way
Galaxy**



4 milljón sólmassar

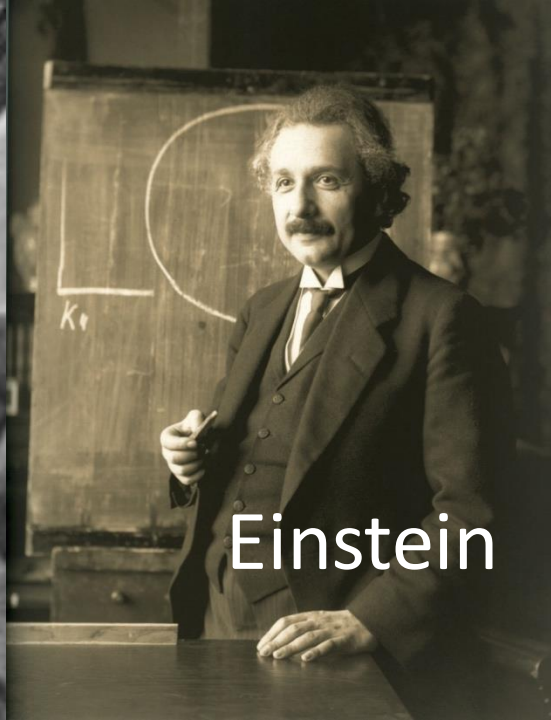
Hvaða svarthol er næst okkar sólkerfi?



EDLISFRÆÐI: Í DAGLEGU LÍFI

**Hvernig vitið þið að svartholið er til.
Og hvernig komust þið að því?**

1915



Einstein



Schwarzschild

Oppenheimer



1939



Snyder



1965

THE NOBEL PRIZE IN PHYSICS 2020



Roger Penrose

"for the discovery that
black hole formation
is a robust prediction
of the general theory
of relativity"



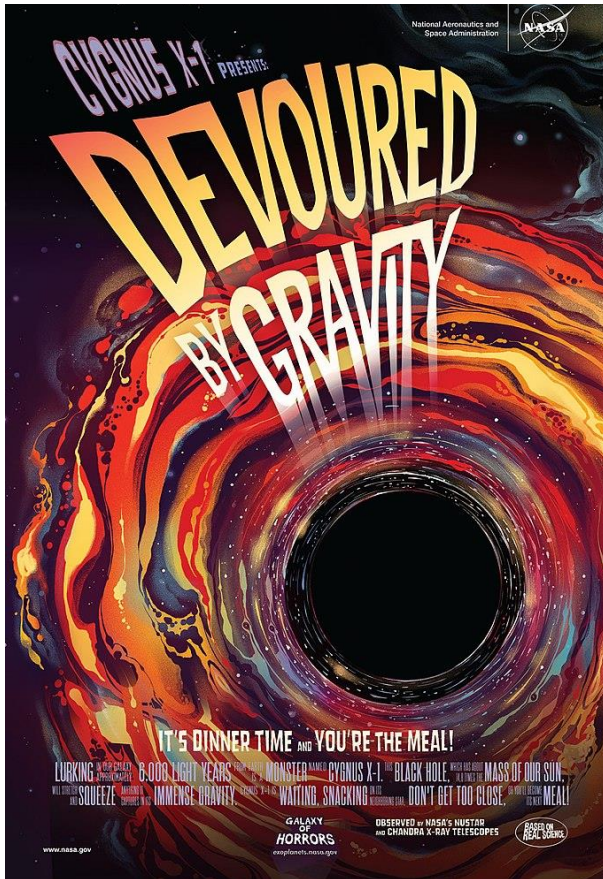
**Reinhard
Genzel**

"for the discovery of a
supermassive compact object
at the centre of our galaxy"

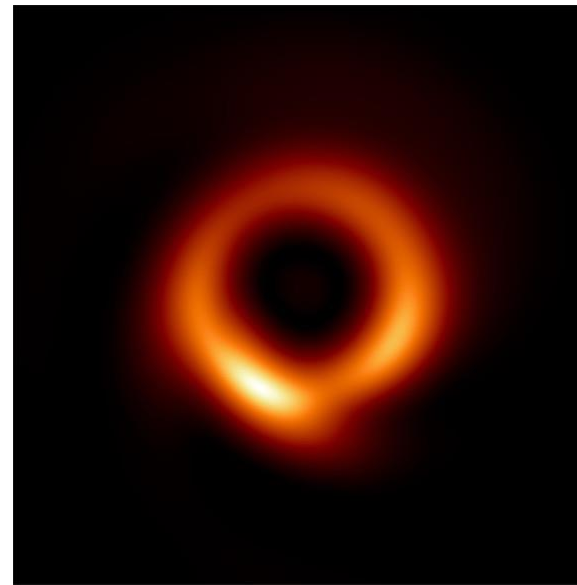


**Andrea
Ghez**

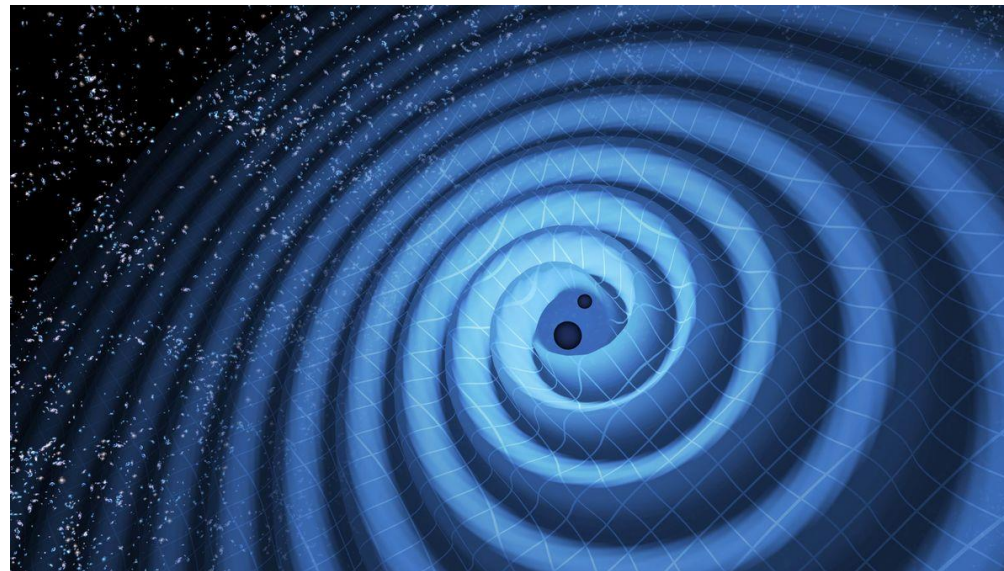
Hvernig vitið þið að svartholið er til.
Og hvernig komust þið að því?



Cygnus X (1965)



EHT (2017)



LIGO (2015)

EDLISFRÆÐI: Í DAGLEGU LÍFI

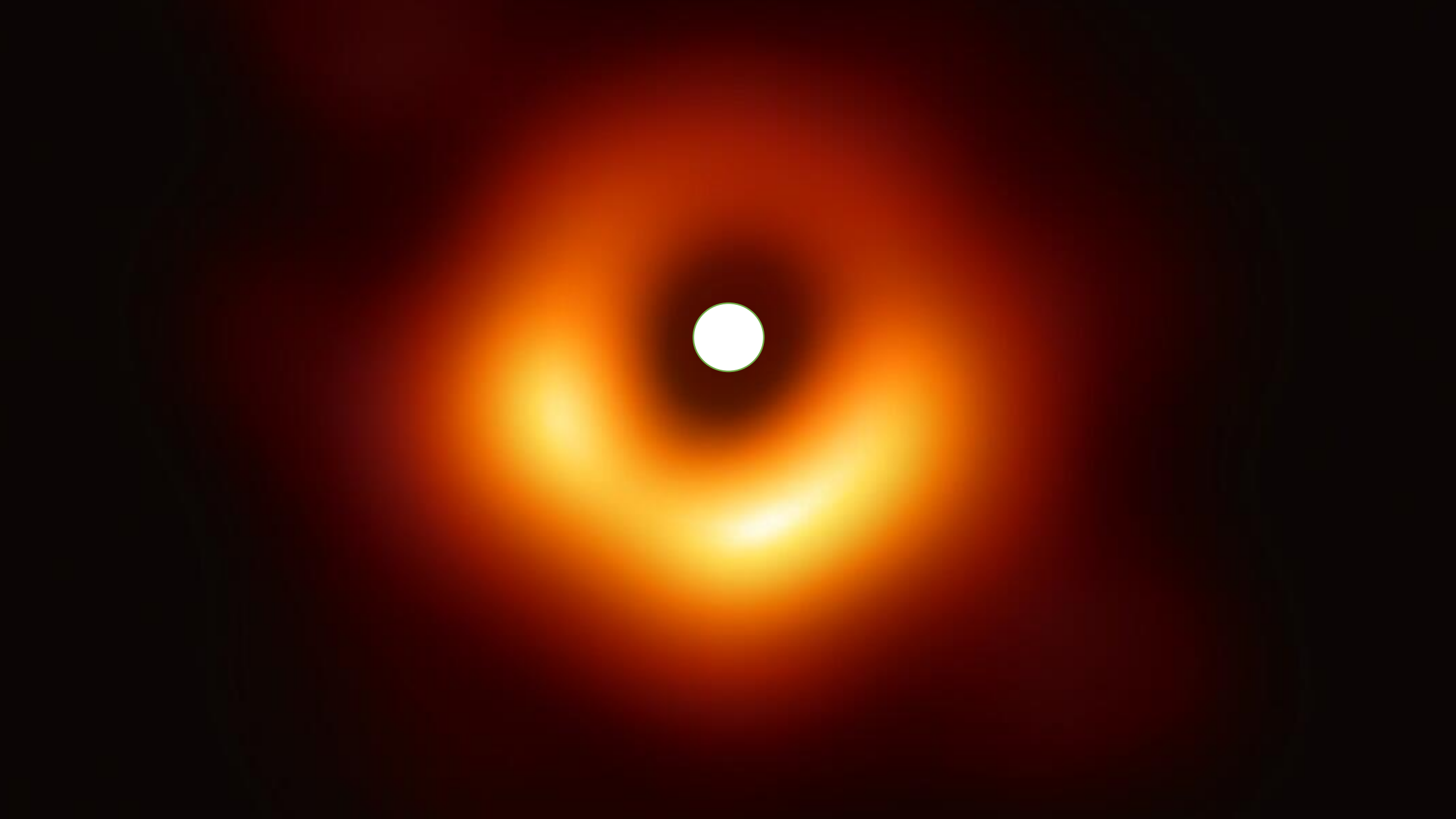
**nennið þið að senda mér myndir af
svartholum og öru sem myndast í
geimnum ???**

M87



55 milljón ljósár í burtu

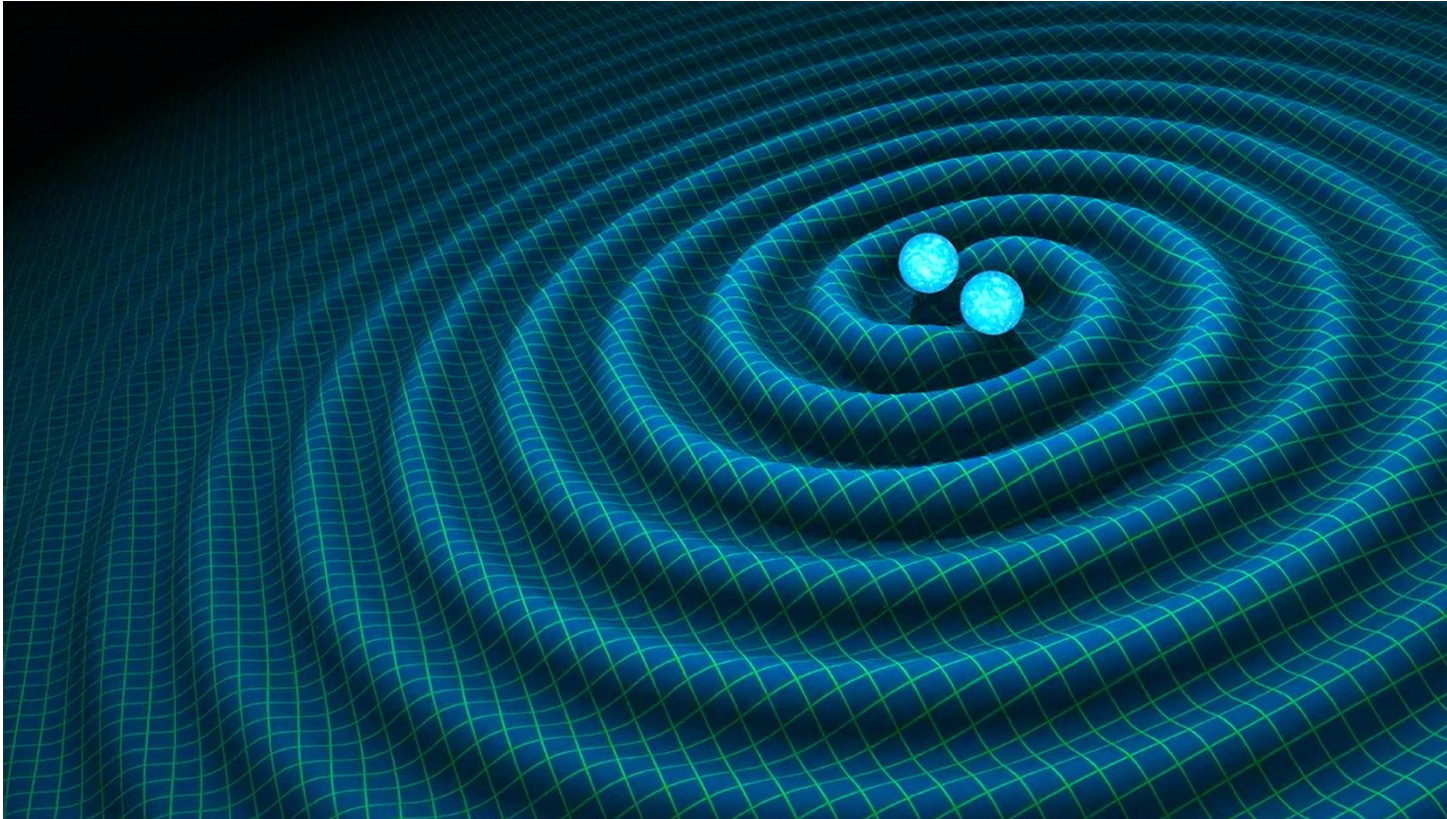
Milljarður af sólum



EDLISFRÆÐI: Í DAGLEGU LÍFI

Getur eitt svarthol gleypst annað svarthol?

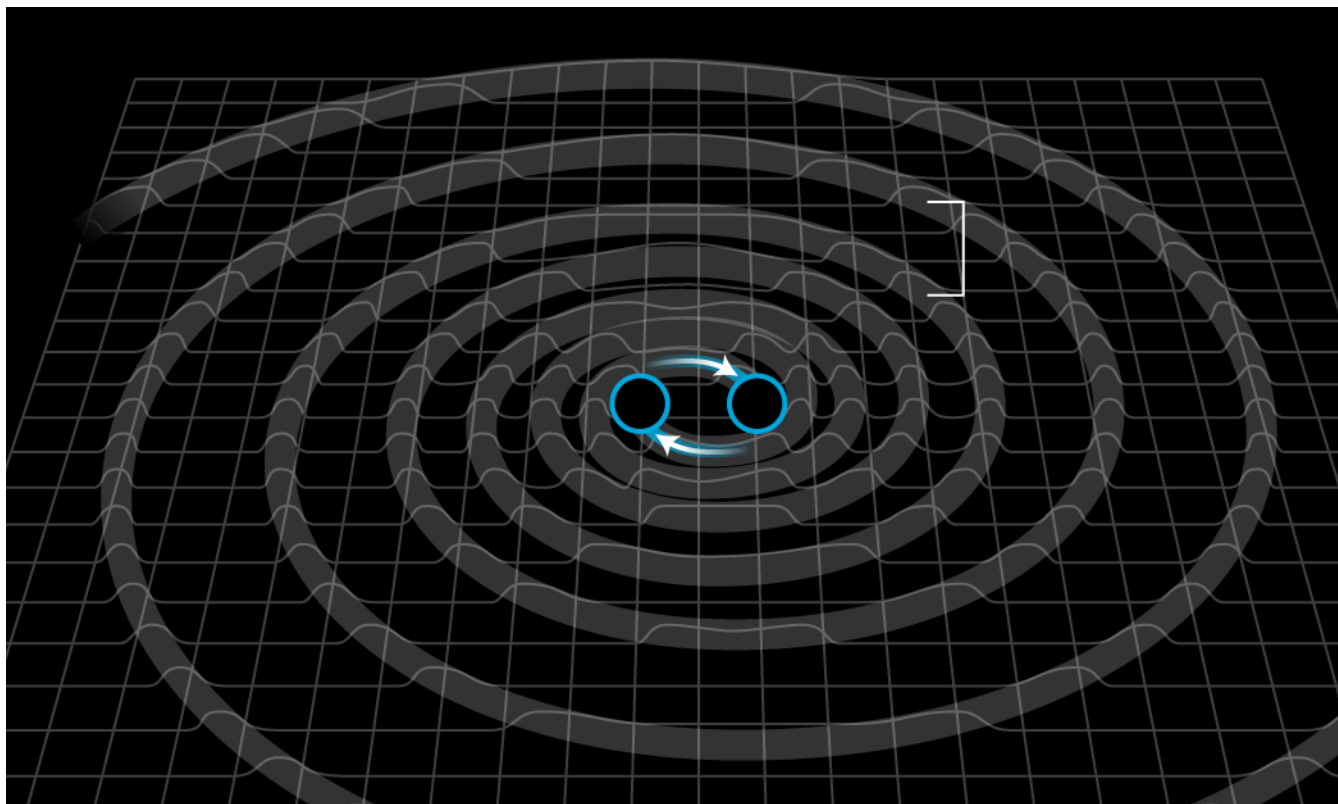
Getur eitt svarthol gleypt annað svarthol?



GW150914

1,5 milljarð ljósár í burtu

Getur eitt svarthol gleypt annað svarthol?



$$M_1 = 35M_{\text{sól}}$$

$$M_2 = 30M_{\text{sól}}$$

$$M = 62M_{\text{sól}}$$

$$35 + 30 = 65???$$

GW150914

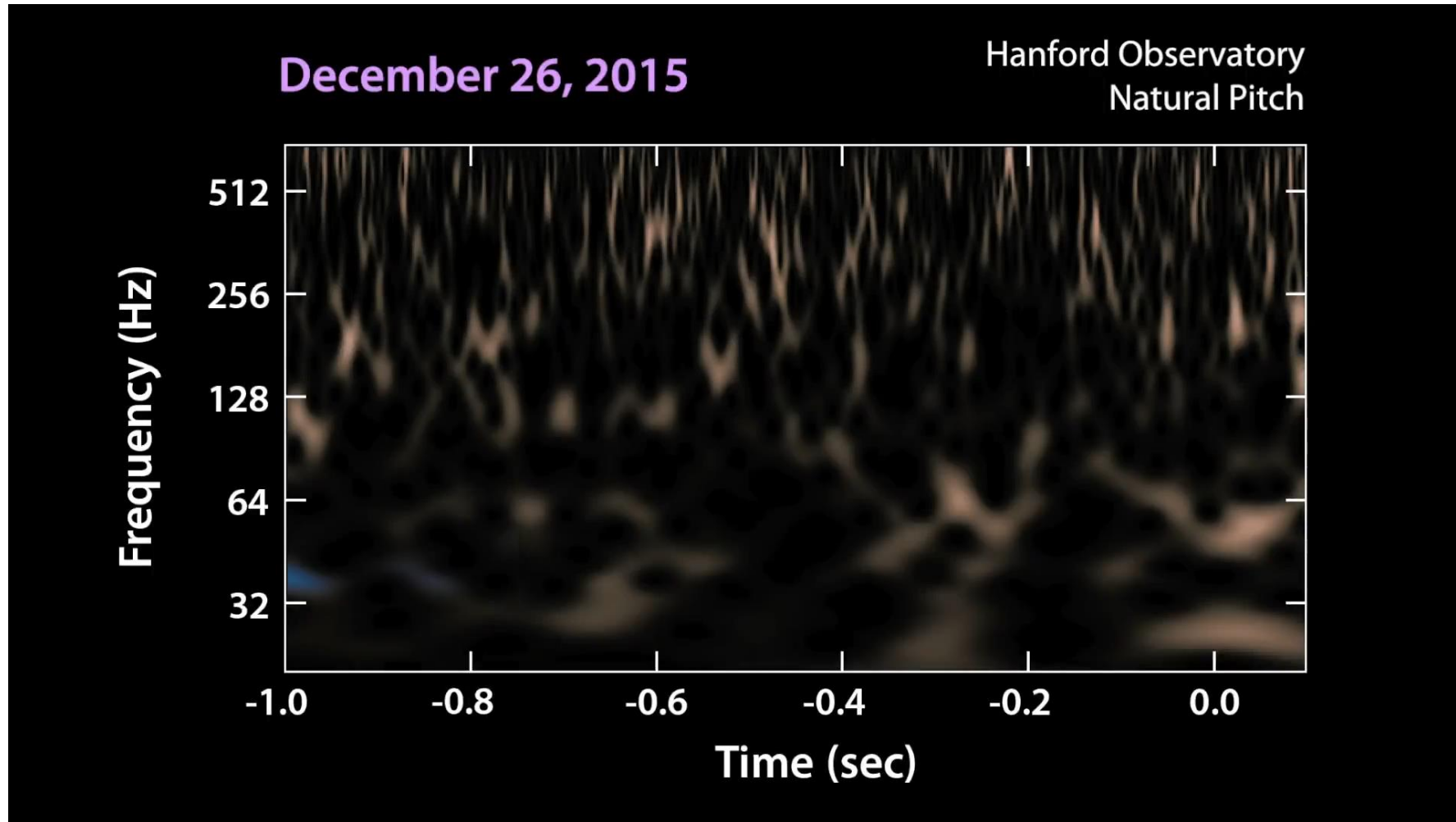
1,5 milljarð ljósár í burtu

#chirpforligo

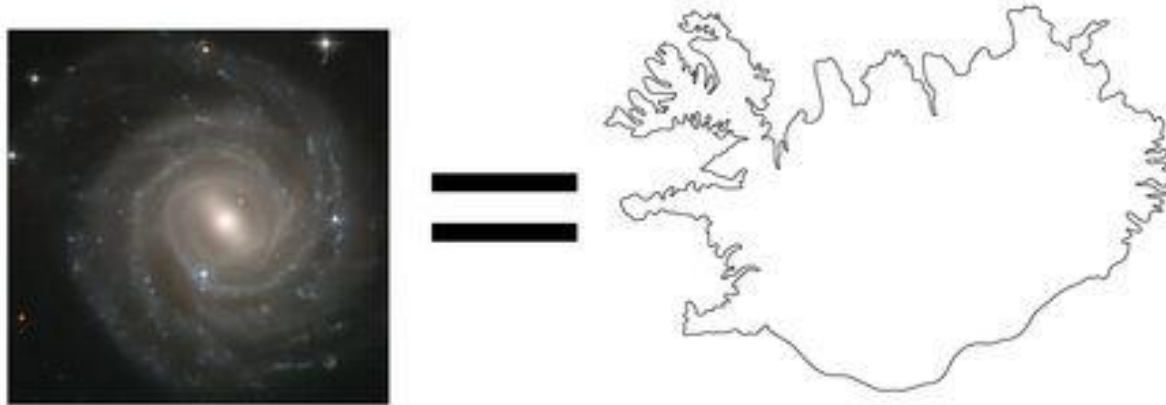
Rumor is the LIGO experiment may have detected gravitational waves. But what if these ripples in spacetime were sound waves instead? What would they sound like?

Physicists and physics fans are giving it their best chirp!

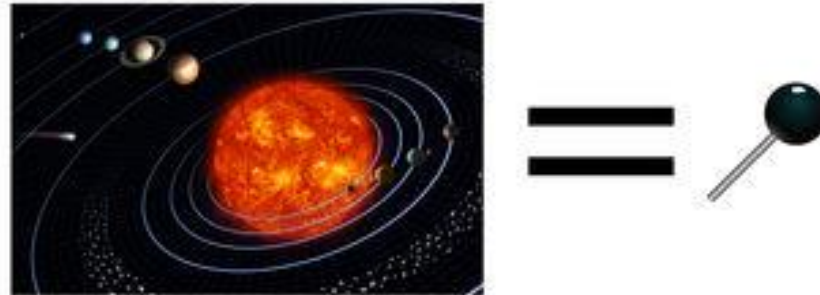
#chirpforligo



Ef vetrarbrautin okkar væri á stærð við Ísland...



...þá kæmust sólin og brautir reikistjarnanna fyrir inni í títiprjónshaus!



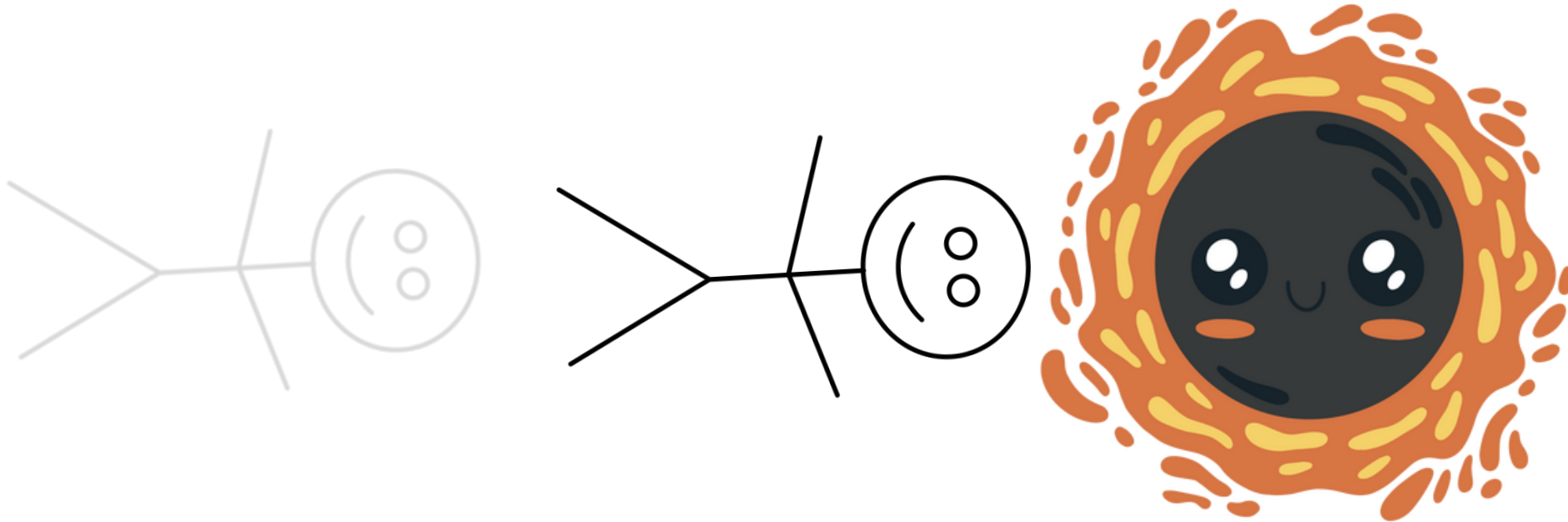
Stjörnufræðivefurinn - www.stjornufraedi.is

Mynd: ESA/Hubble & NASA/Sverrir Guðmundsson

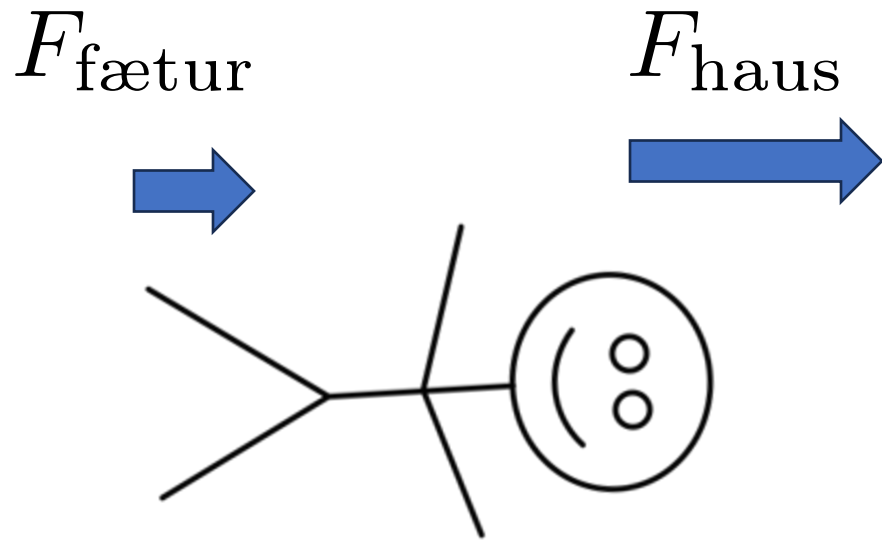
EDLISFRÆÐI: Í DAGLEGU LÍFI

**Hvað myndi gerast ef maður myndi
fara inn í svarthol?**

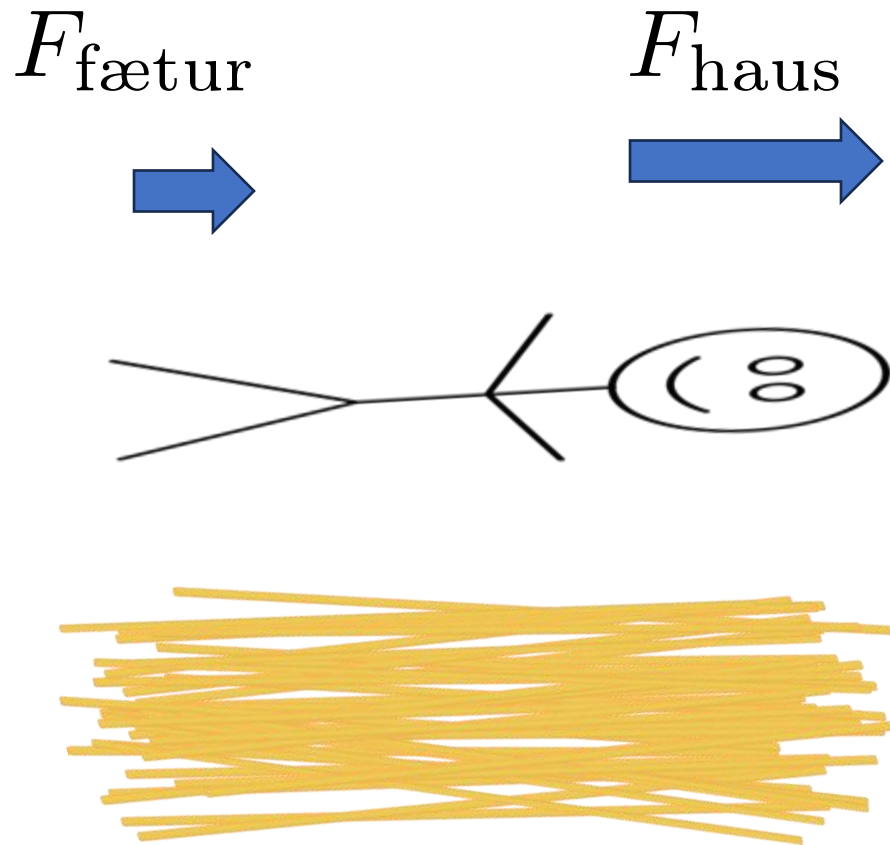
Hvað myndi gerast ef maður myndi fara inn í svarthol?



Hvað myndi gerast ef maður myndi fara inn í svarthol?



Hvað myndi gerast ef maður myndi fara inn í svarthol?

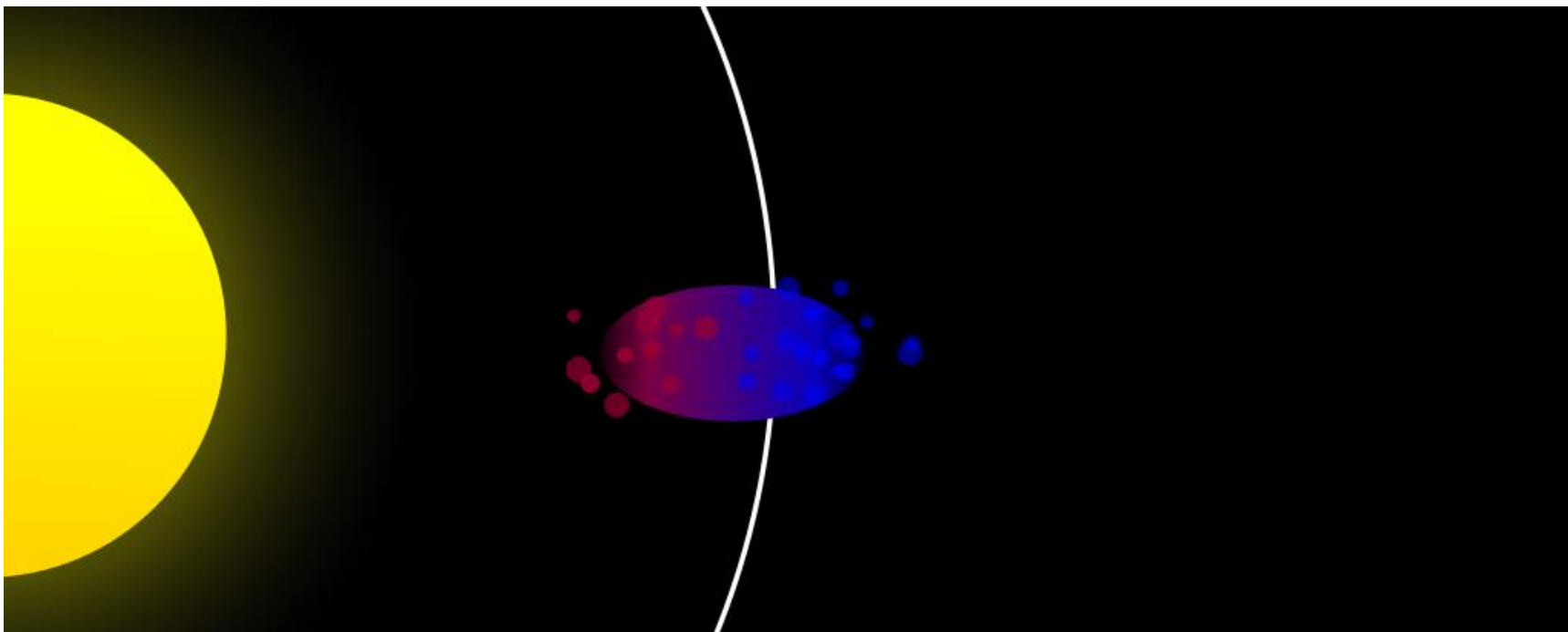
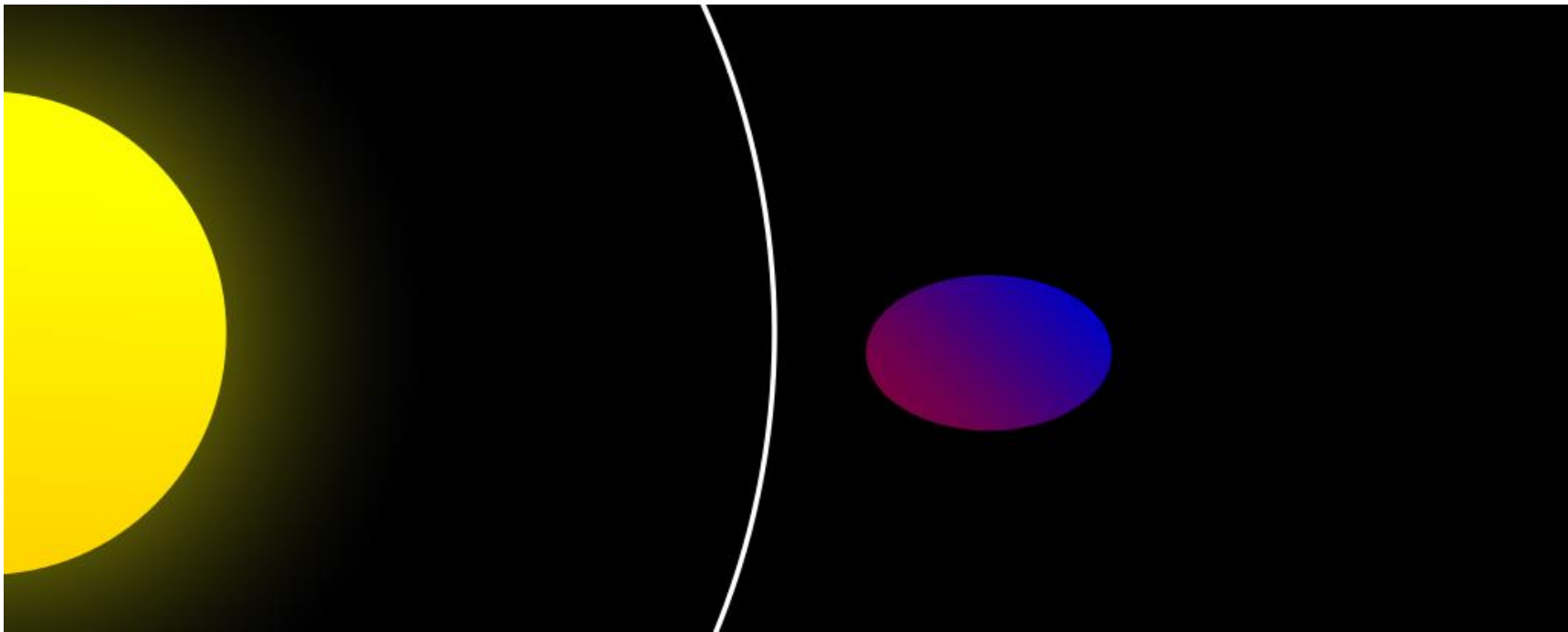


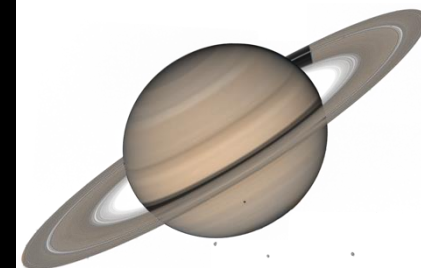
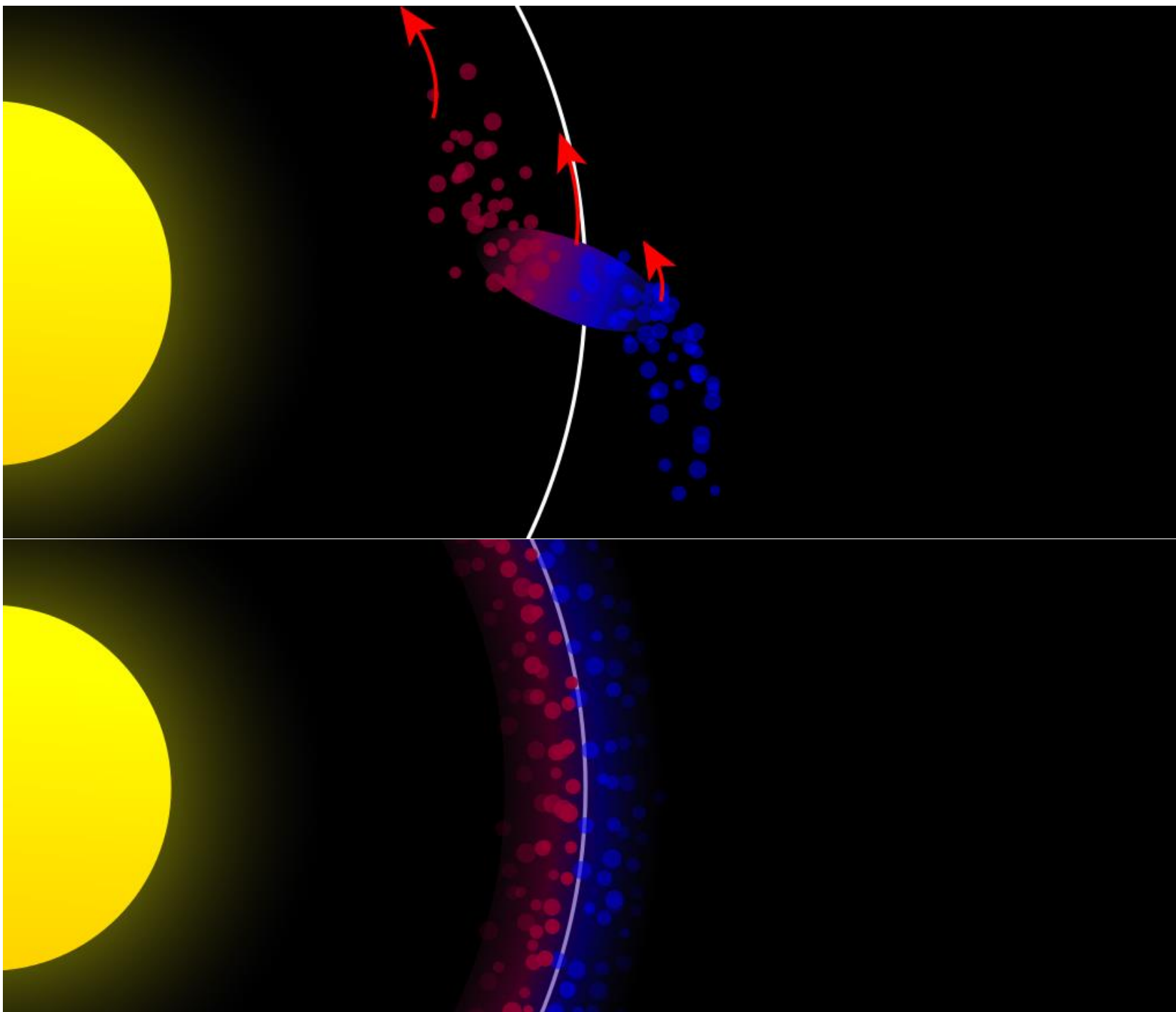


50 millió ár

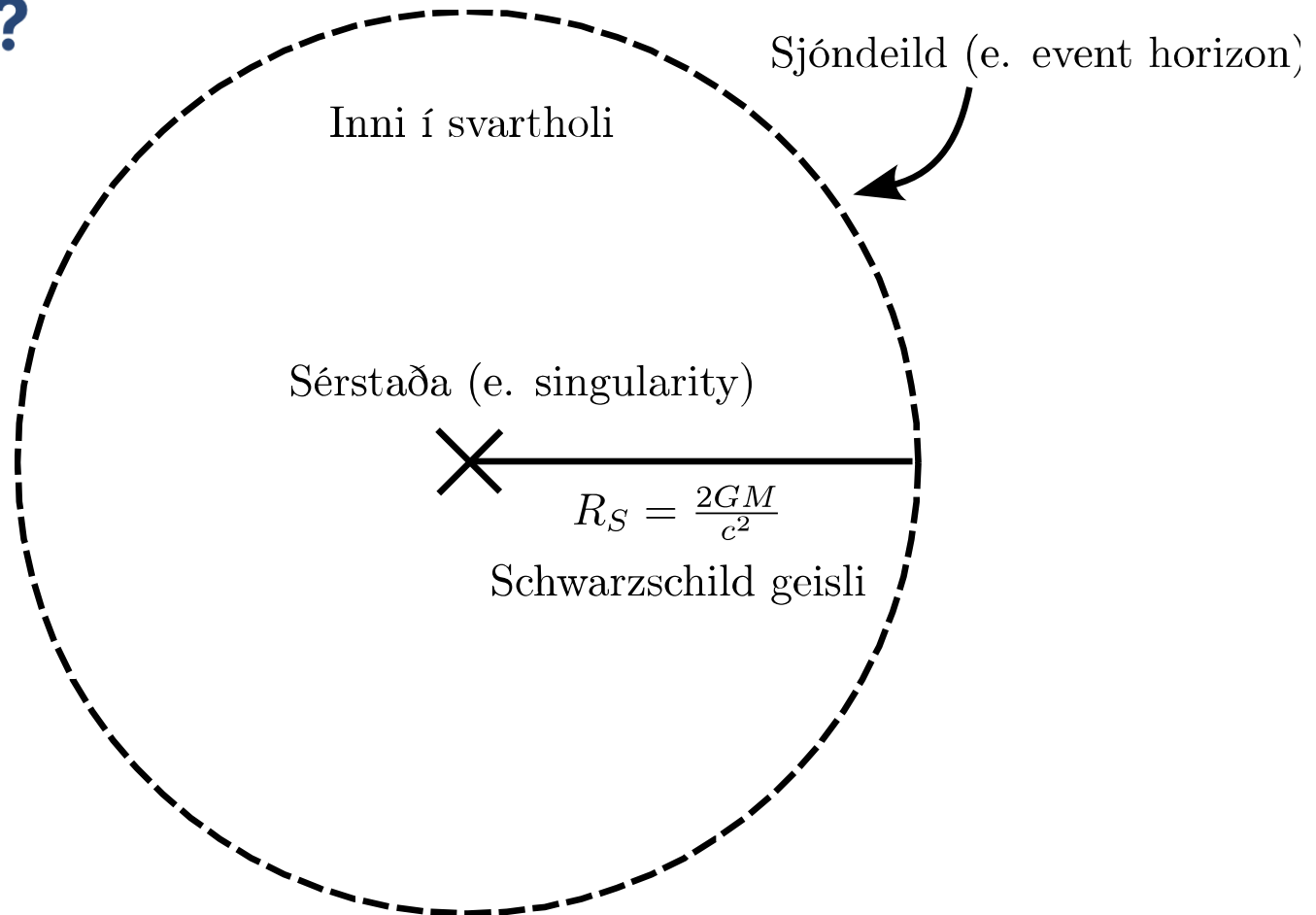
Mars

Fóbos





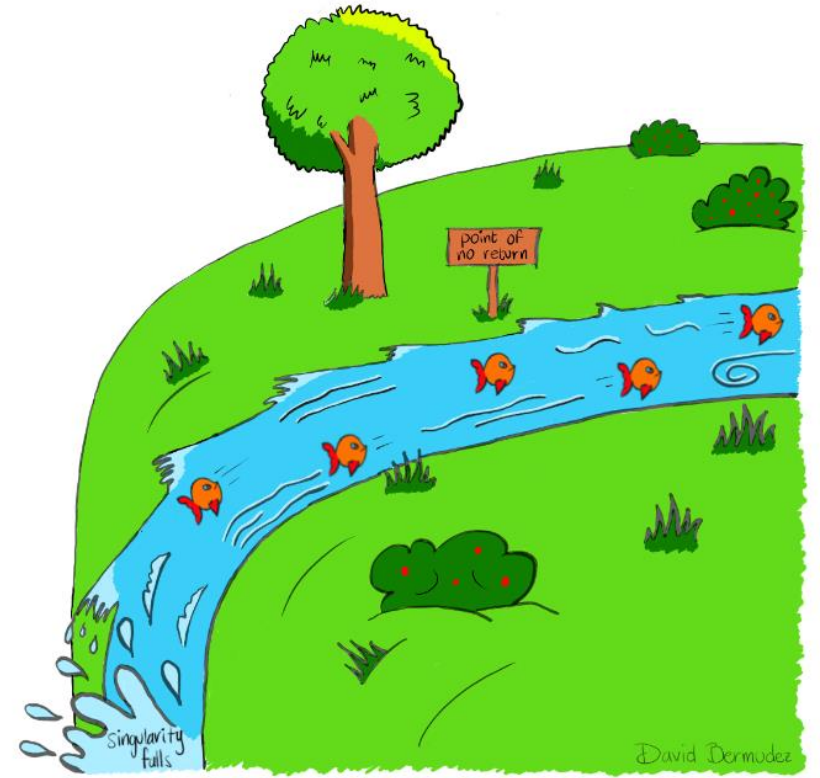
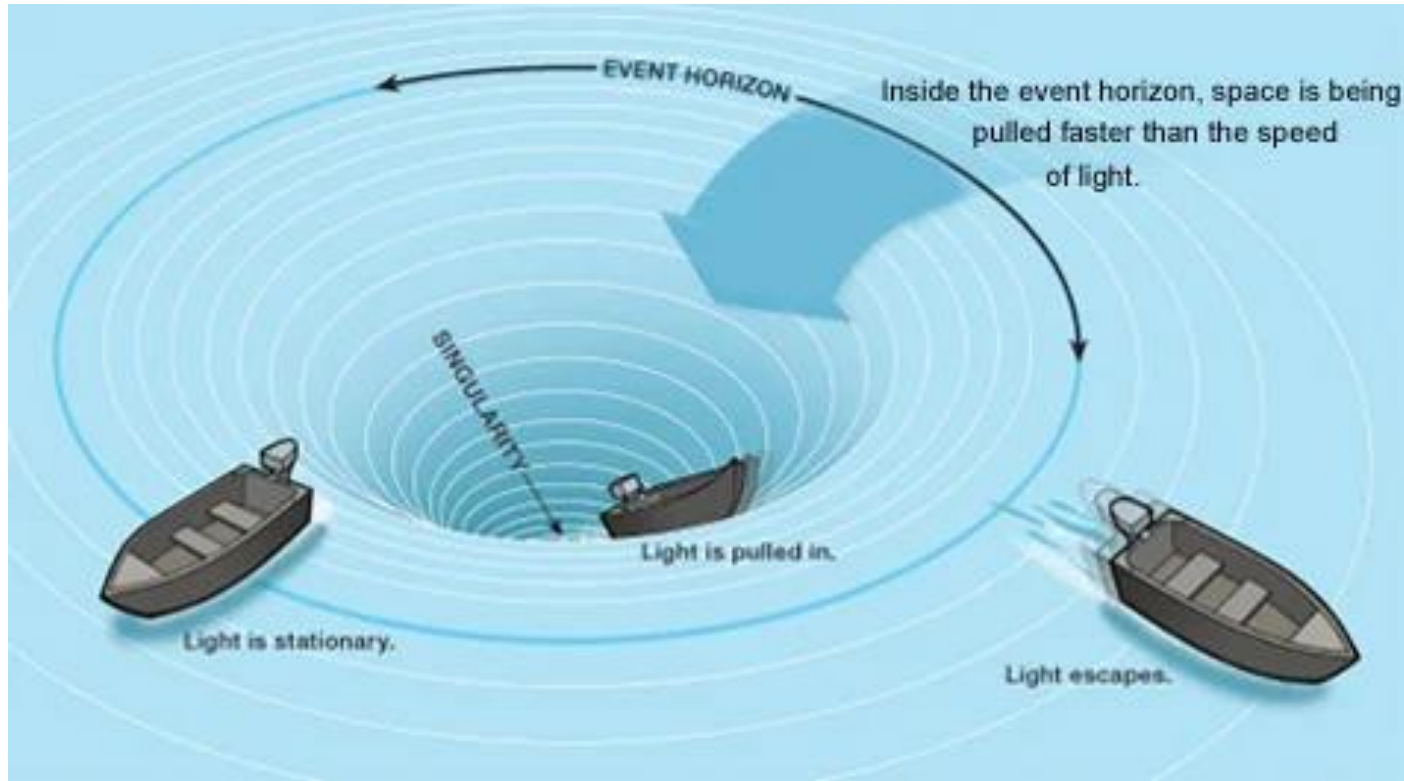
Hvað myndi gerast ef maður myndi fara inn í svarthol?





Baldur

Anna

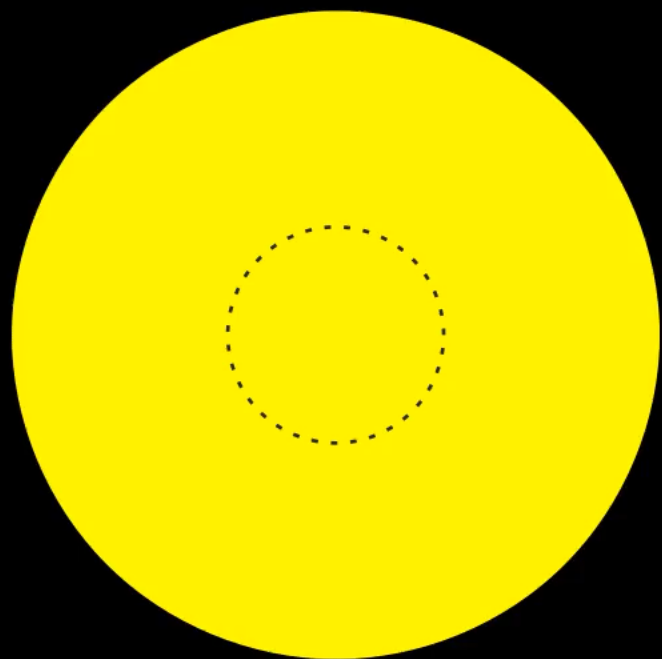




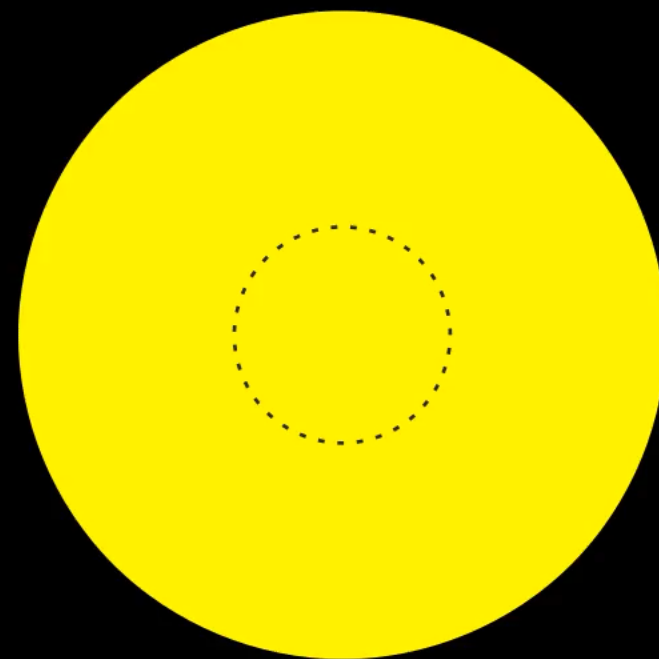
Baldur

Anna

Athugandi á yfirborði



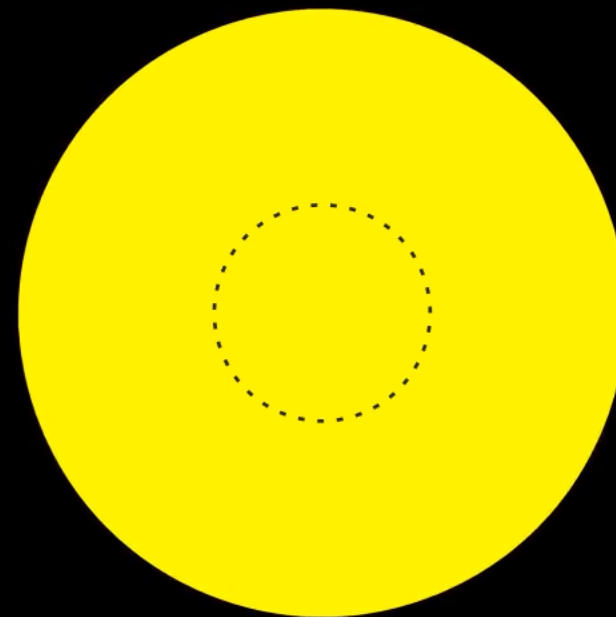
Fjarlægur athugandi



Athugandi á yfirborði



Fjarlægur athugandi

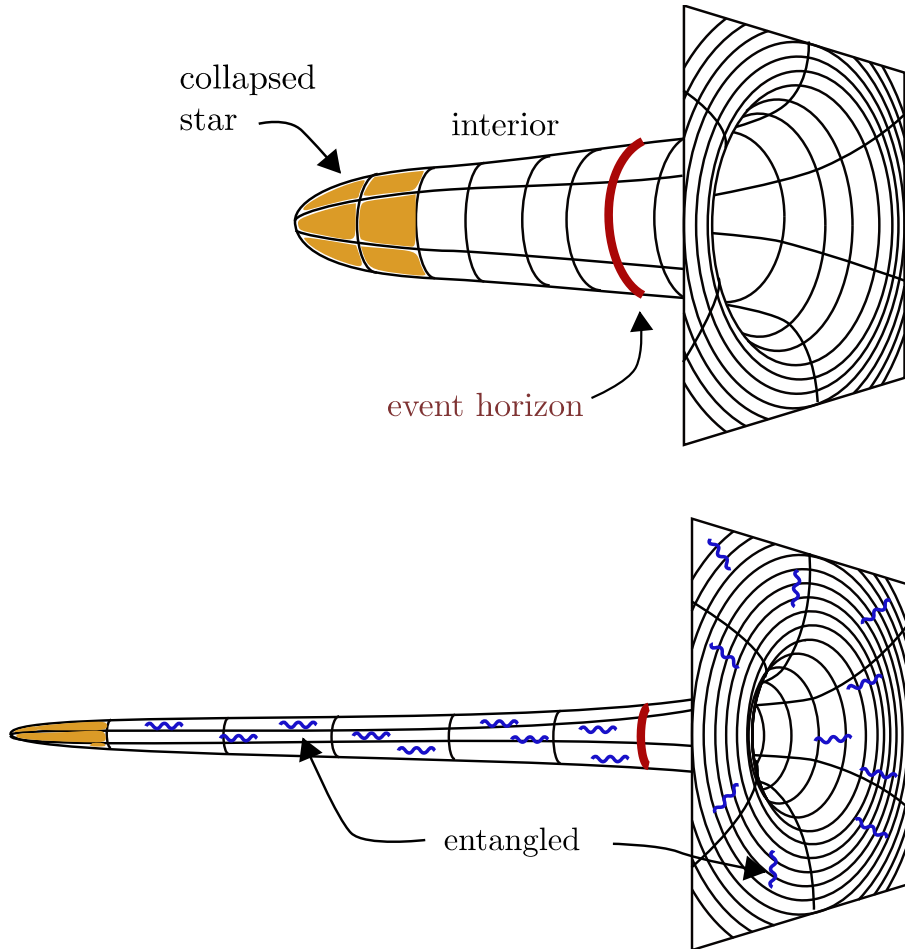


Eyðast svarthol einhverntíman, eiga þau eftir að söga allt í heiminum í sig?

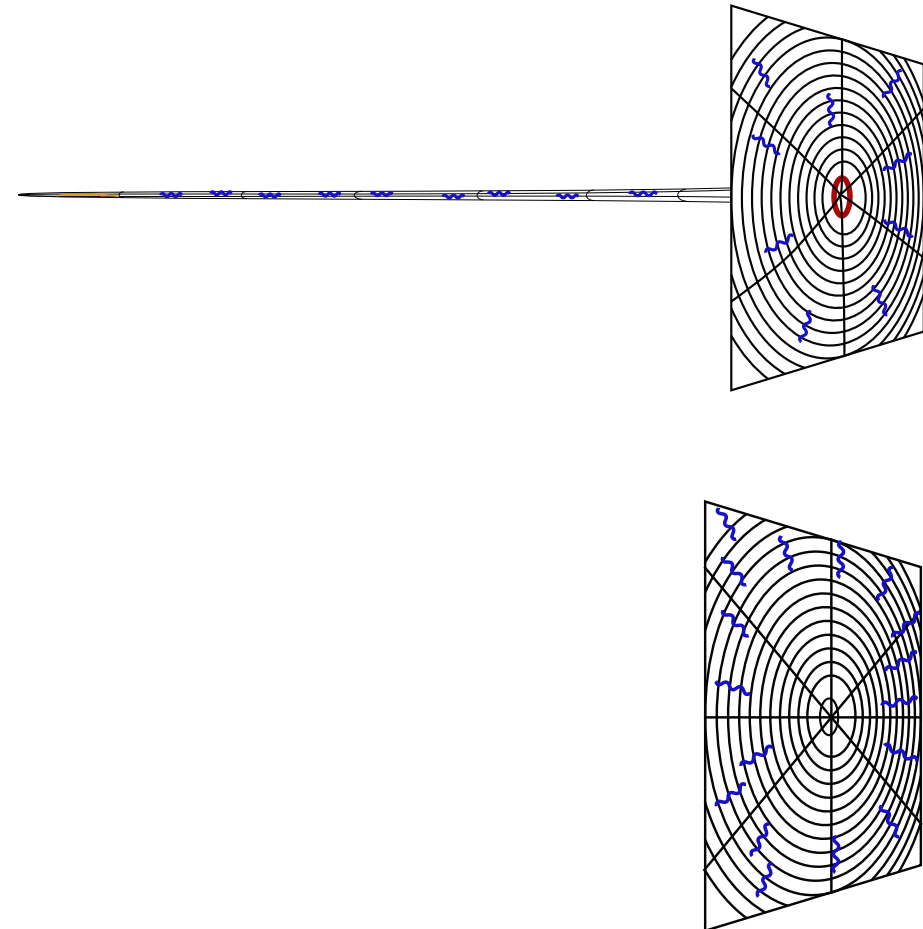
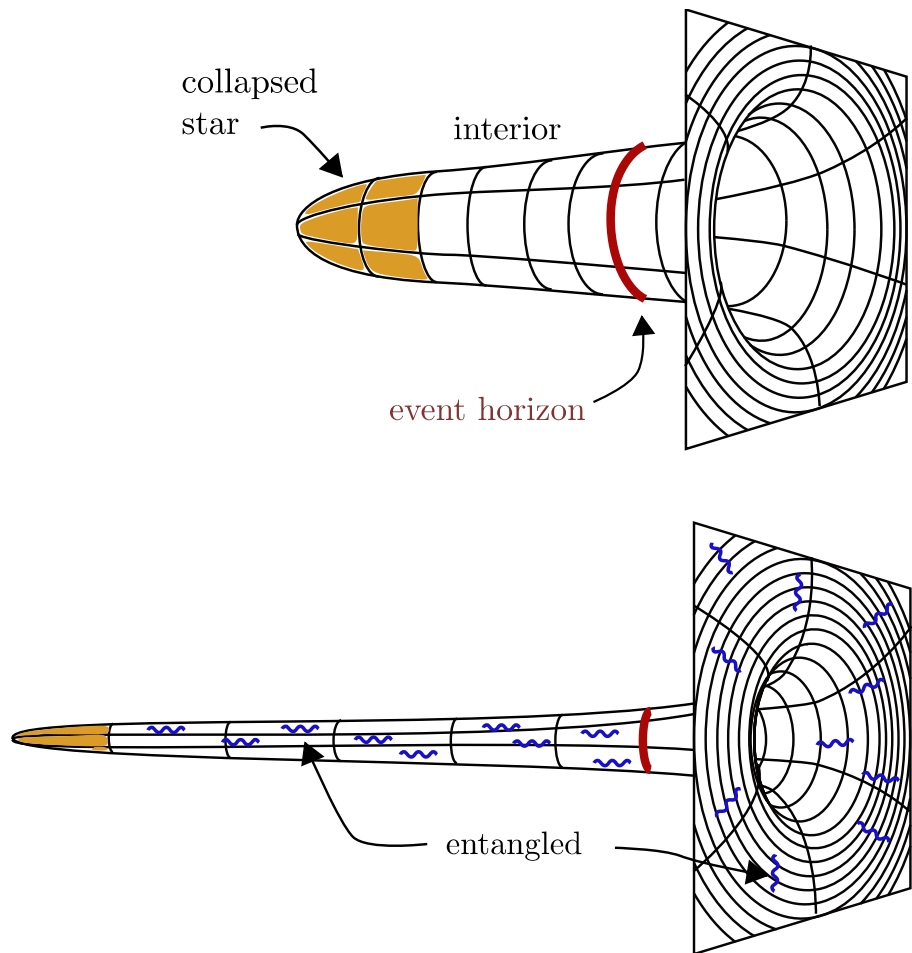


Stephen Hawking

Eyðast svarthol einhverntíman, eiga þau eftir að söga allt í heiminum í sig?



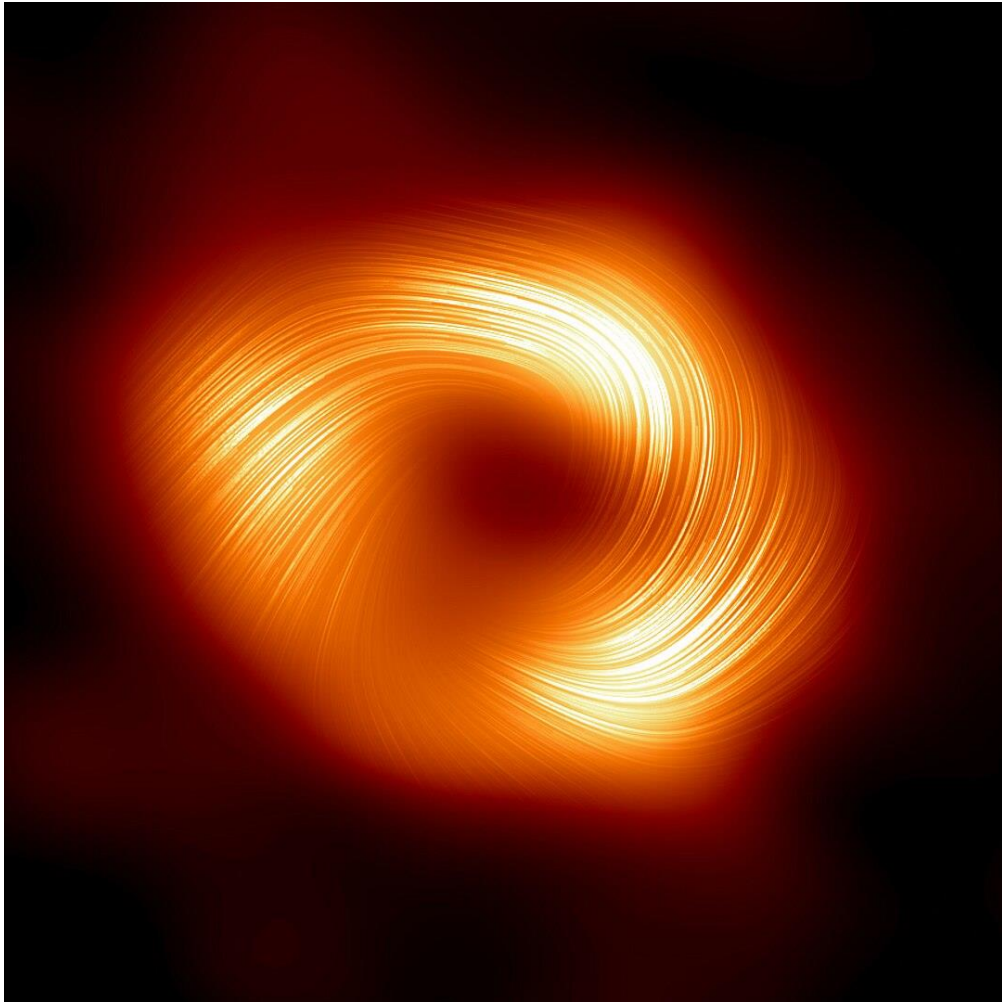
Eyðast svarthol einhverntíman, eiga þau eftir að söga allt í heiminum í sig?



EDLISFRÆÐI: Í DAGLEGU LÍFI

Hversu lengi endast svarthol?

Hversu lengi endast svarthol?



Sagittarius A^*

$$M = 4,3 \cdot 10^6 M_{\text{sól}}$$

$$T_H = \frac{\hbar c^3}{8\pi k_B G M} = 14 \text{ fK}$$

$$\tau_H = \frac{5120\pi G^2}{c^4 \hbar} M^3 = 1,7 \cdot 10^{87} \text{ ár}$$

Hversu lengi endast svarthol?

LHC (Large Hadron Collider)

7 TeV árekstrar

$$M = 1,2 \cdot 10^{-23} \text{ kg}$$

$$r_S = 1,8 \cdot 10^{-50} \text{ m}$$

$$T_H = 9,8 \cdot 10^{45} \text{ K}$$

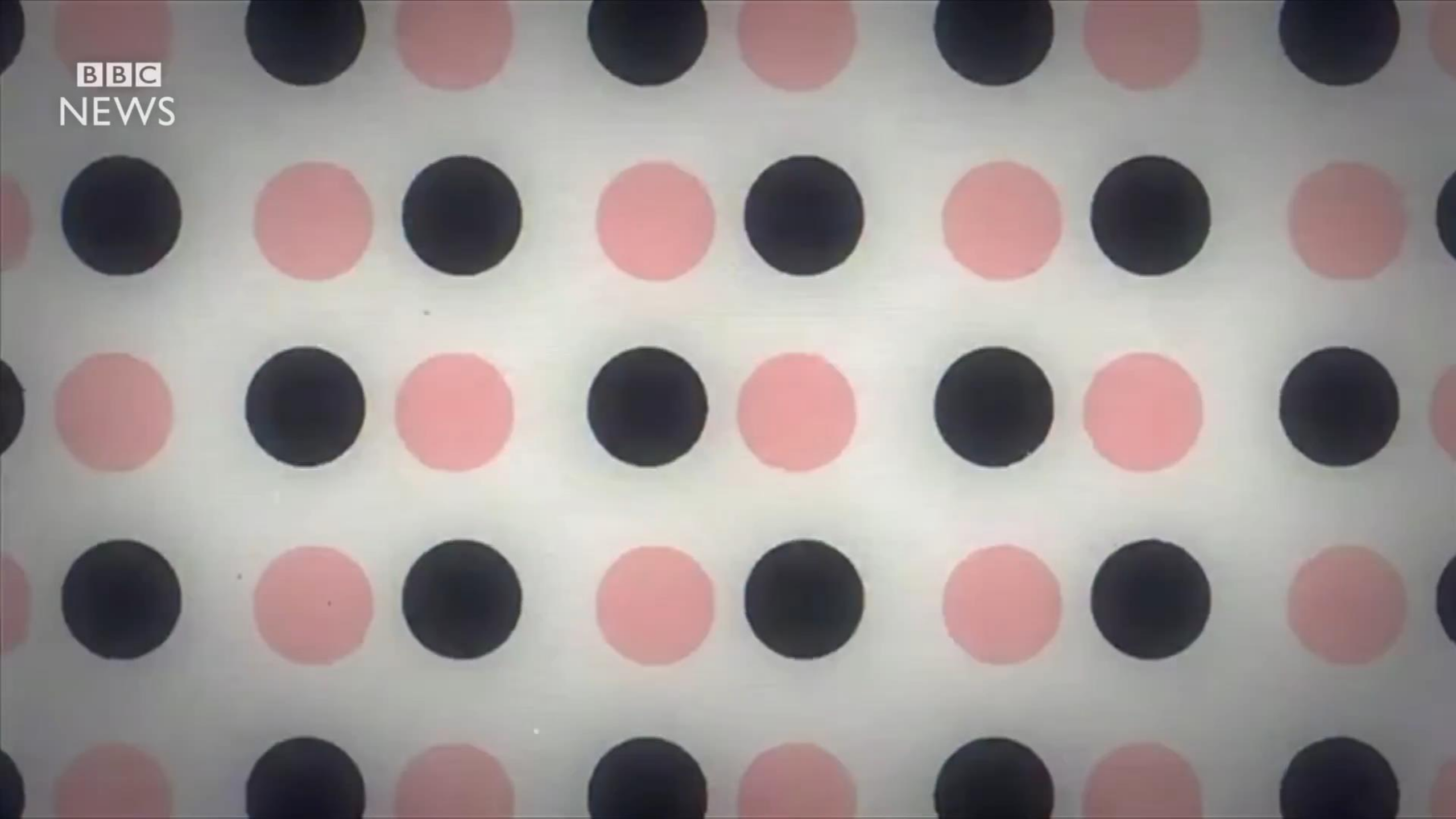
$$\tau_H = 1,6 \cdot 10^{-85} \text{ s}$$



EÐLISFRÆÐI: Í DAGLEGU LÍFI

Hver er upplýsingabversögnin?

Hvað verður um upplýsingarnar í svartholinu?



Takk fyrir áheyrnina

Spurningar?

Er hægt að kanna svarthol með því að senda ómannað geimskip inn í það?

Væri hægt að senda vélmenni með myndavél til að skoða og taka mynd af svartholi?

Getur maður séð hnakkann sinn ef maður stendur inni í svartholi?

Er hætta á rogue svartholi?

Ef svarthol er í miðju Vetrarbrautarinnar hvers vegna kemur þá ljós þaðan á myndum?

Ef hegðun efnis í miðju svarthols er á skjön við kenningar okkar, eru þær þá ekki rangar?