

Svarthol fyrir almenning

Matthias Harksen

EÐLISFRÆÐI: Í DAGLEGU LÍFI

Hvernig eru svarthol á litinn?

EÐLISFRÆÐI: Í DAGLEGU LÍFI

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

EÐLISFRÆÐI: Í DAGLEGU LÍFI

**Hvernig komumst við að því að
svarthol séu til?**

EÐLISFRÆÐI: Í DAGLEGU LÍFI

Er svarthol endilega svart?

EÐLISFRÆÐI: Í DAGLEGU LÍFI

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

EÐLISFRÆÐI: Í DAGLEGU LÍFI

Getur eitt svarthol gleypit annað svarthol?

EÐLISFRÆÐI: Í DAGLEGU LÍFI

**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

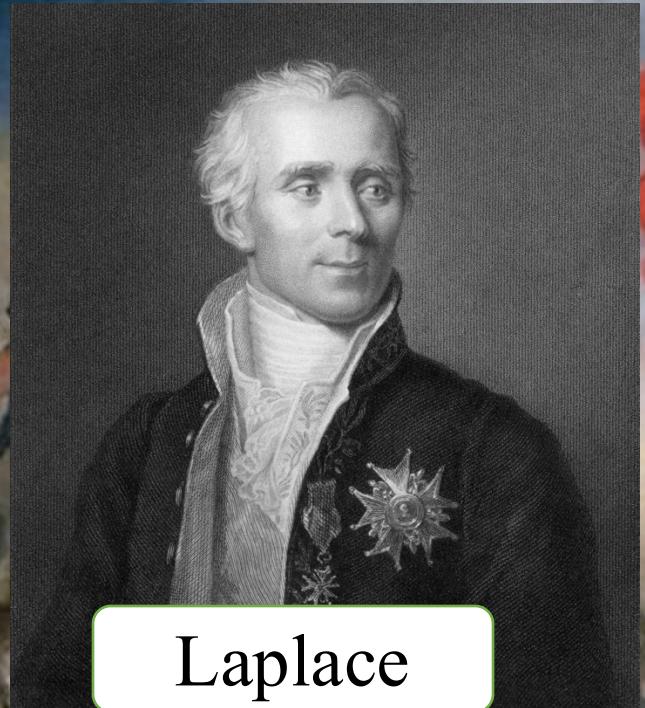


EÐLISFRÆÐI: Í DAGLEGU LÍFI

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

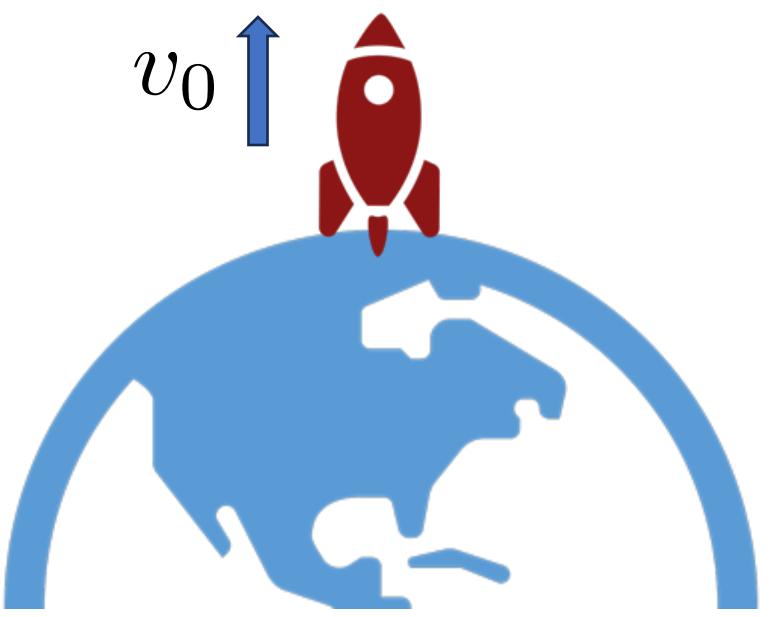
EÐLISFRÆÐI: Í DAGLEGU LÍFI

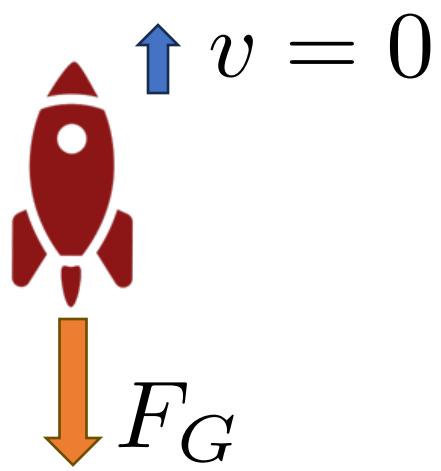
Hvað er svarthol?

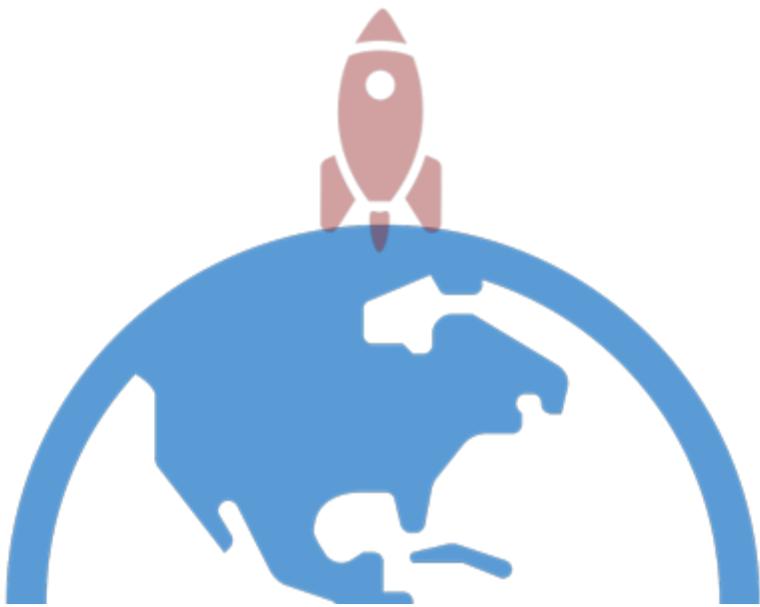
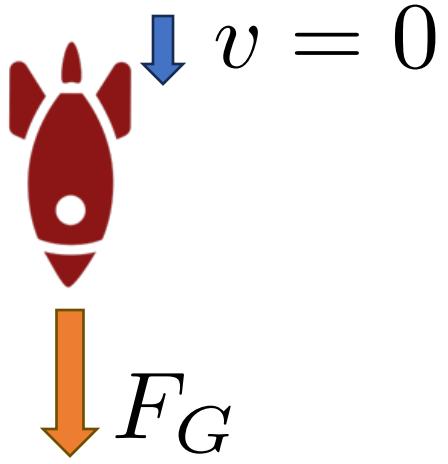


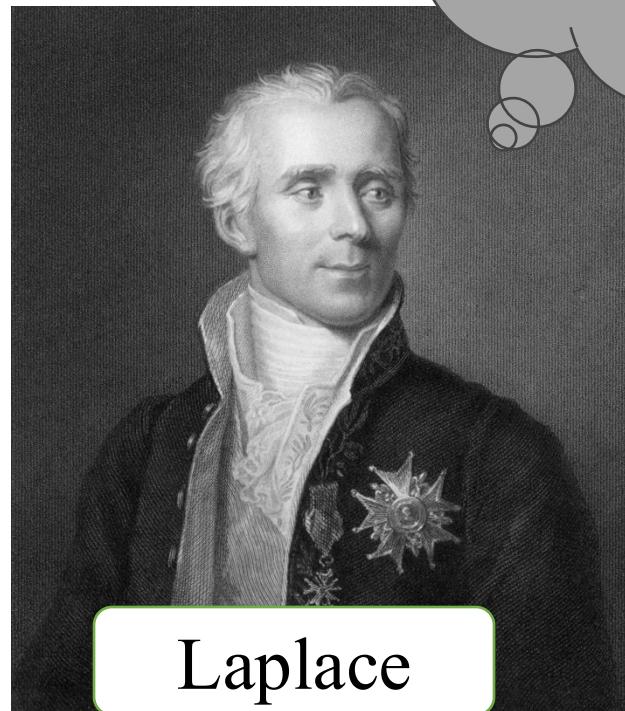
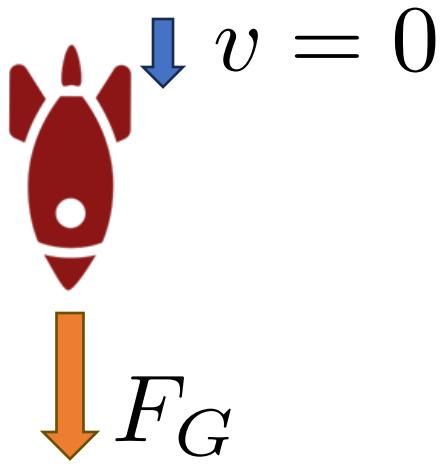
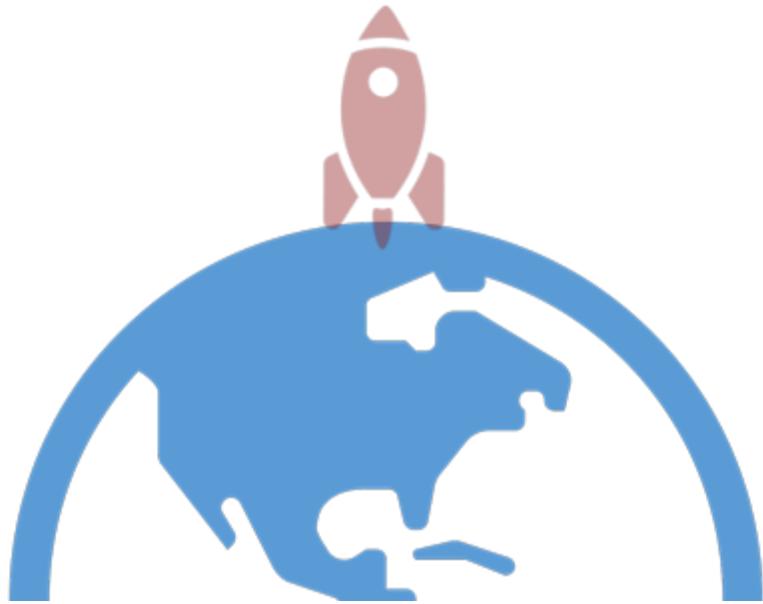
Laplace



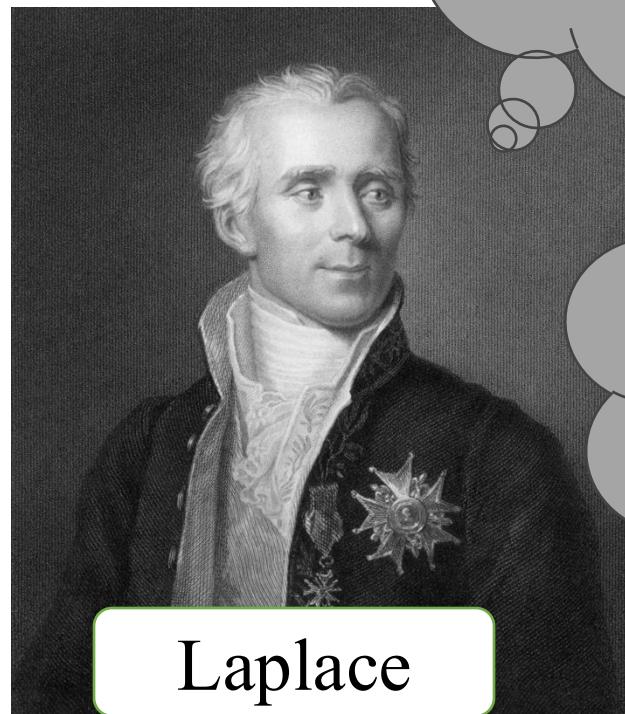
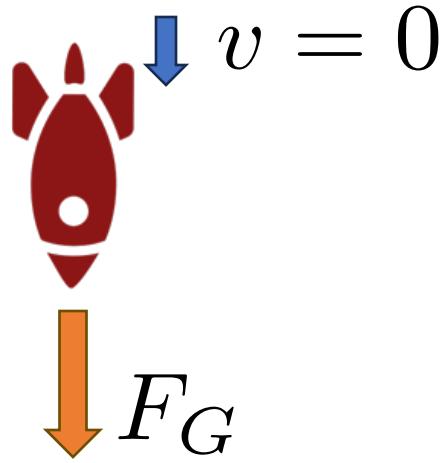
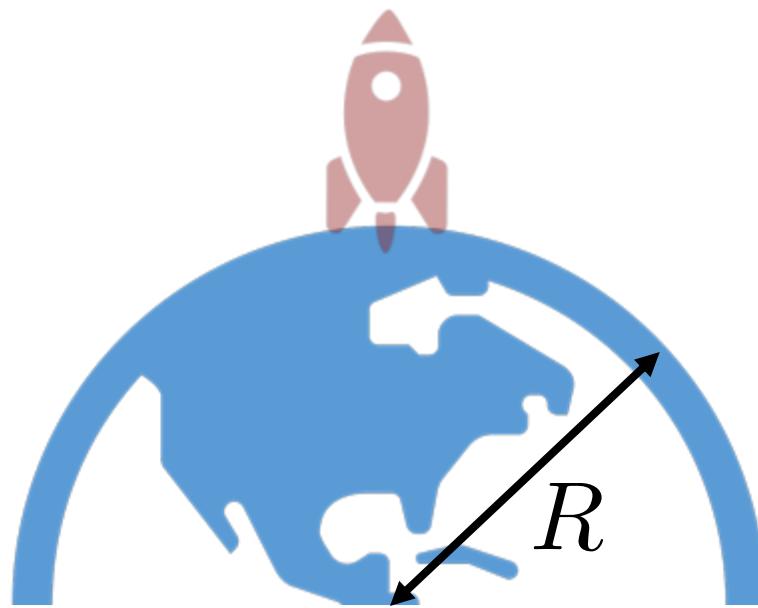








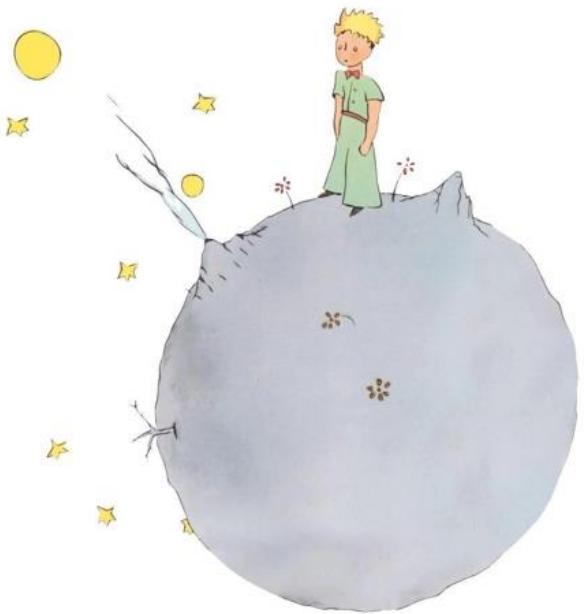
Laplace



Hvað ef hún
myndi aldrei
snúa við?

Þá þyrfti:

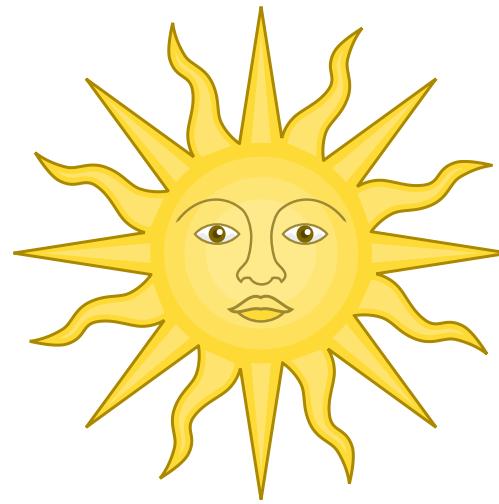
$$v_0 \geq \sqrt{\frac{2GM}{R}}$$



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



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



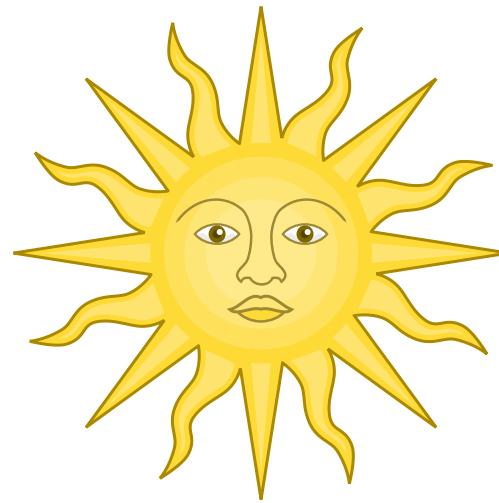
$$v_0 = 619 \text{ km/s}$$



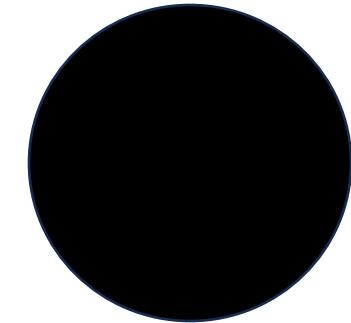
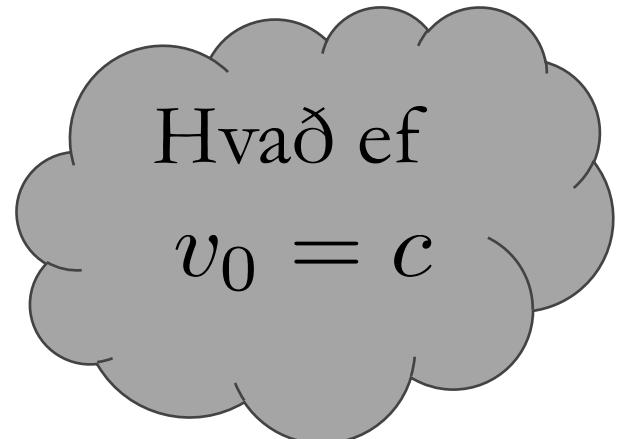
$$v_0 = 0,3 \text{ km/s}$$



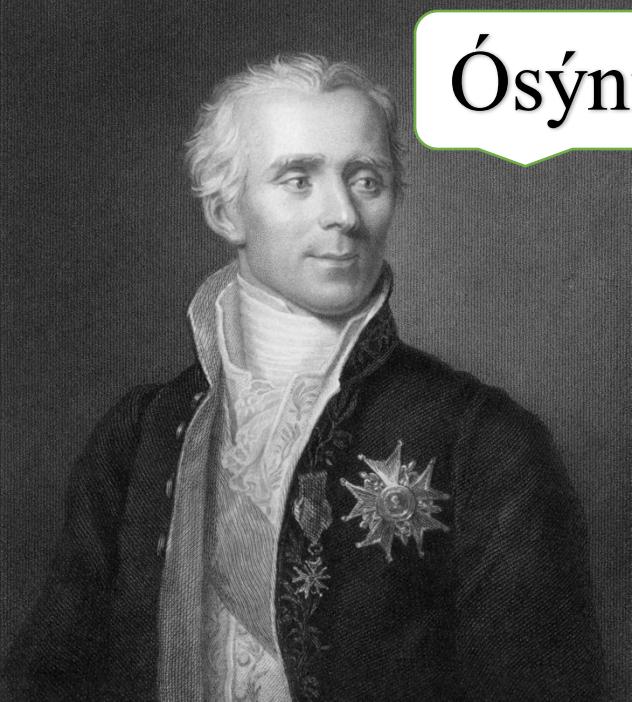
$$v_0 = 11,2 \text{ km/s}$$



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



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



Ósýnileg

EÐLISFRÆÐI: Í DAGLEGU LÍFI

Hvernig eru svarthol á litinn?

EÐLISFRÆÐI: Í DAGLEGU LÍFI

Af hverju er erfitt að sjá svarthol?

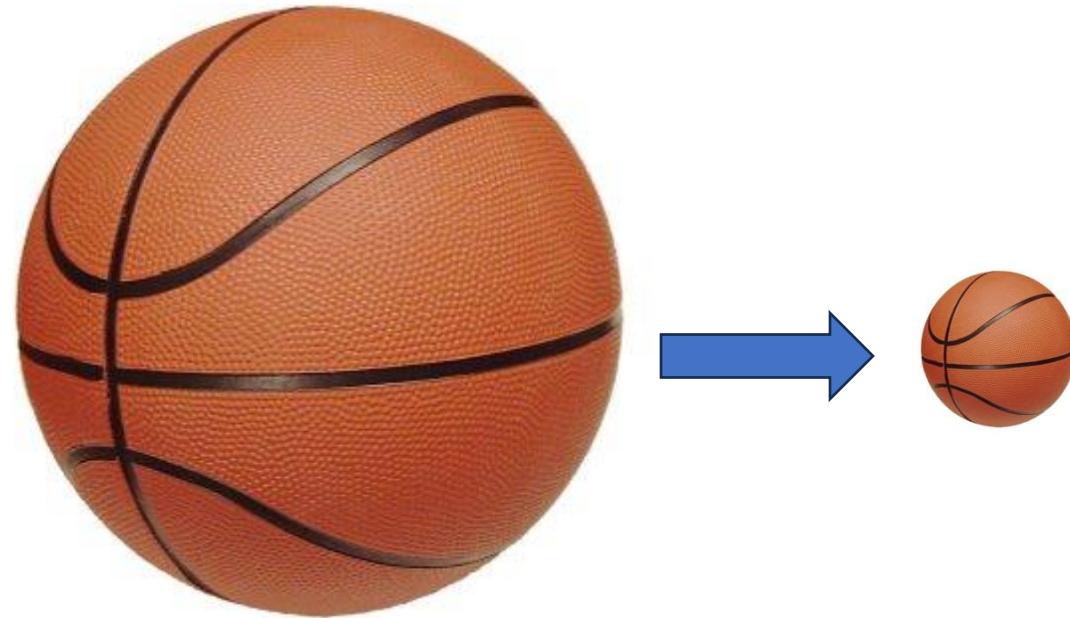


Svört

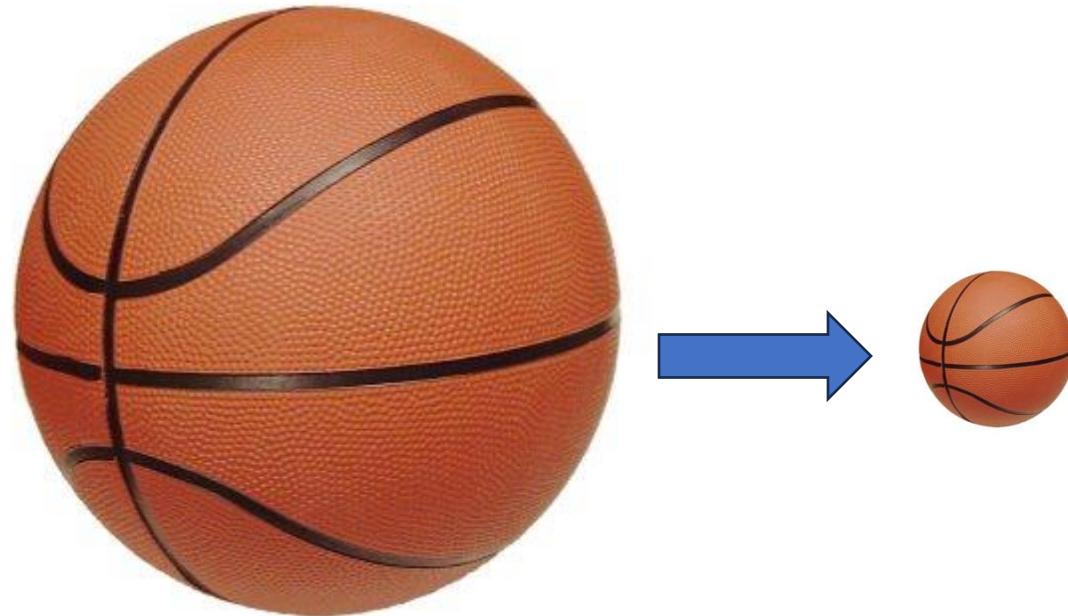
EÐLISFRÆÐI: Í DAGLEGU LÍFI

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

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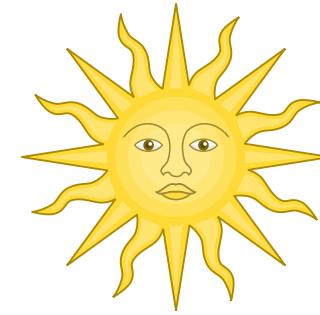
$$R = 12 \text{ cm}$$

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

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

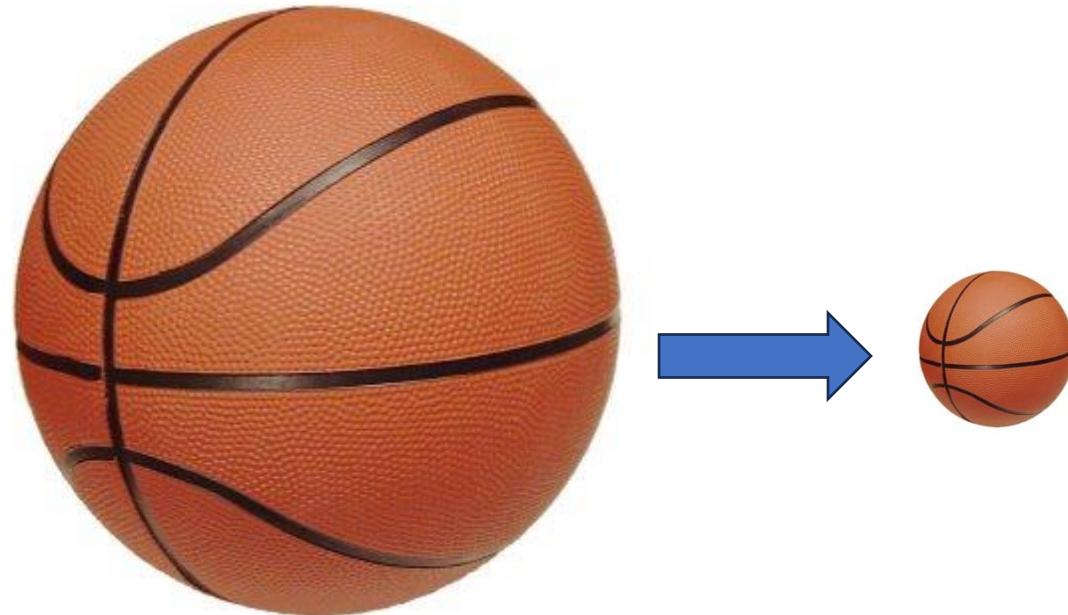
$$M = 625 \text{ g}$$

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



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

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



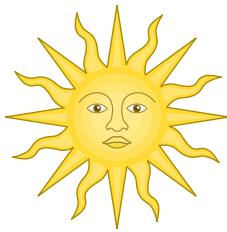
$$R = 12 \text{ cm}$$

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

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

Er hægt að búa til svarthol á tilraunastofu?



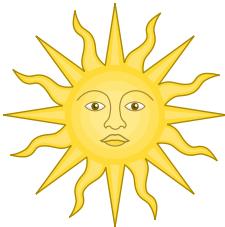
Er hægt að búa til svarthol á tilraunastofu?



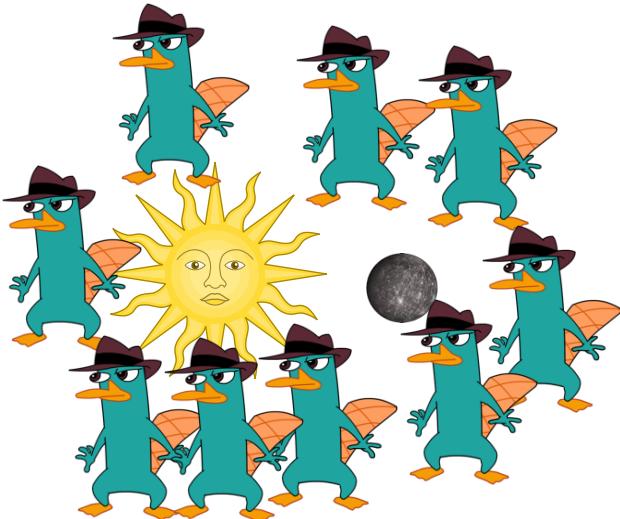
Pési Breiðnefur



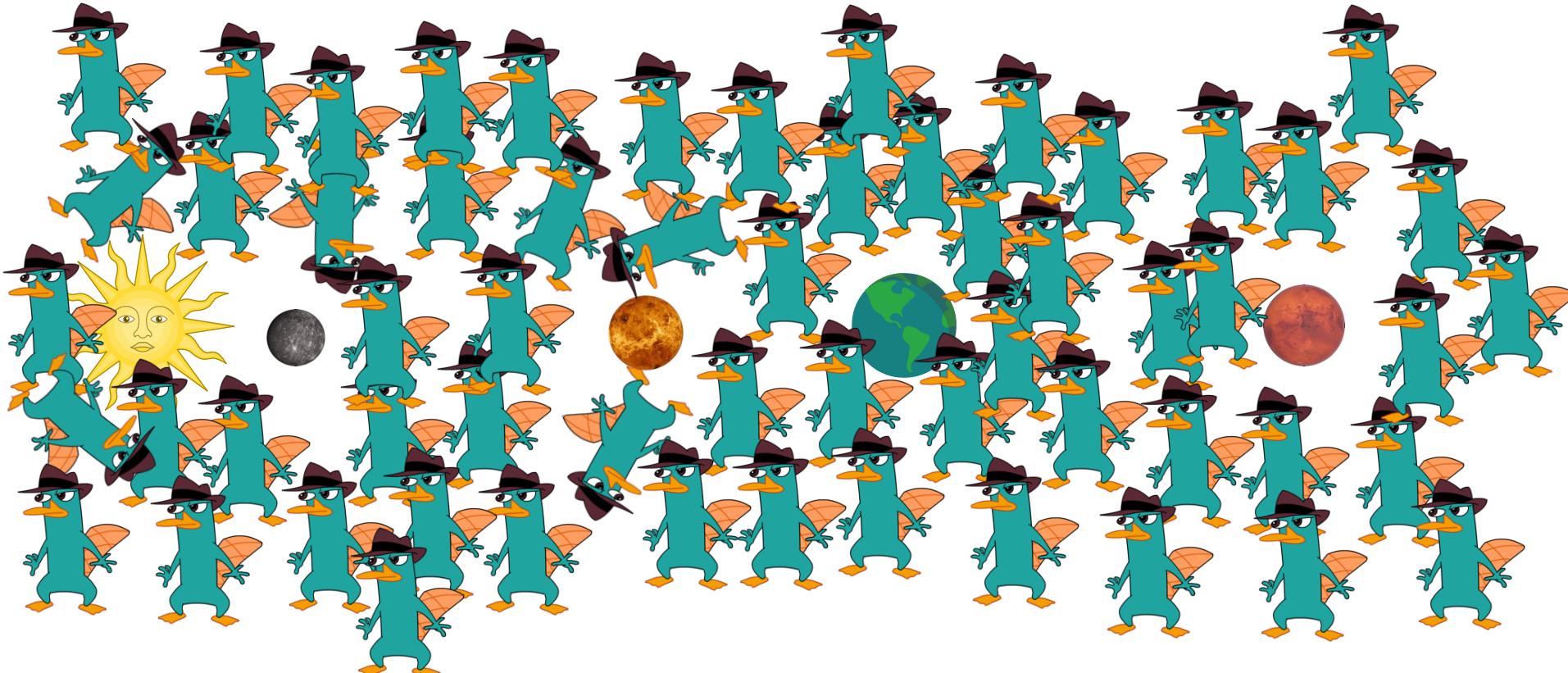
Doktor Hinrik Diðrik



Er hægt að búa til svarthol á tilraunastofu?



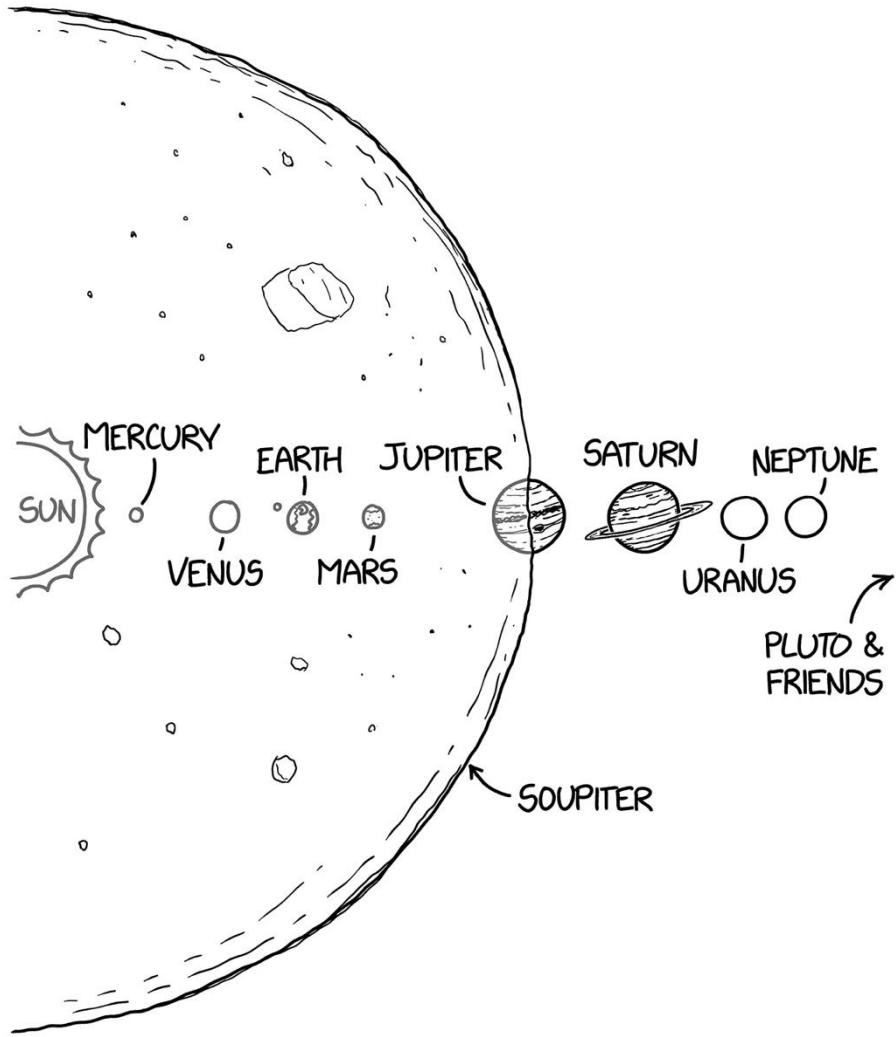
Er hægt að búa til svarthol á tilraunastofu?



$$\rho = 1000 \text{ kg/m}^3 \quad R_S = 2,7 \text{ AU}$$

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

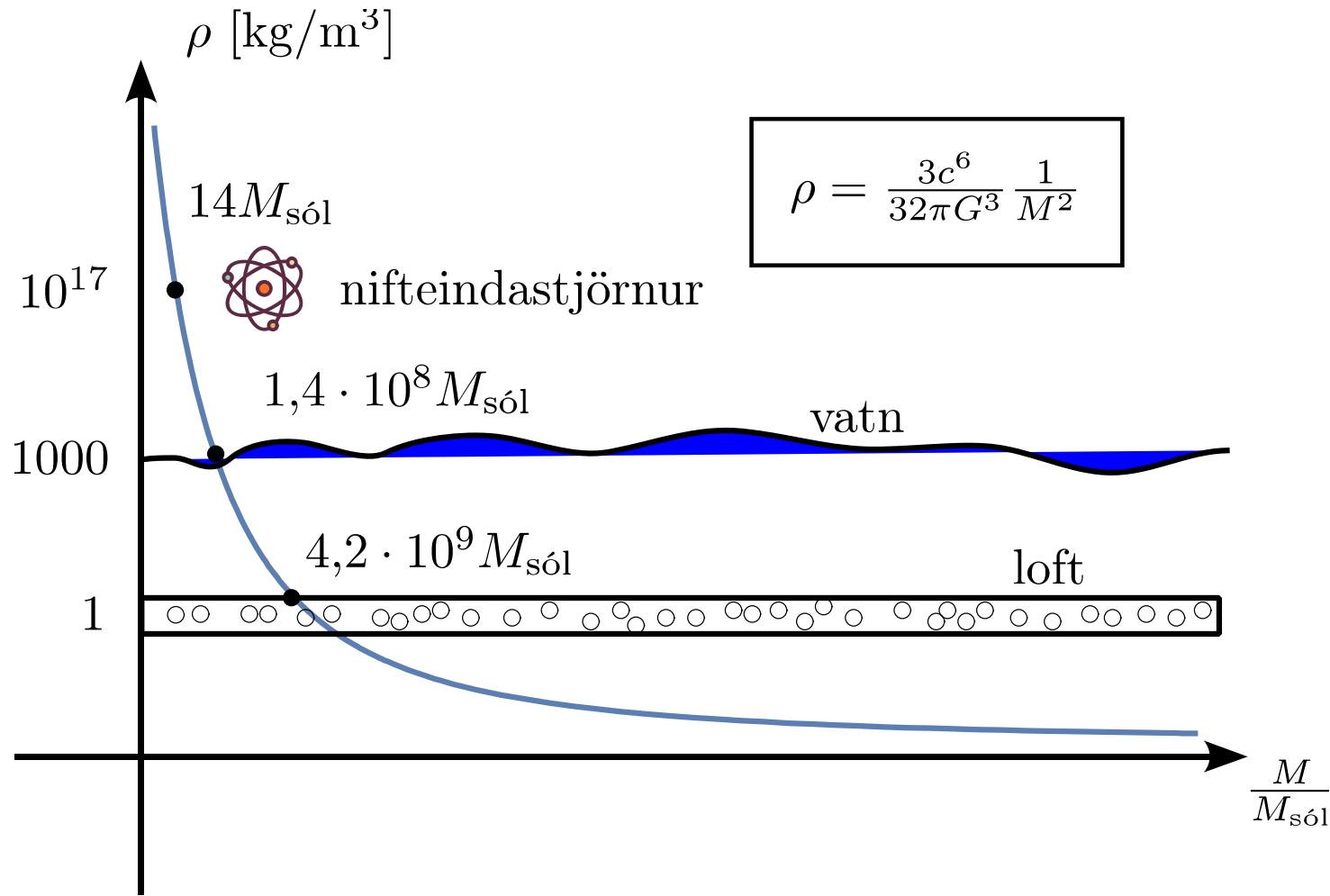
—Amelia, age 5



EÐLISFRÆÐI: Í DAGLEGU LÍFI

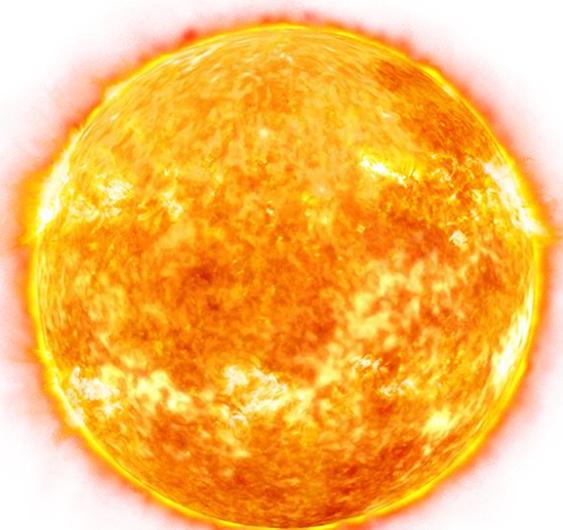
Hver er eðlismassi svarthols?

Hver er eðlismassi svartehols?



Tvær gerðir af svartholum

Dauðar stjörnur



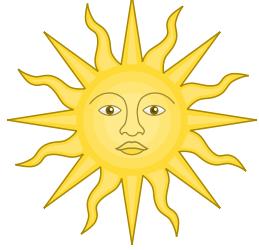
$5\text{-}100 M_{\text{sól}}$

Risasvarthol í miðjum vetrarbrauta

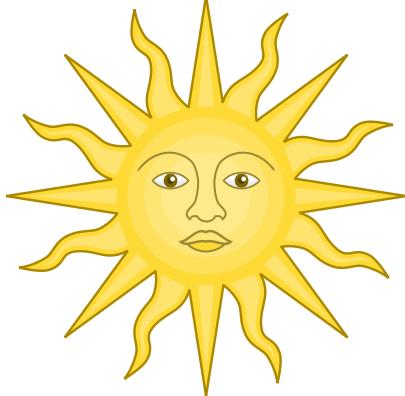


Milljón $M_{\text{sól}}$

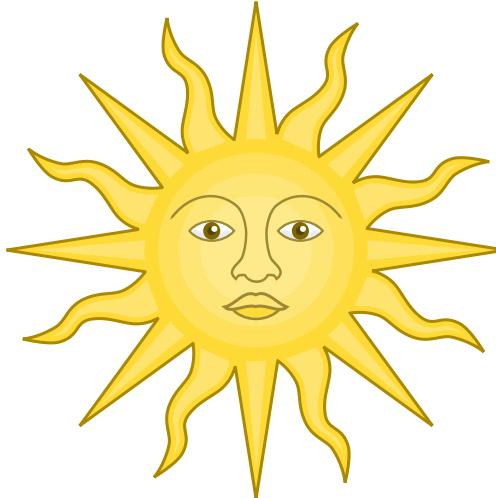
Chandrasekhar-mörk



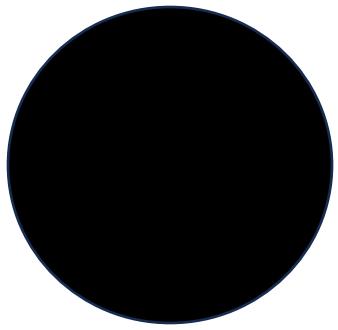
$< 10M_{\text{sól}}$



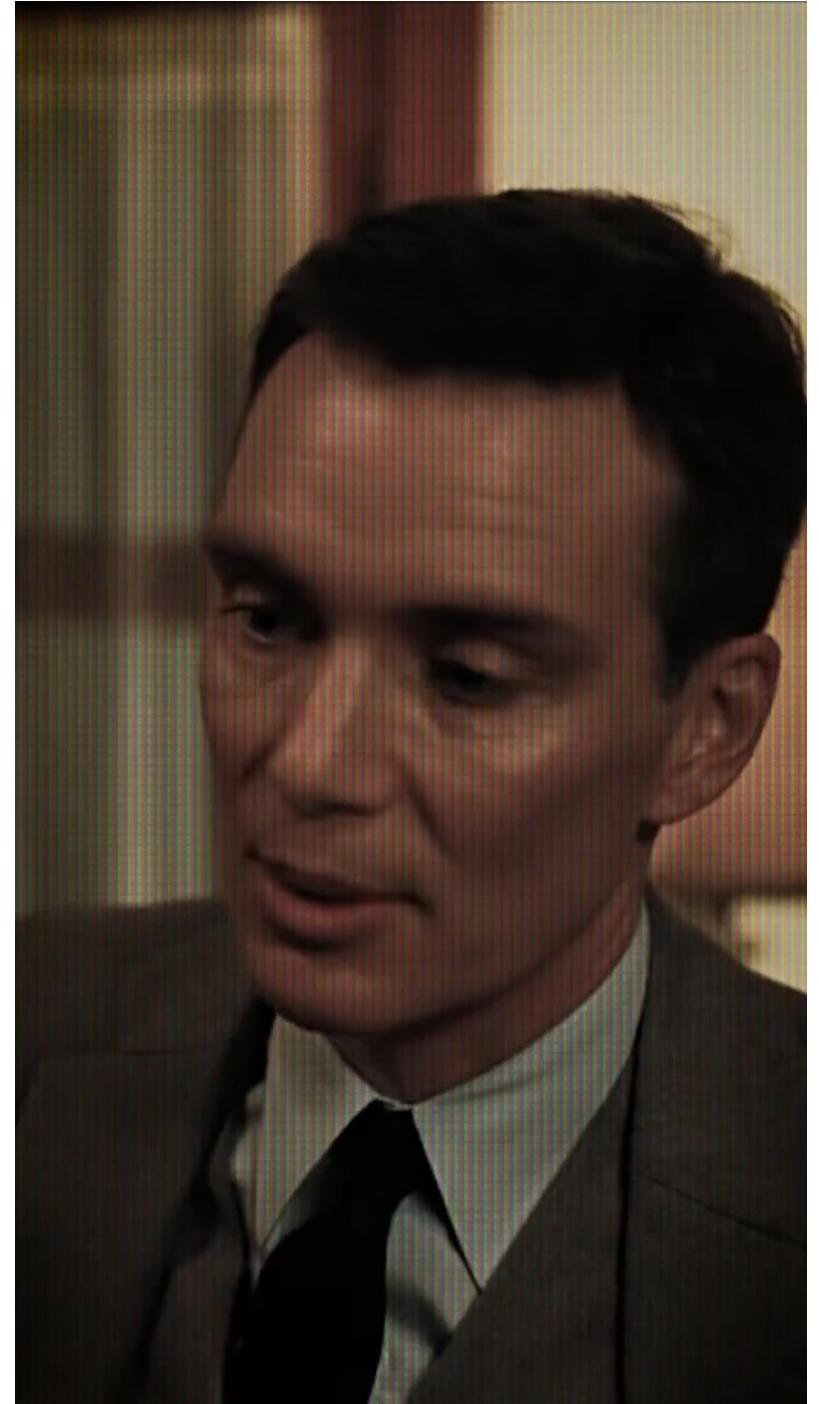
$< 30M_{\text{sól}}$



$> 30M_{\text{sól}}$



Tolman–Oppenheimer–Volkoff-mörk



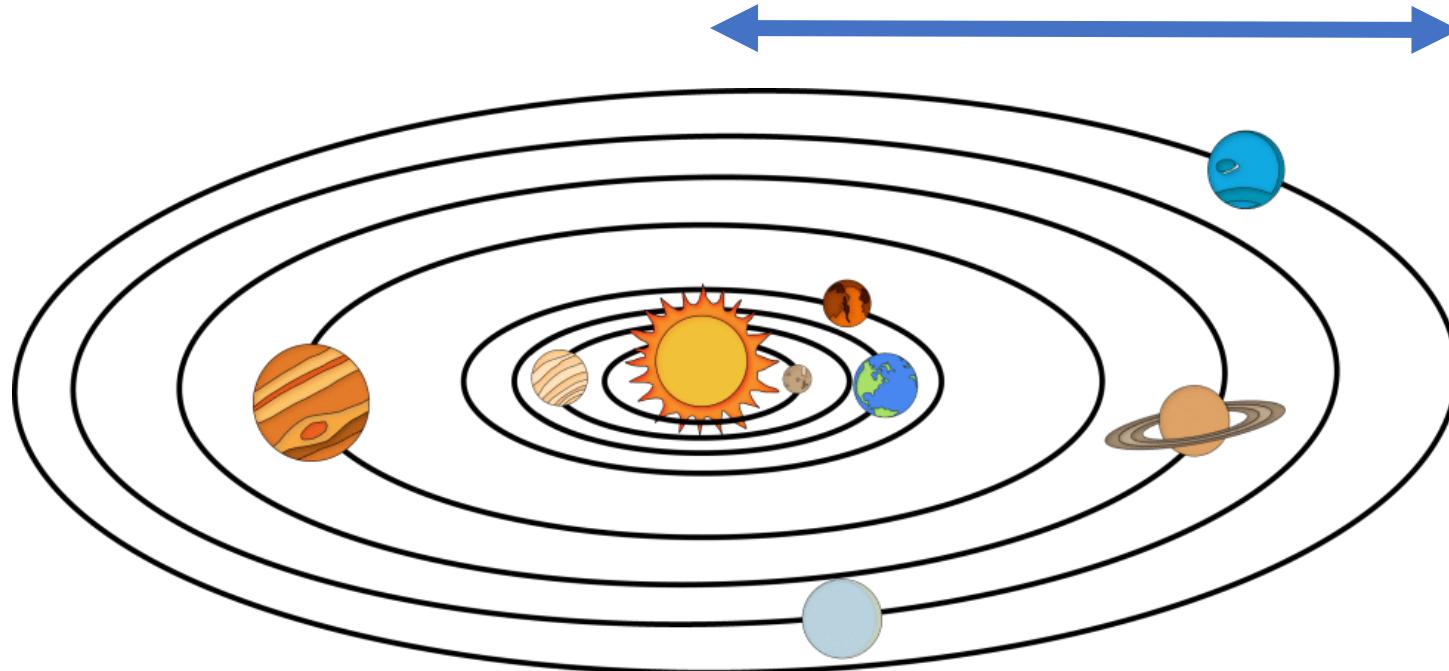
EÐLISFRÆÐI: FRÆÐILEG

Hvaða svarthol er næst okkar sólkerfi?

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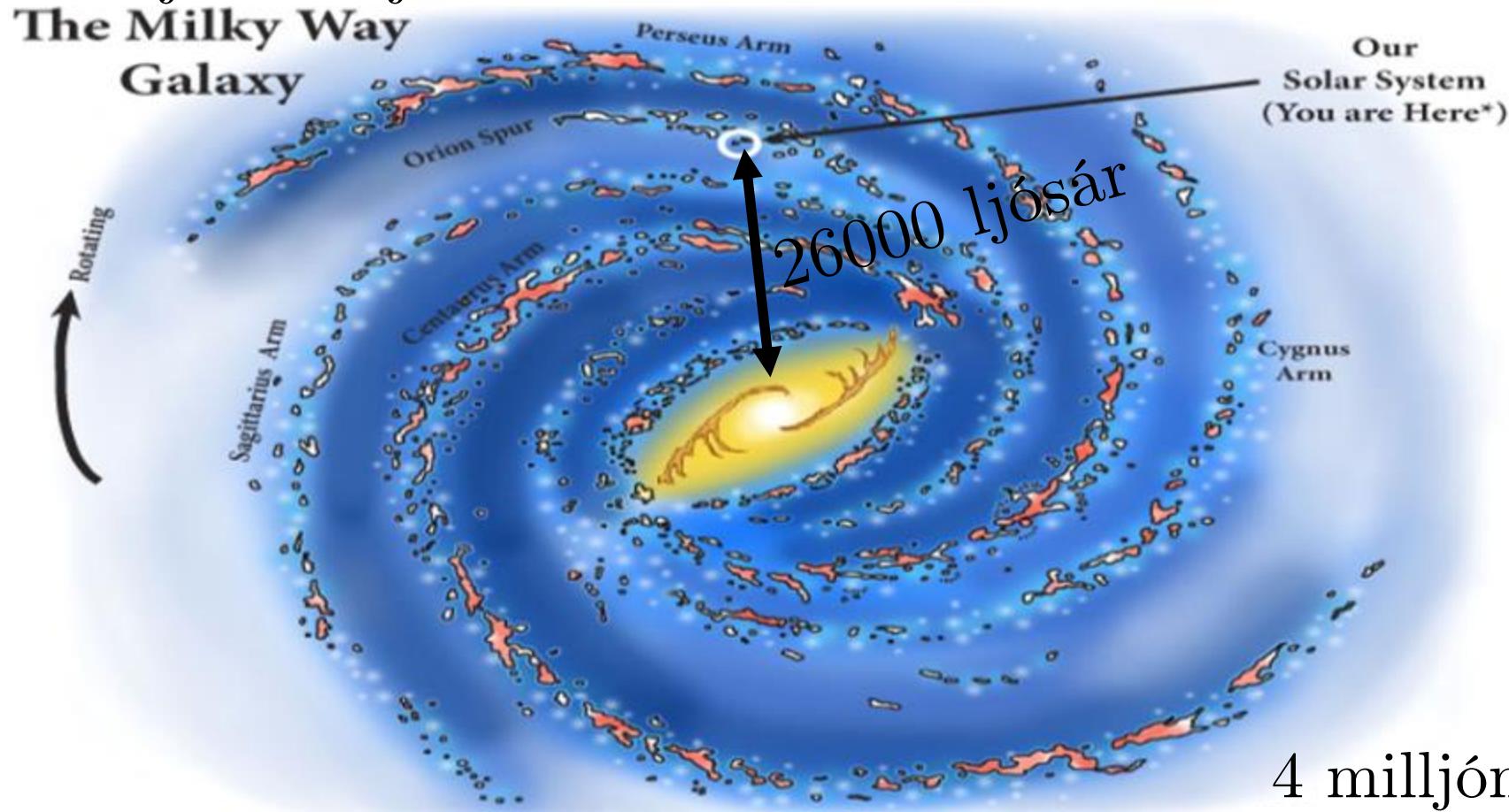
Sólkerfið okkar

250 ljósmínútur

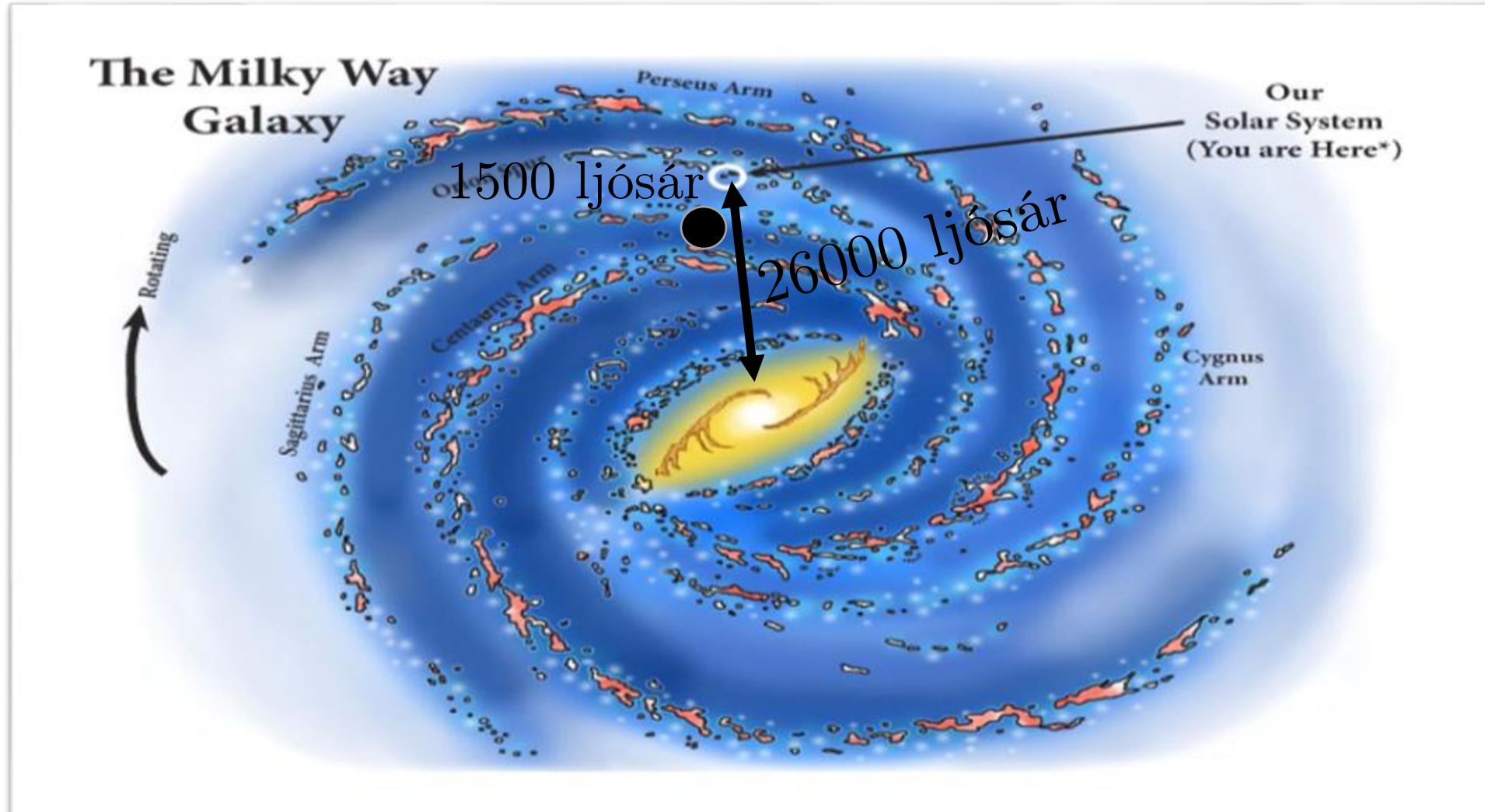


Hvaða svarthol er næst okkar sólkerfi?

100 milljarðar stjarna



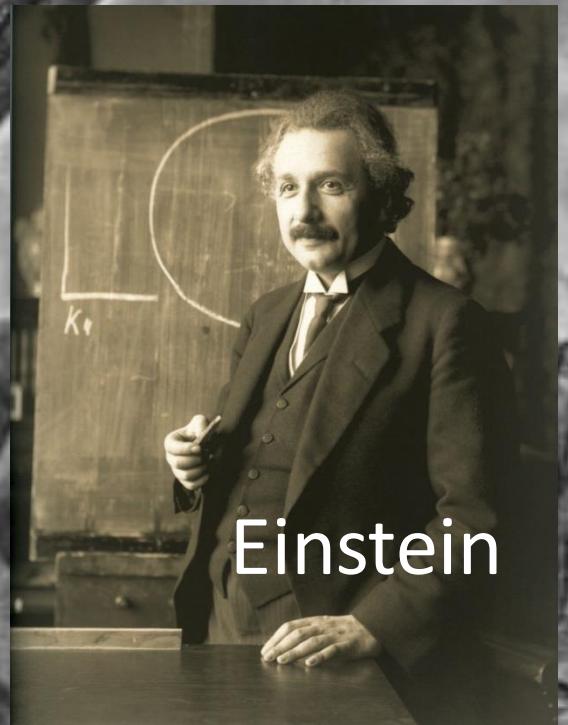
Hvaða svarthol er næst okkar sólkerfi?



EÐLISFRÆÐI: Í DAGLEGU LÍFI

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

1915

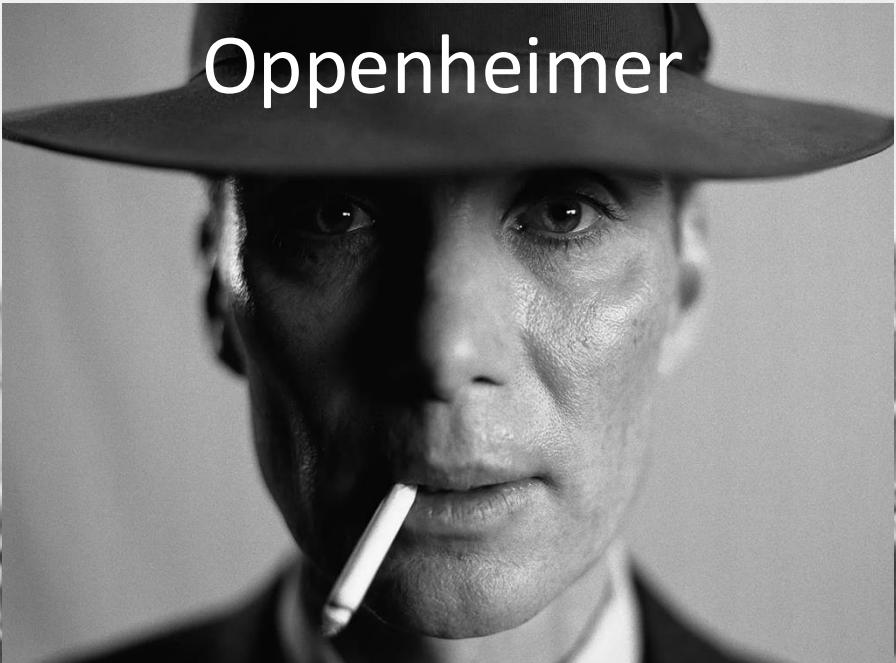


Einstein



Schwarzschild

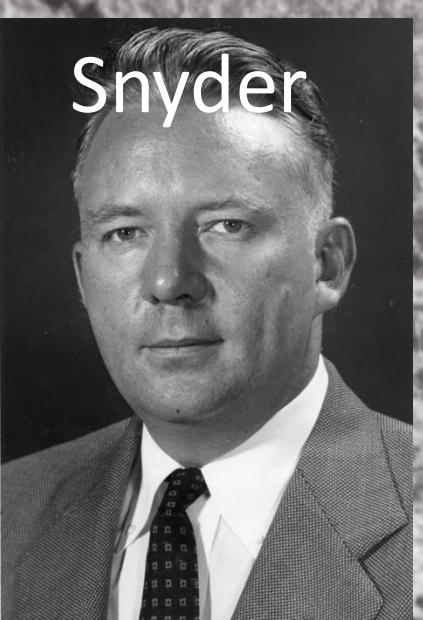




Oppenheimer

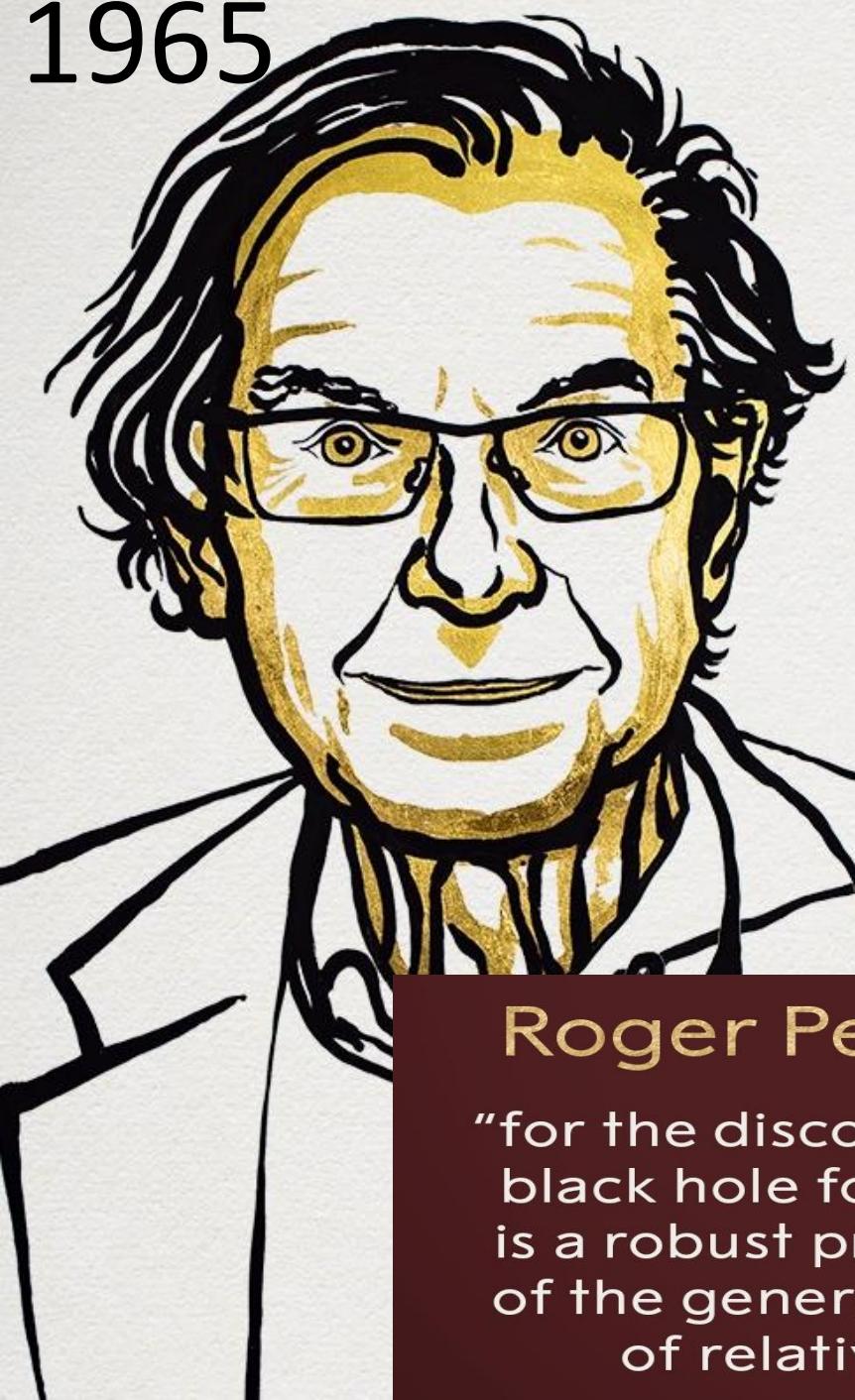


1939

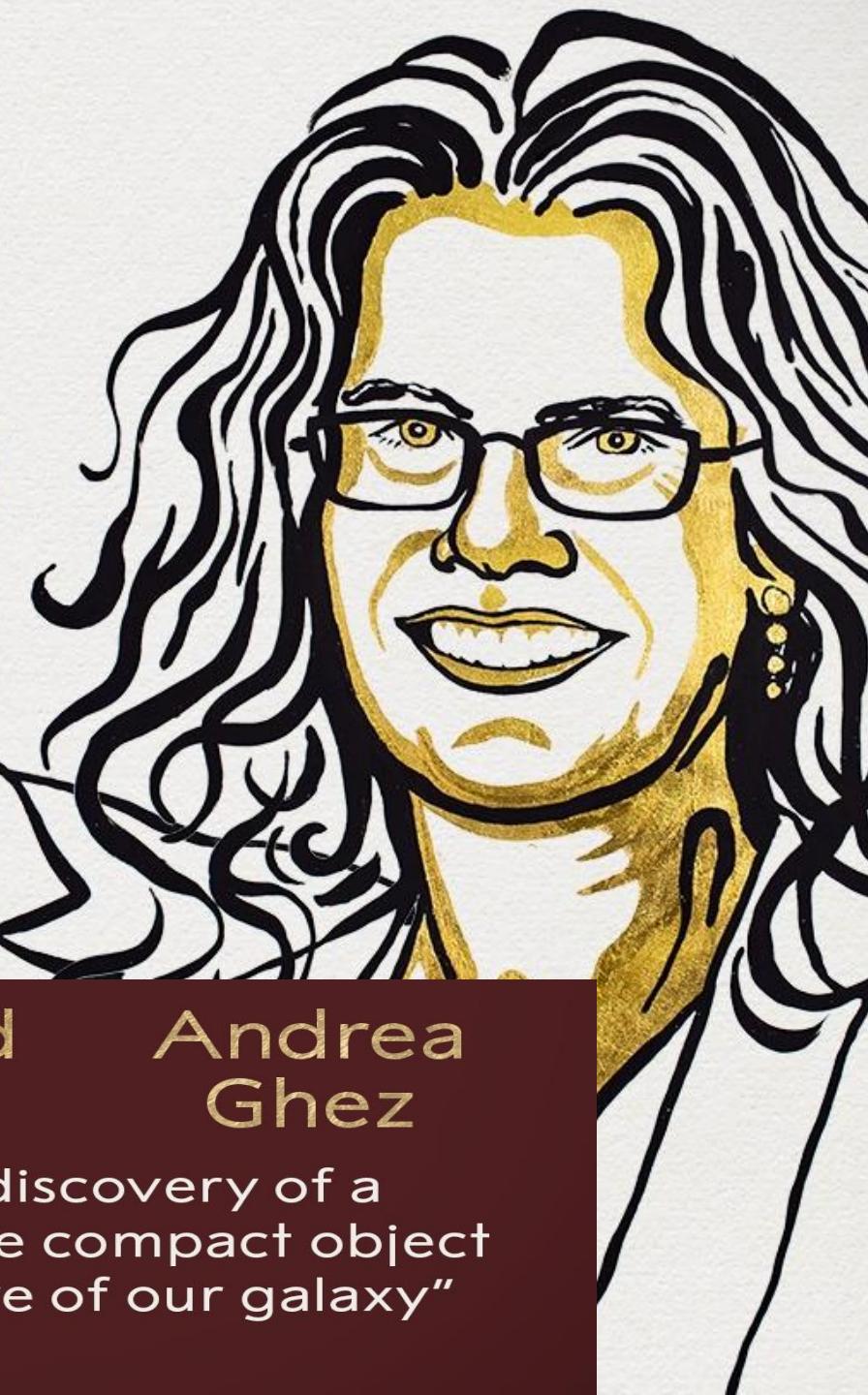
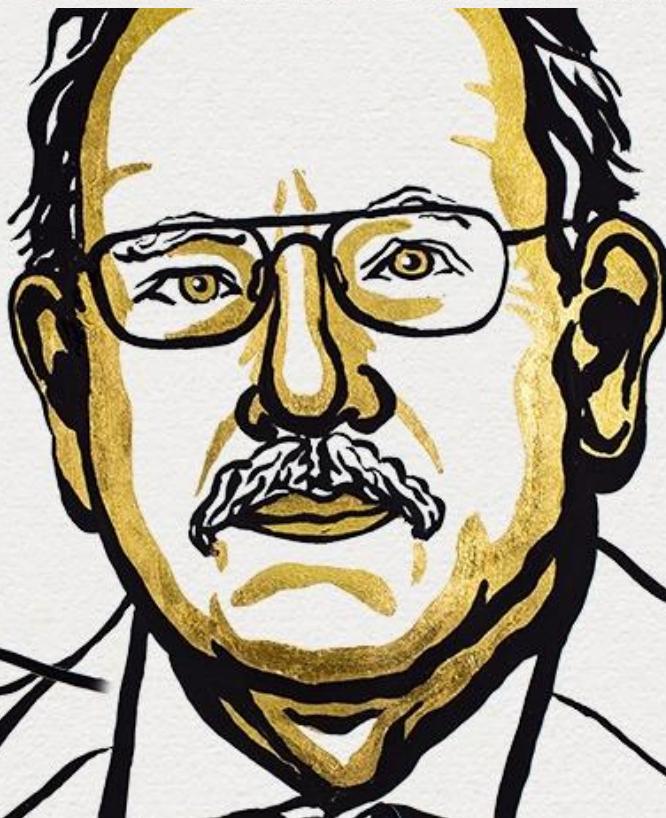


Snyder

1965



THE NOBEL PRIZE IN PHYSICS 2020



Roger Penrose

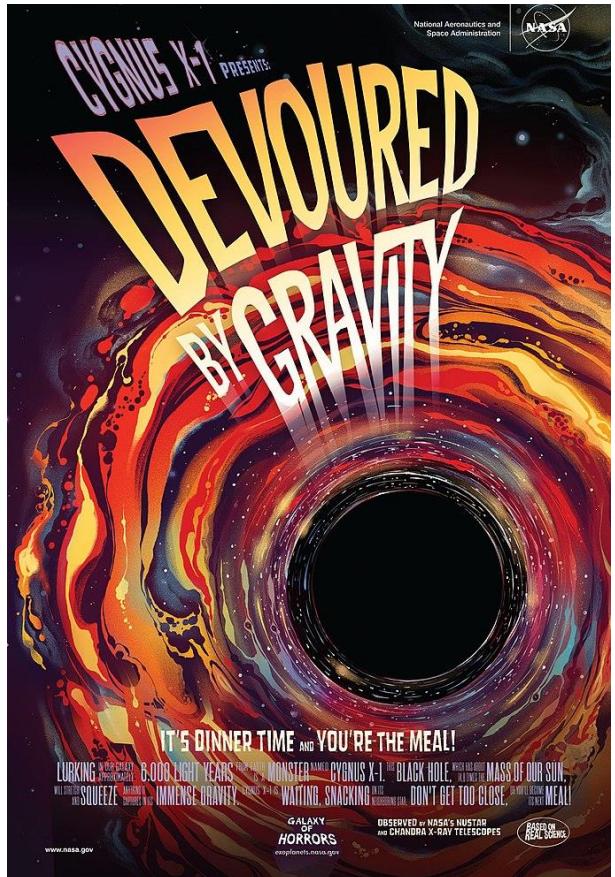
"for the discovery that black hole formation is a robust prediction of the general theory of relativity"

Reinhard
Genzel

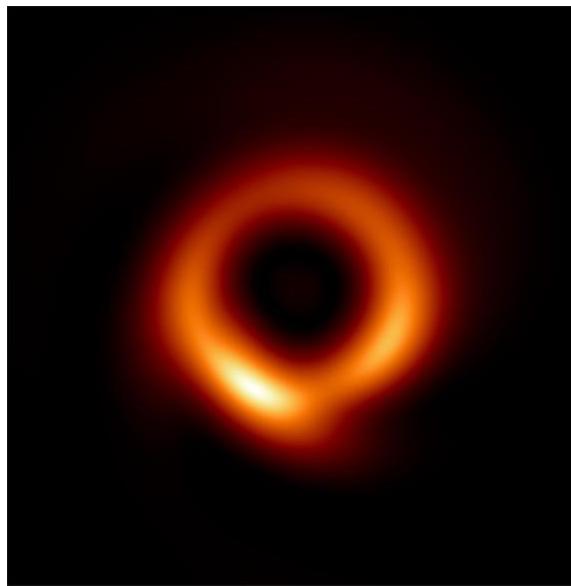
"for the discovery of a supermassive compact object at the centre of our galaxy"

Andrea
Ghez

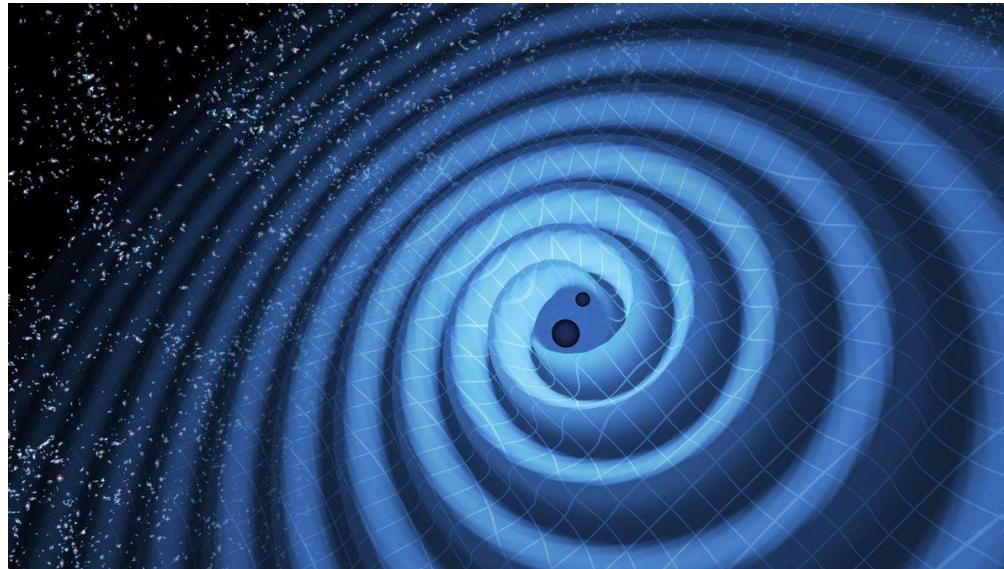
Hvernig vitið þið að svartholið er til. Og hvernig komust þið að því?



Cygnus X (1965)



EHT (2017)



LIGO (2015)

EÐLISFRÆÐI: Í DAGLEGU LÍFI

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

M87

55 milljón ljósár í burtu

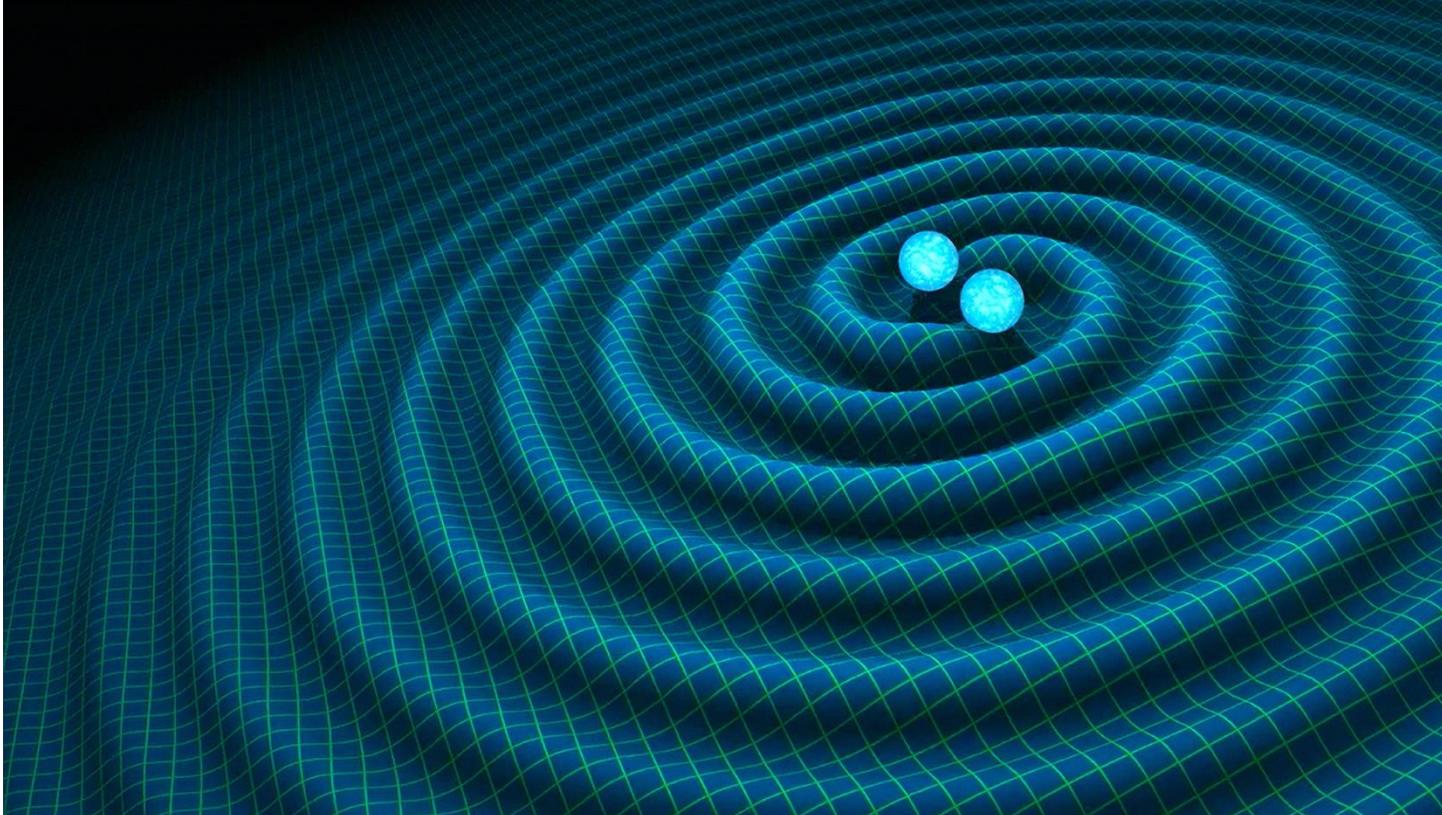
Milljarður af sólum



EÐLISFRÆÐI: Í DAGLEGU LÍFI

Getur eitt svarthol gleyp্ত annað svarthol?

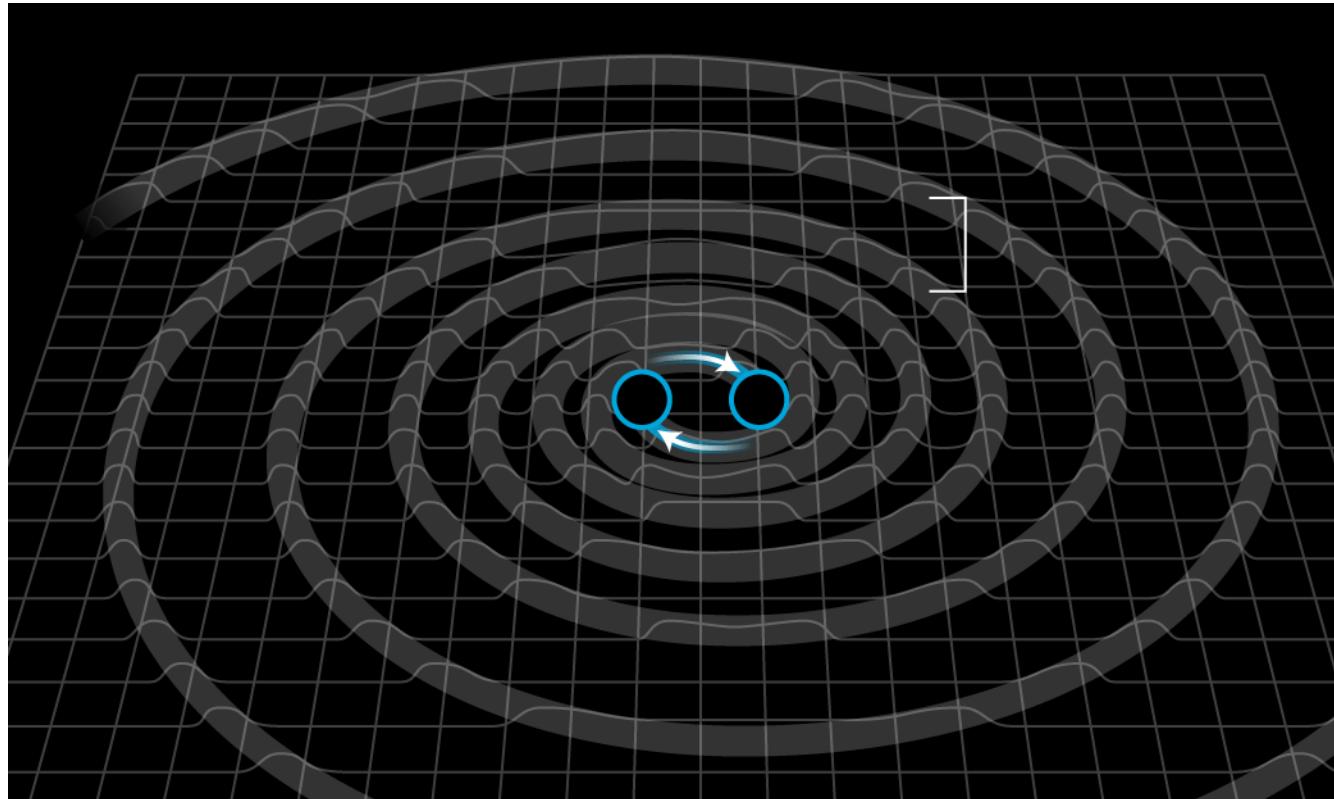
Getur eitt svarthol gleyp特 annað svarthol?



GW150914

1,5 milljarð ljósár í burtu

Getur eitt svarthol gleypit annað svarthol?



GW150914

1,5 milljarð ljósár í burtu

$$M_1 = 35M_{\text{sól}}$$

$$M_2 = 30M_{\text{sól}}$$

$$M = 62M_{\text{sól}}$$

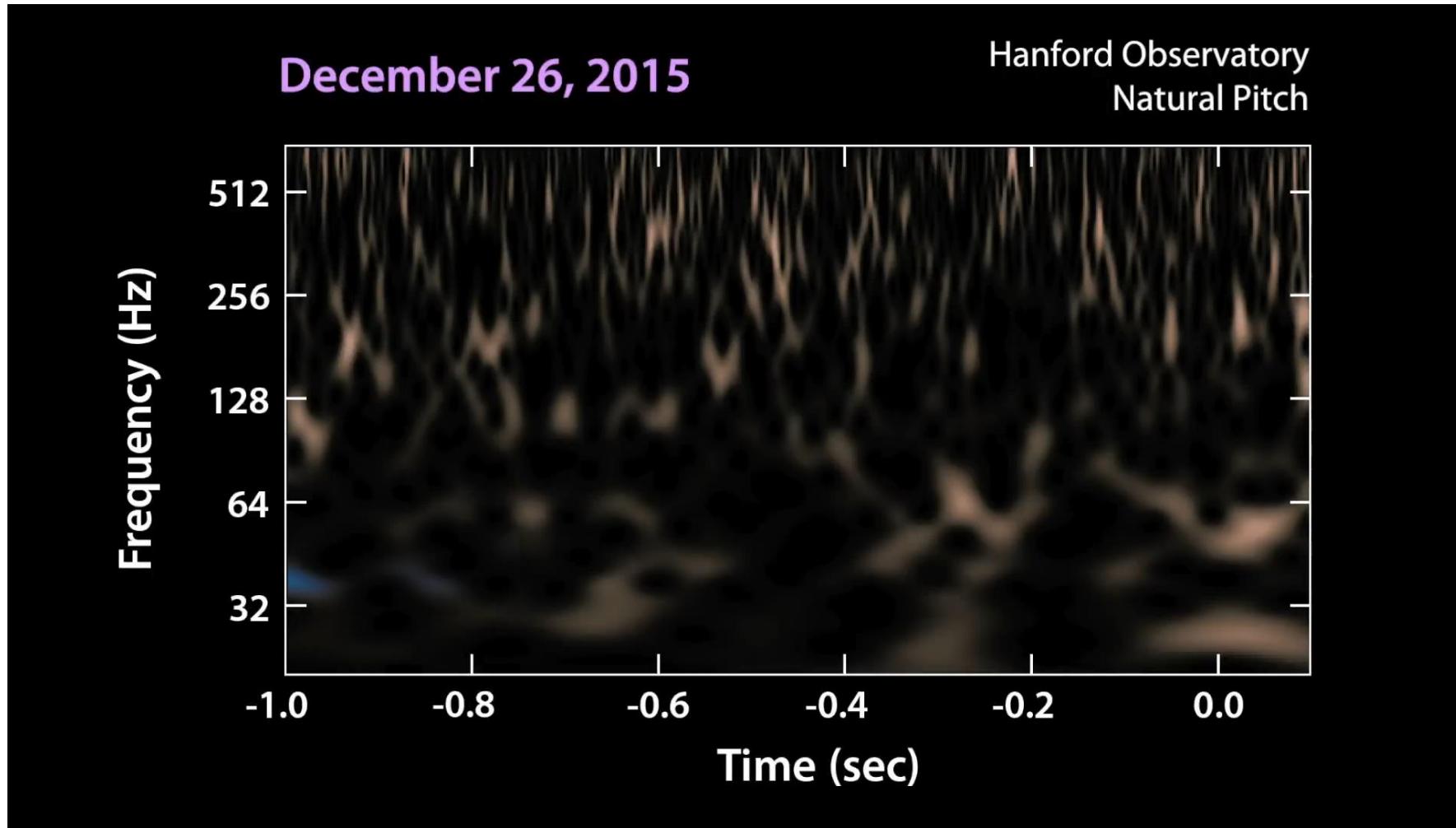
$$35 + 30 = 65???$$

#chirpforligo

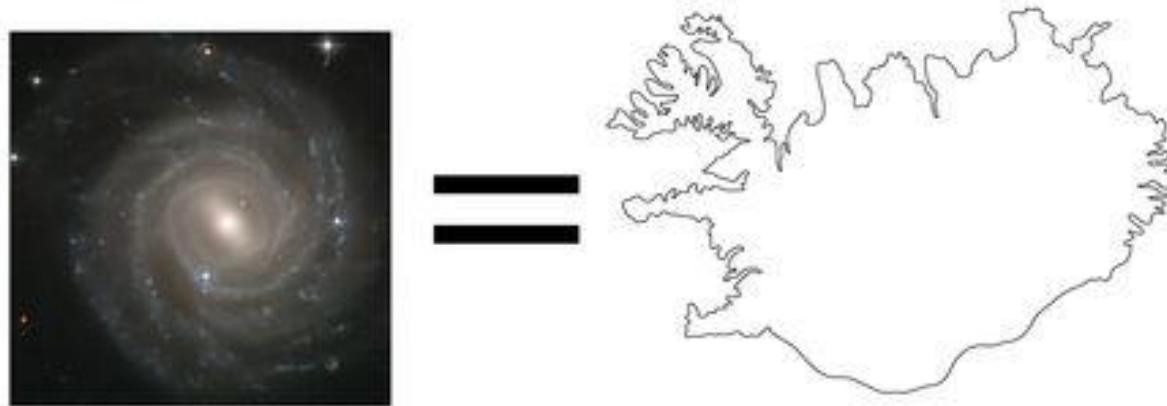
Rumor is the LIGO experiment may have detected gravitational waves. But what if these ripples in spacetime were sound waves instead? What would they sound like?

Physicists and physics fans are giving it their best chirp!

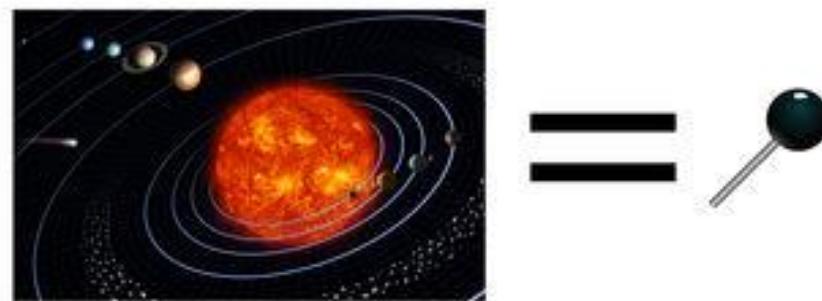
#chirpforligo



Ef vetrarbrautin okkar væri á stærð við Ísland...



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



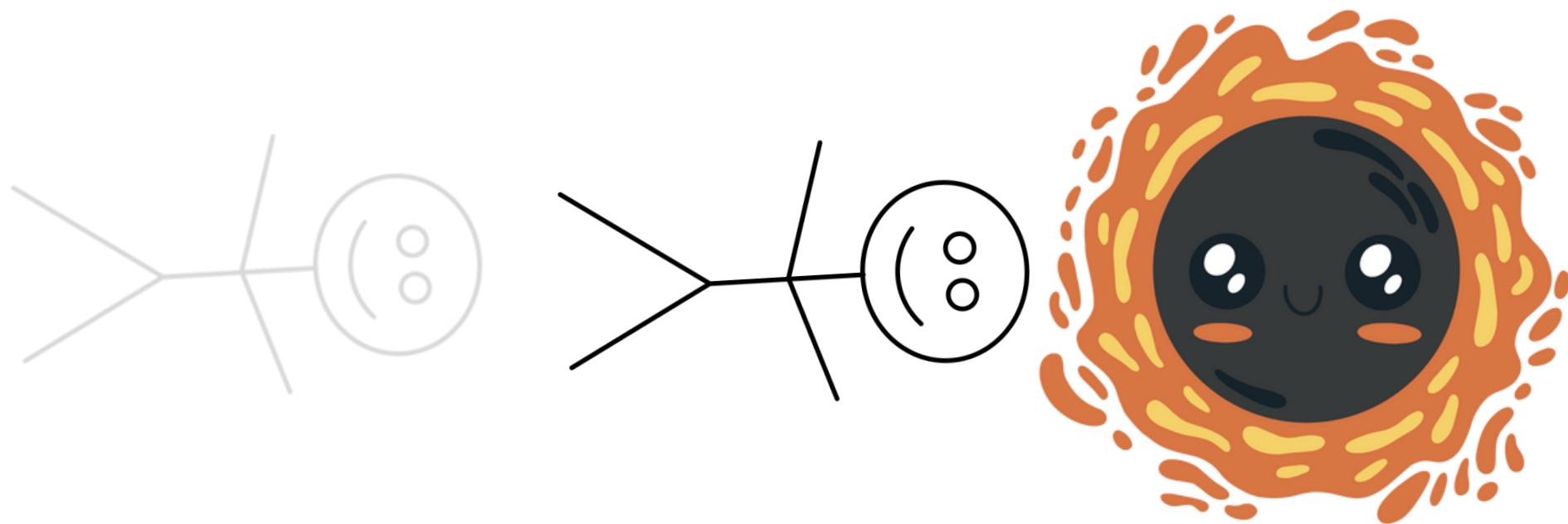
Stjörnufræðivefurinn - www.stjornufraedi.is

Mynd: ESA/Hubble & NASA/Sverrir Guðmundsson

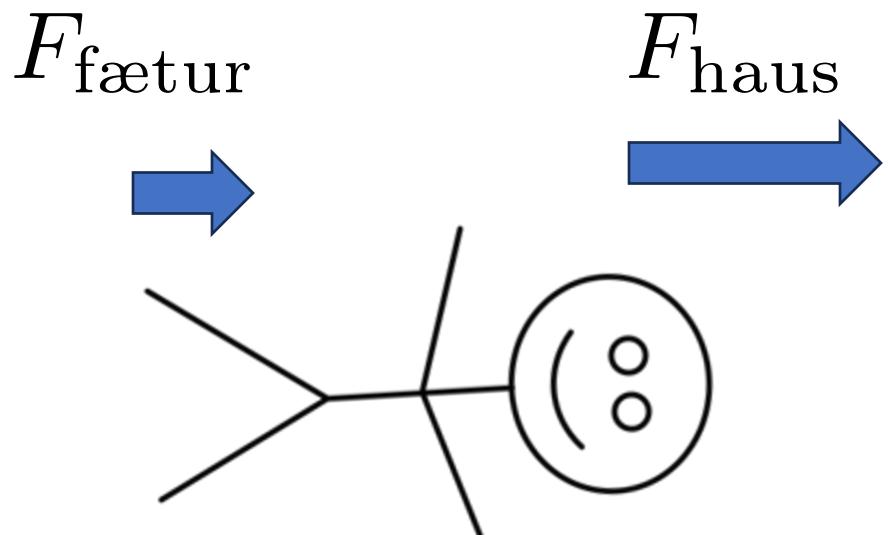
EÐLISFRÆÐI: Í DAGLEGU LÍFI

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

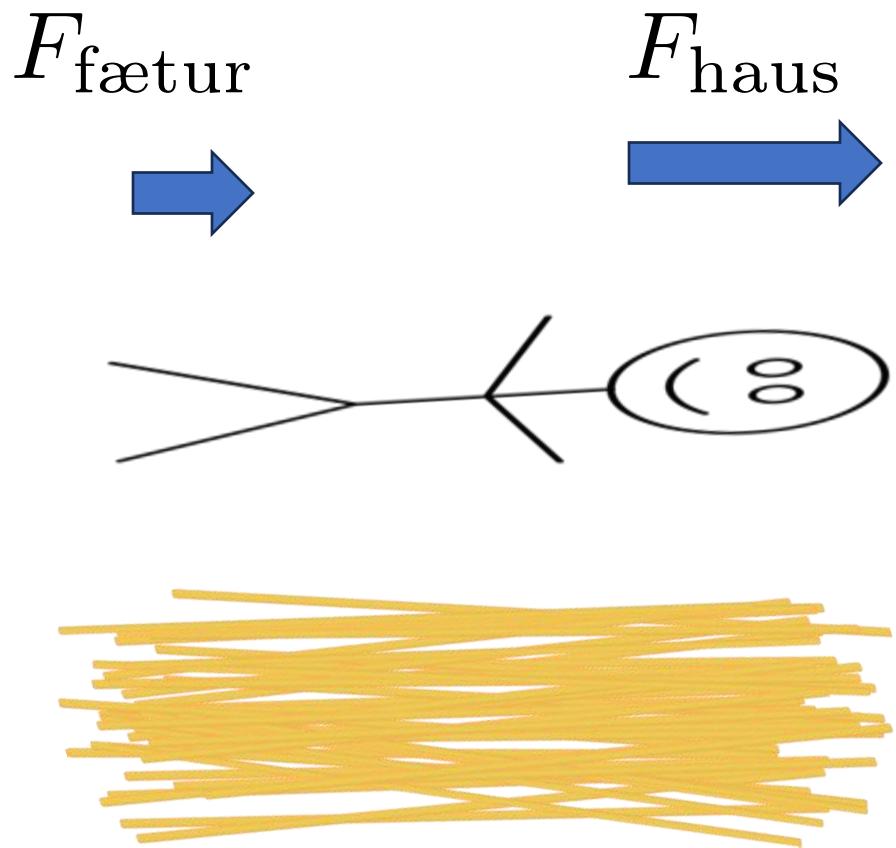
Hvað myndi gerast ef maður myndi fara inn í svarthol?



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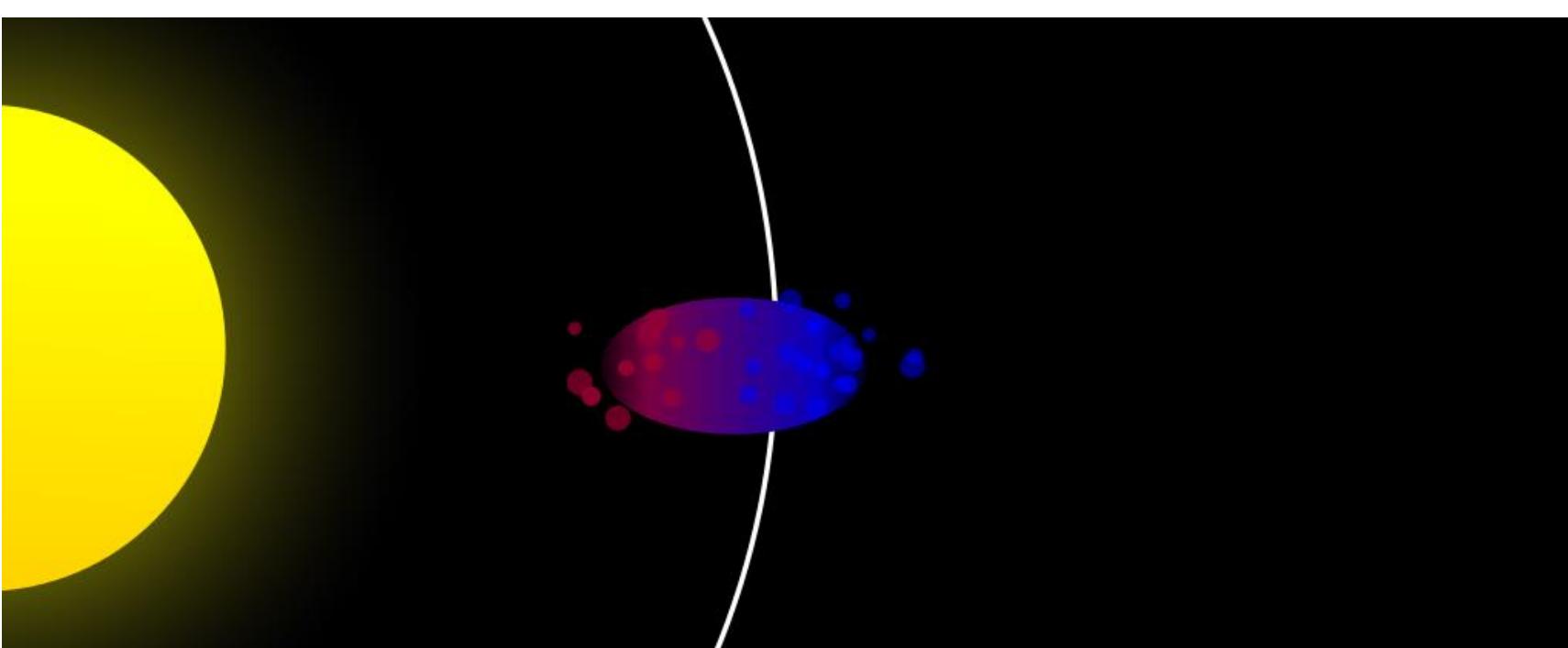
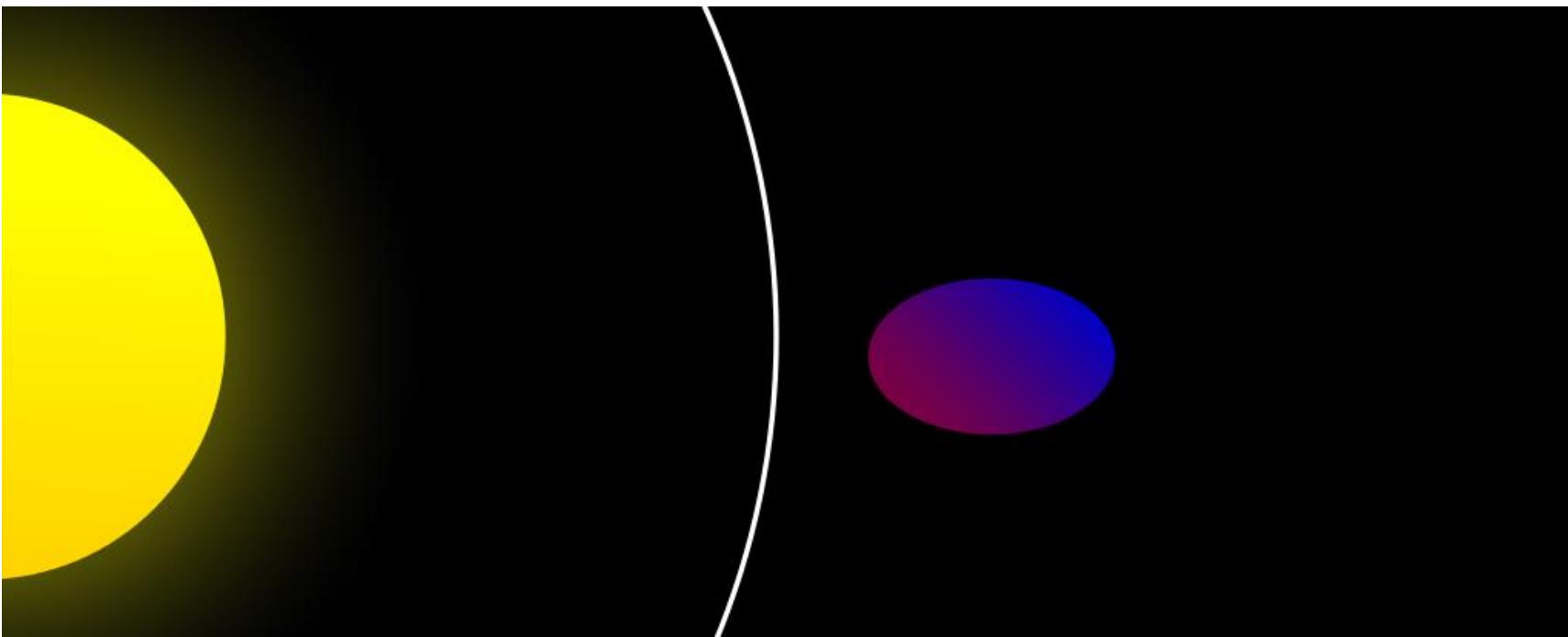
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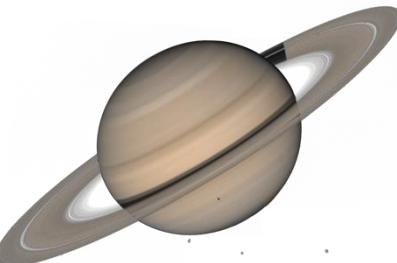
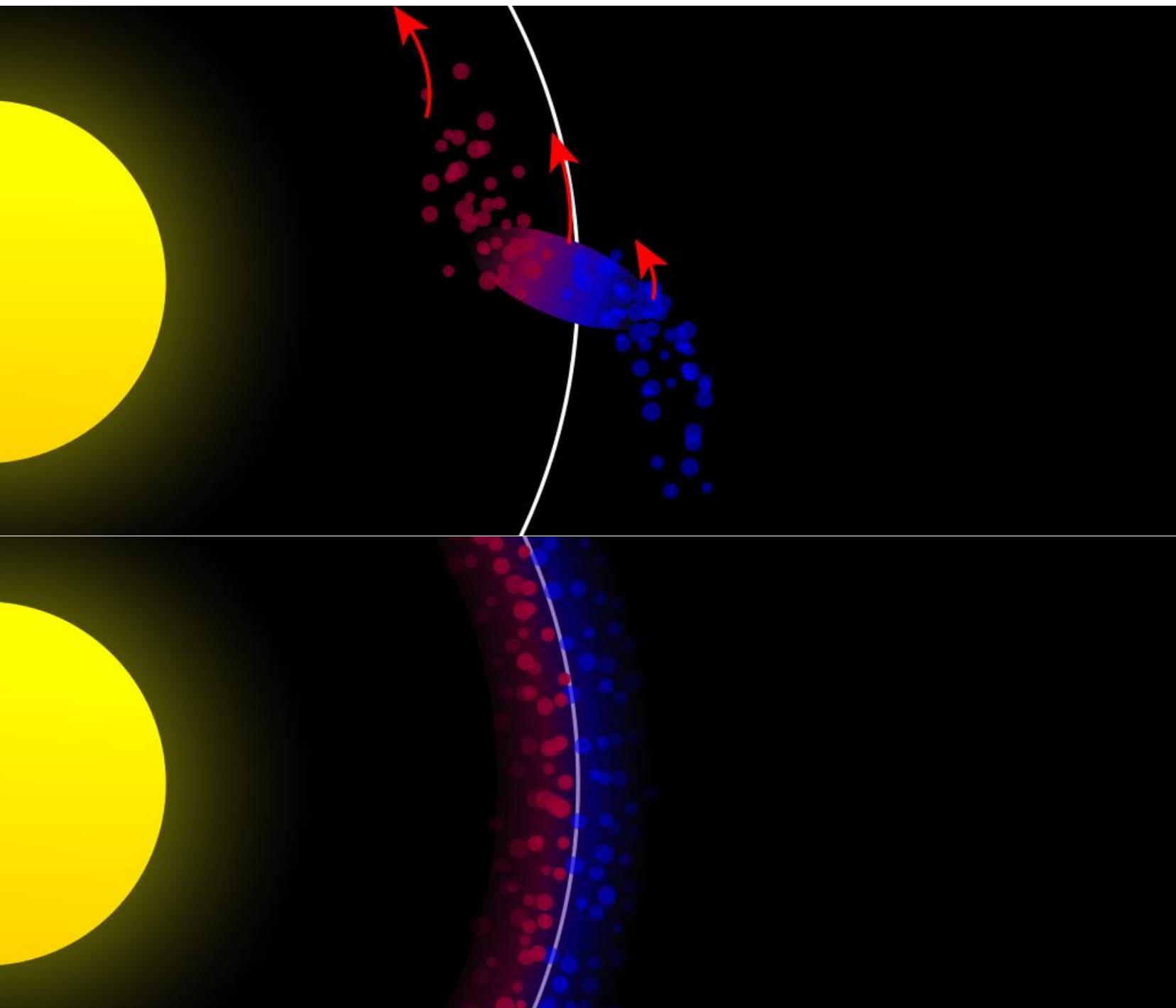


Mars

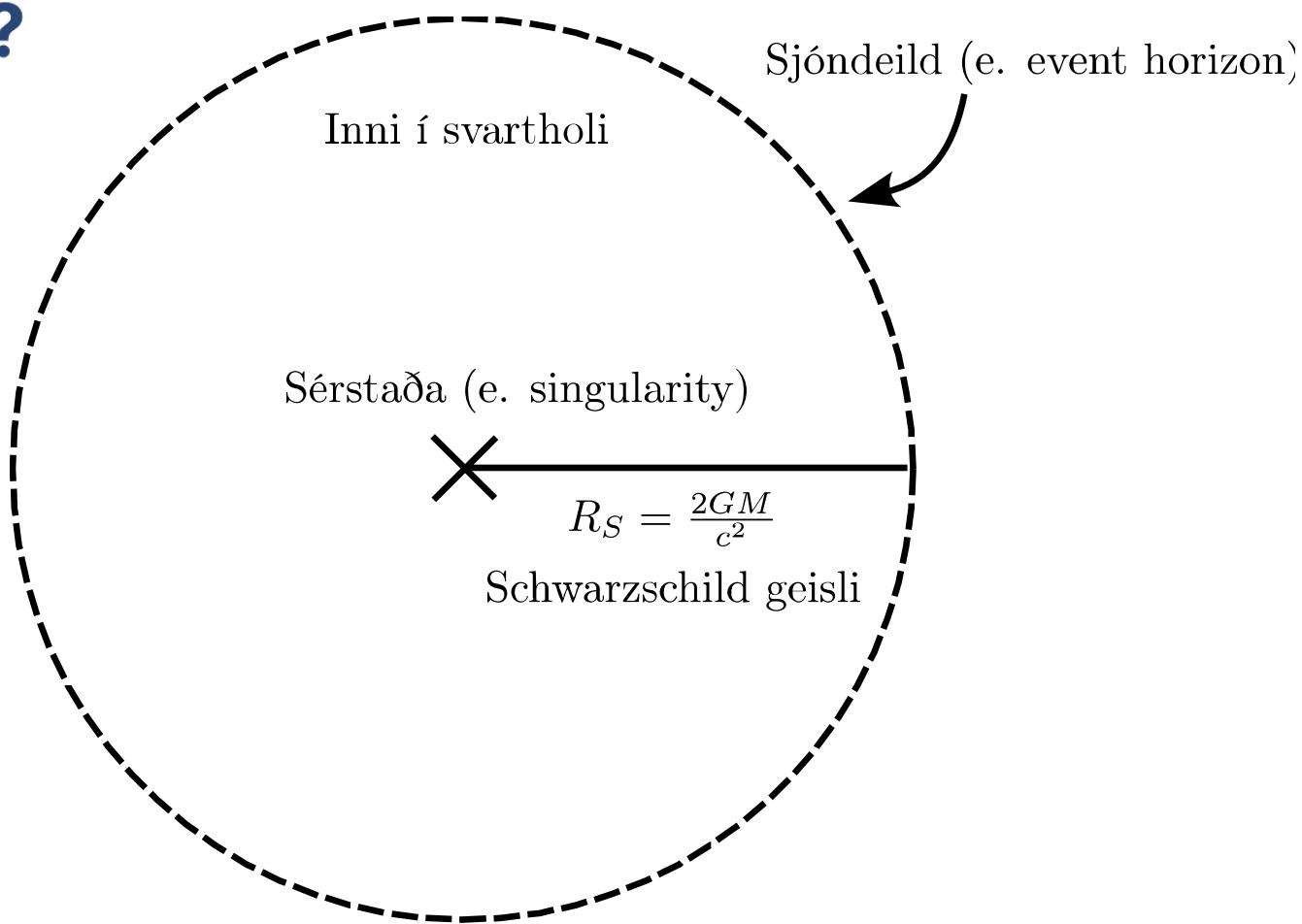
50 milljón ár

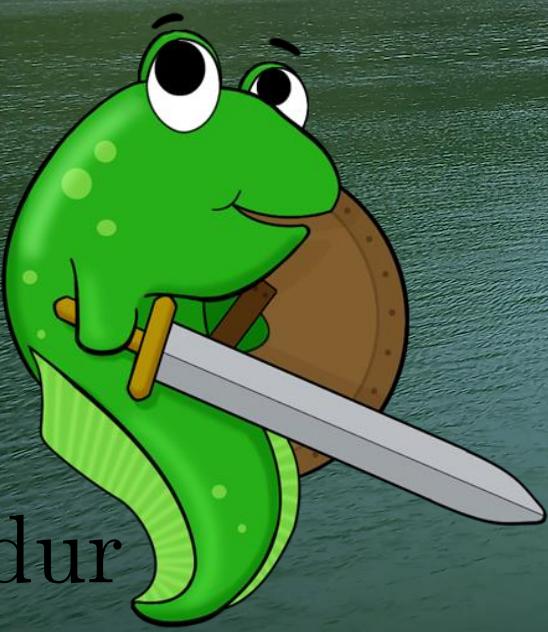
Fóbos





Hvað myndi gerast ef maður myndi fara inn í svarthol?

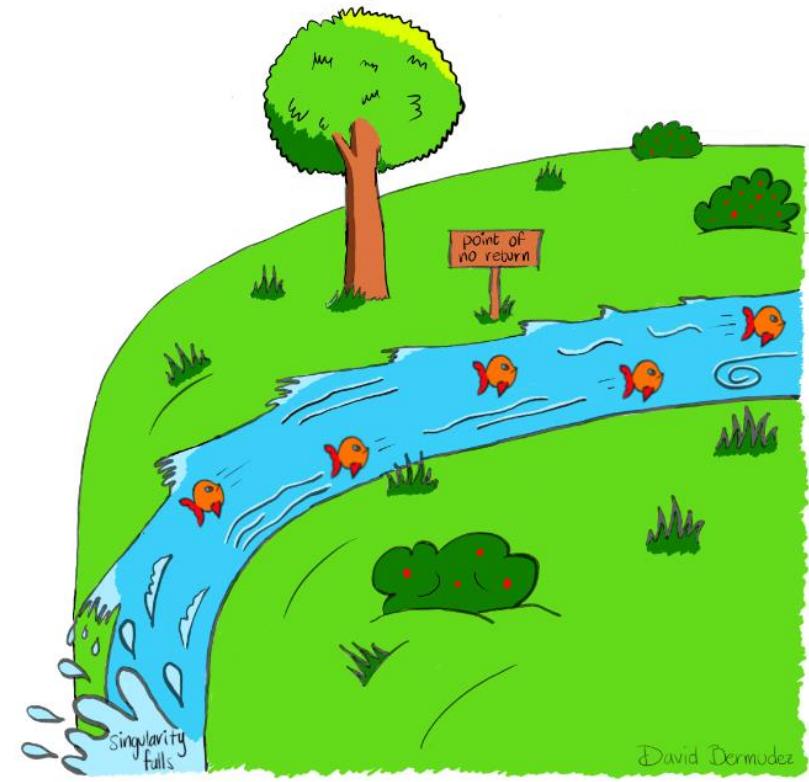
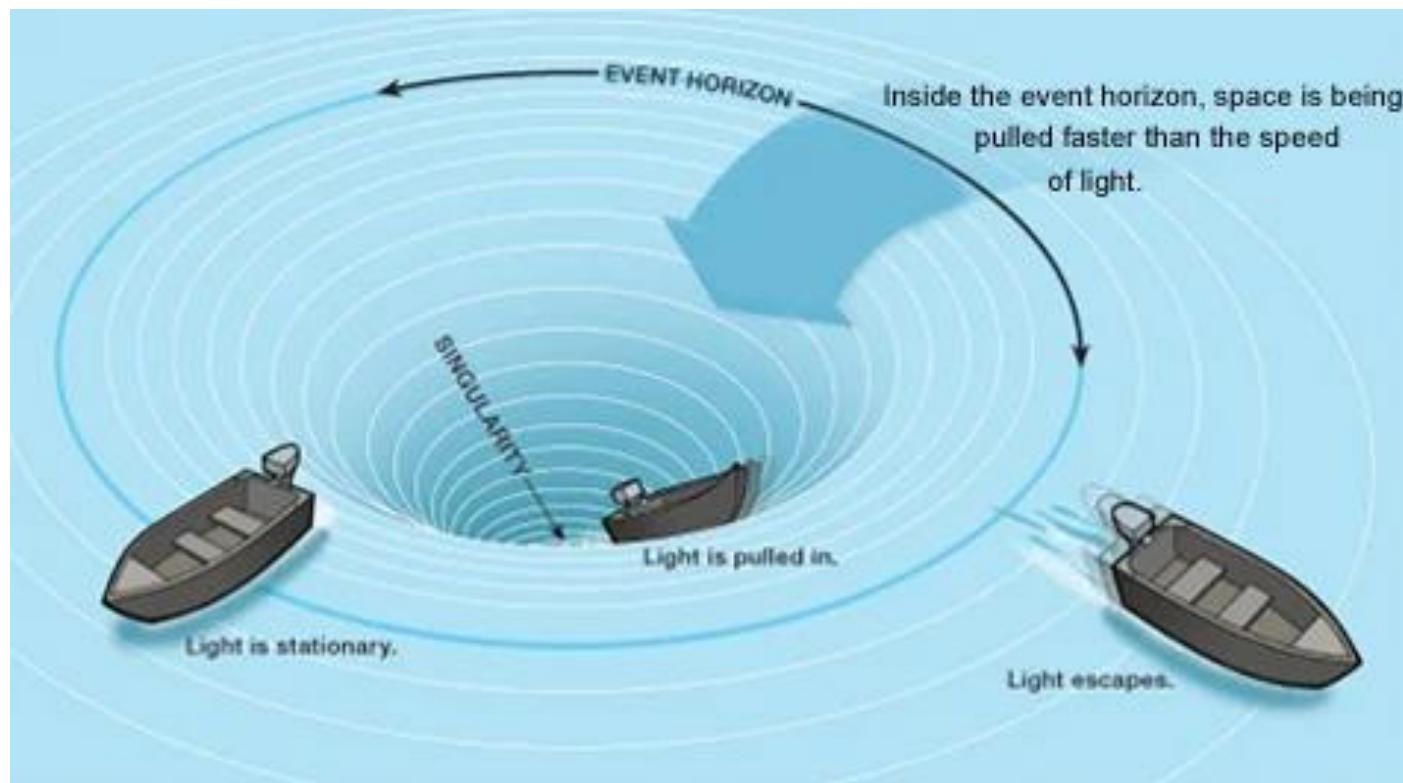


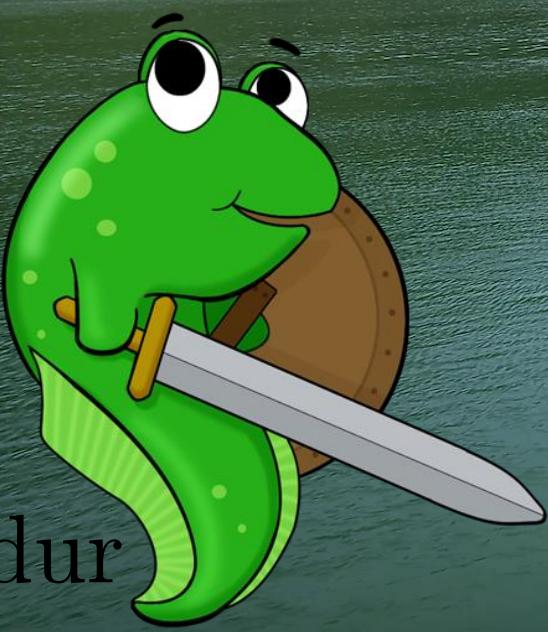


Baldur

Anna





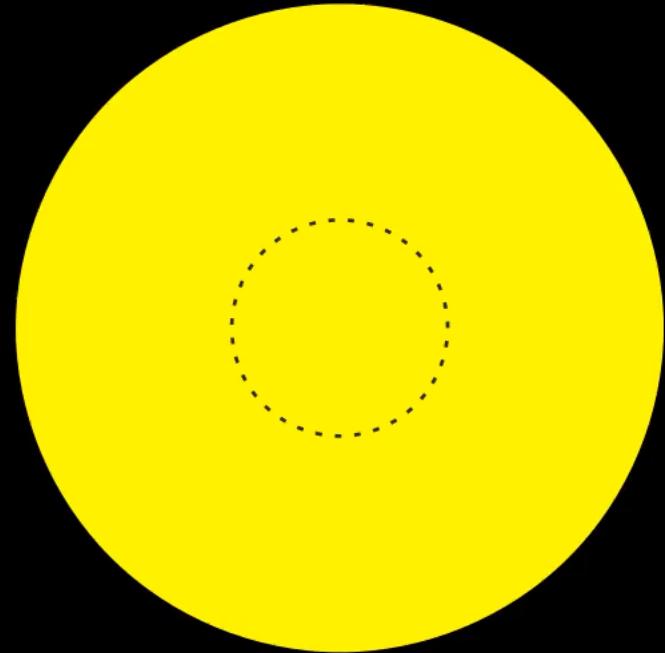


Baldur

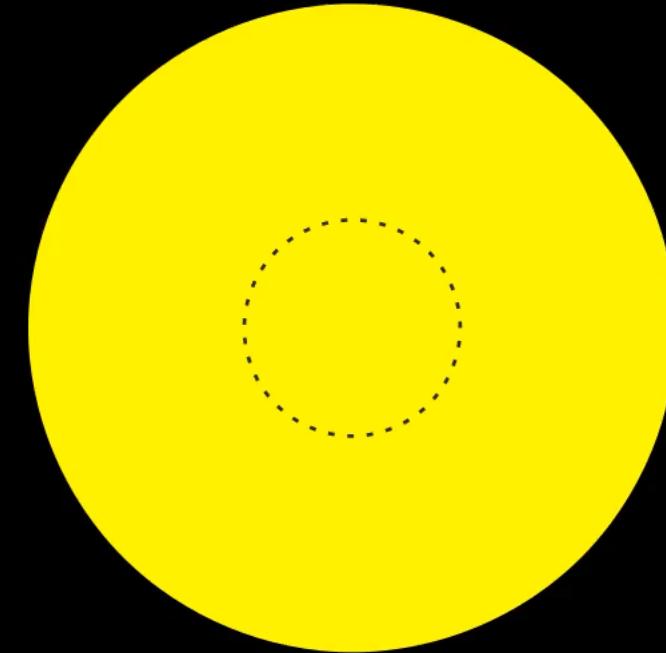
Anna



Athugandi á yfirborði



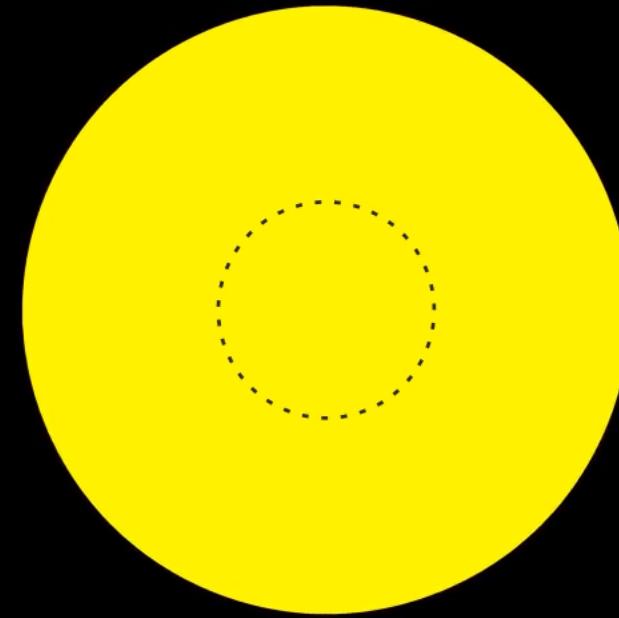
Fjarlægur athugandi



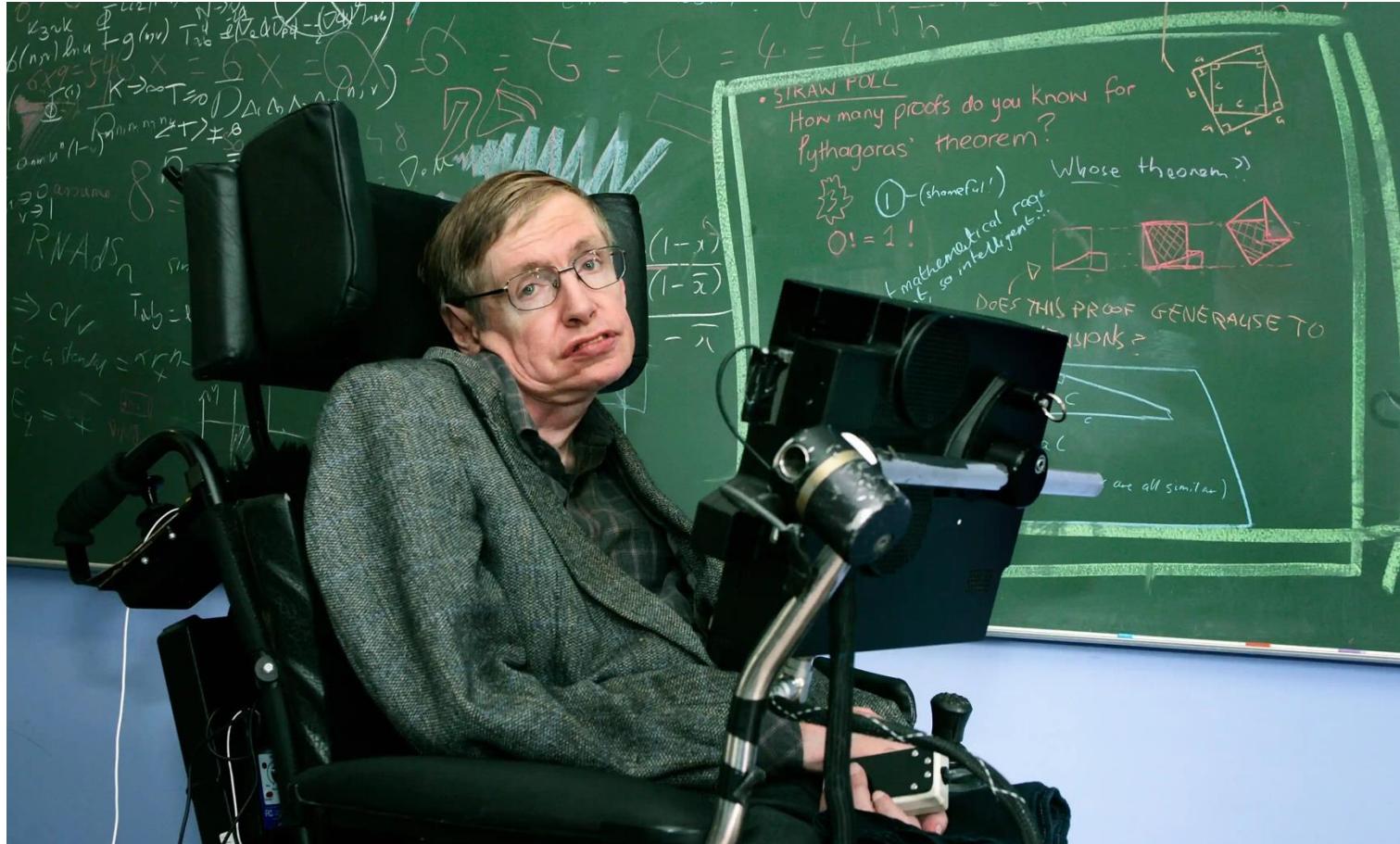
Athugandi á yfirborði



Fjarlægur athugandi

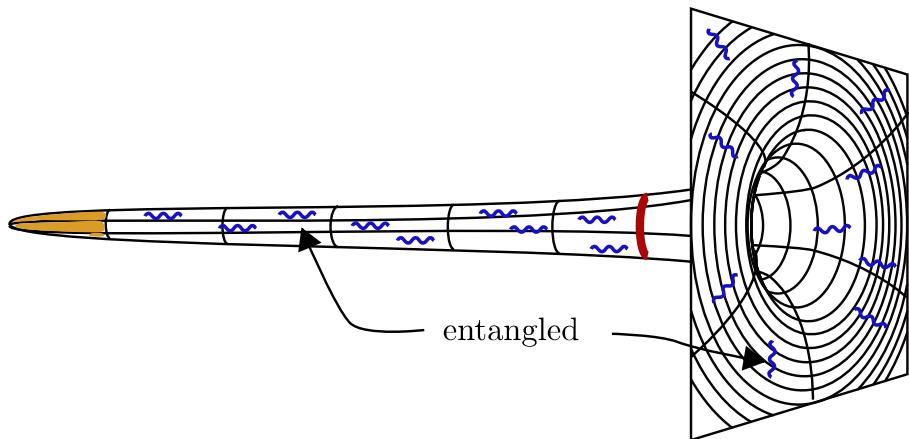
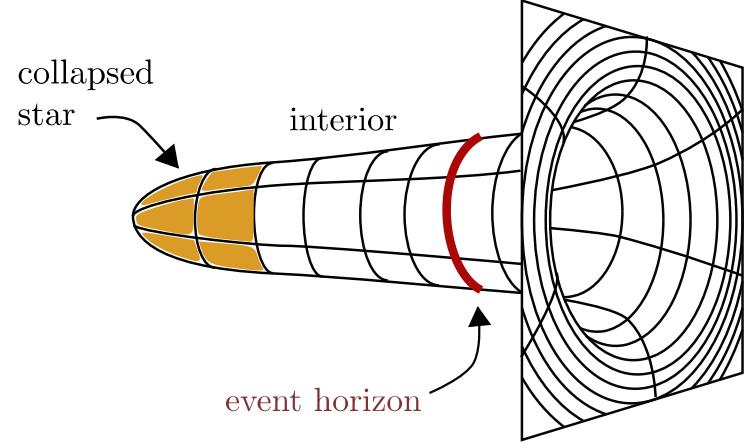


Eyðast svarthol einhverntíman, eiga þau eftir að soga allt í heiminum í sig?

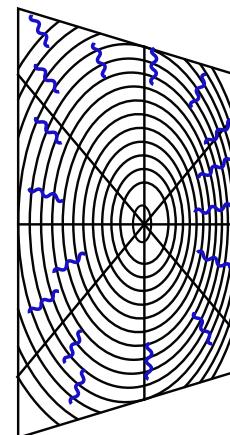
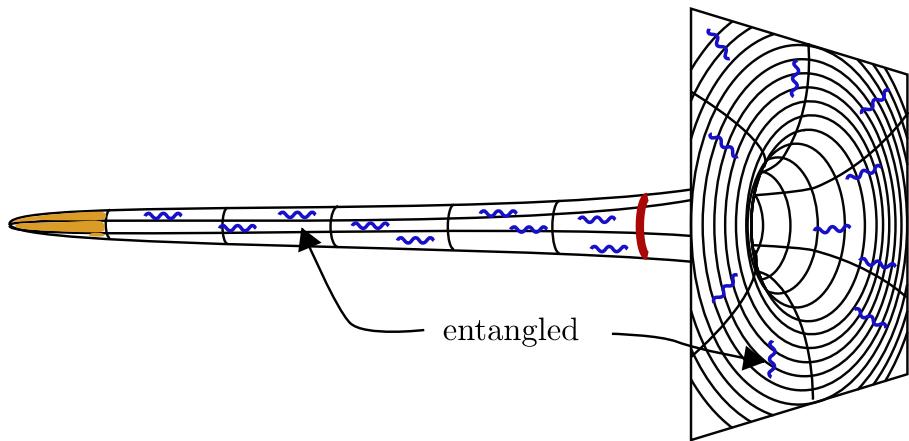
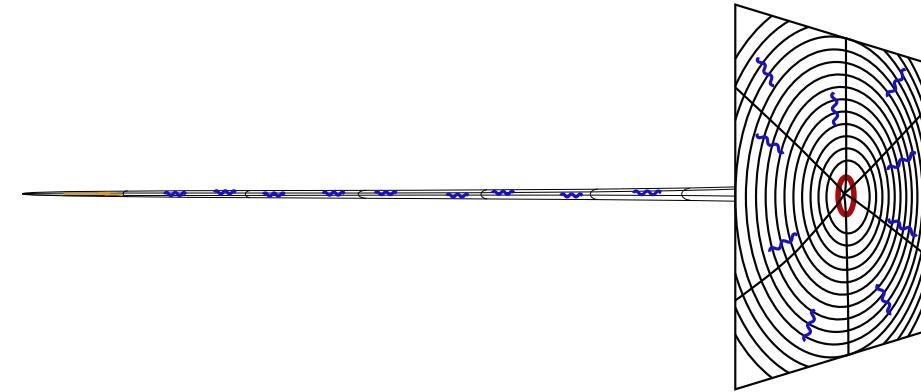
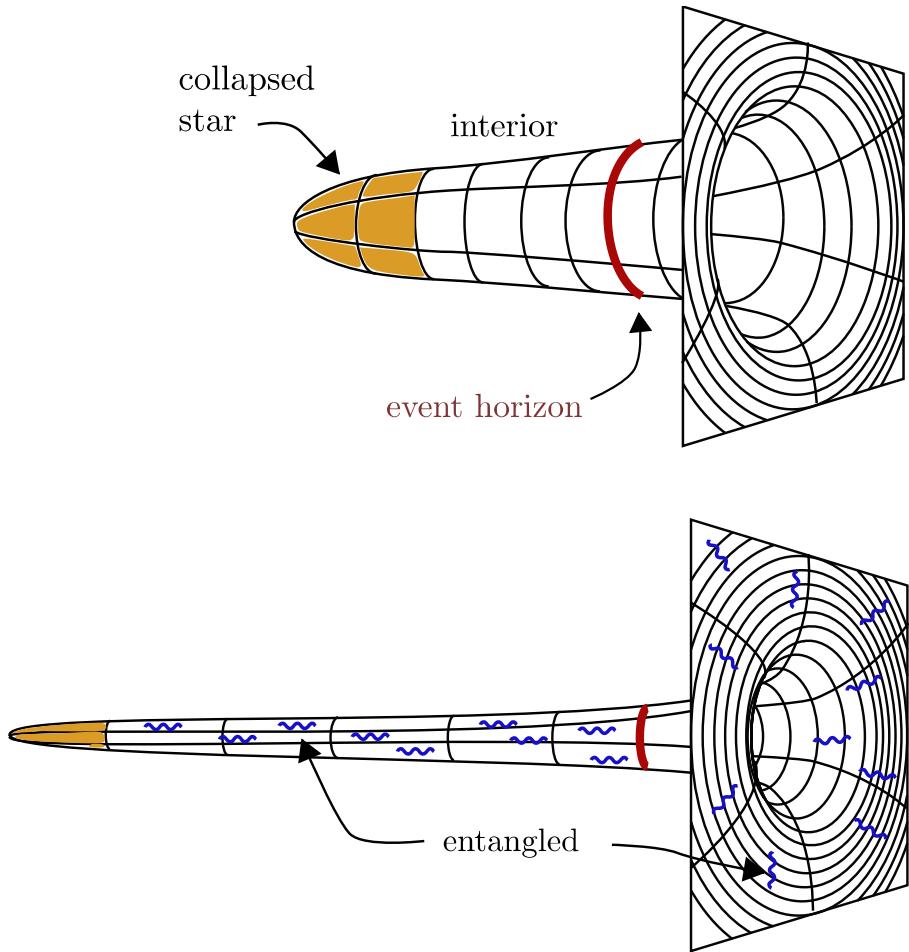


Stephen Hawking

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



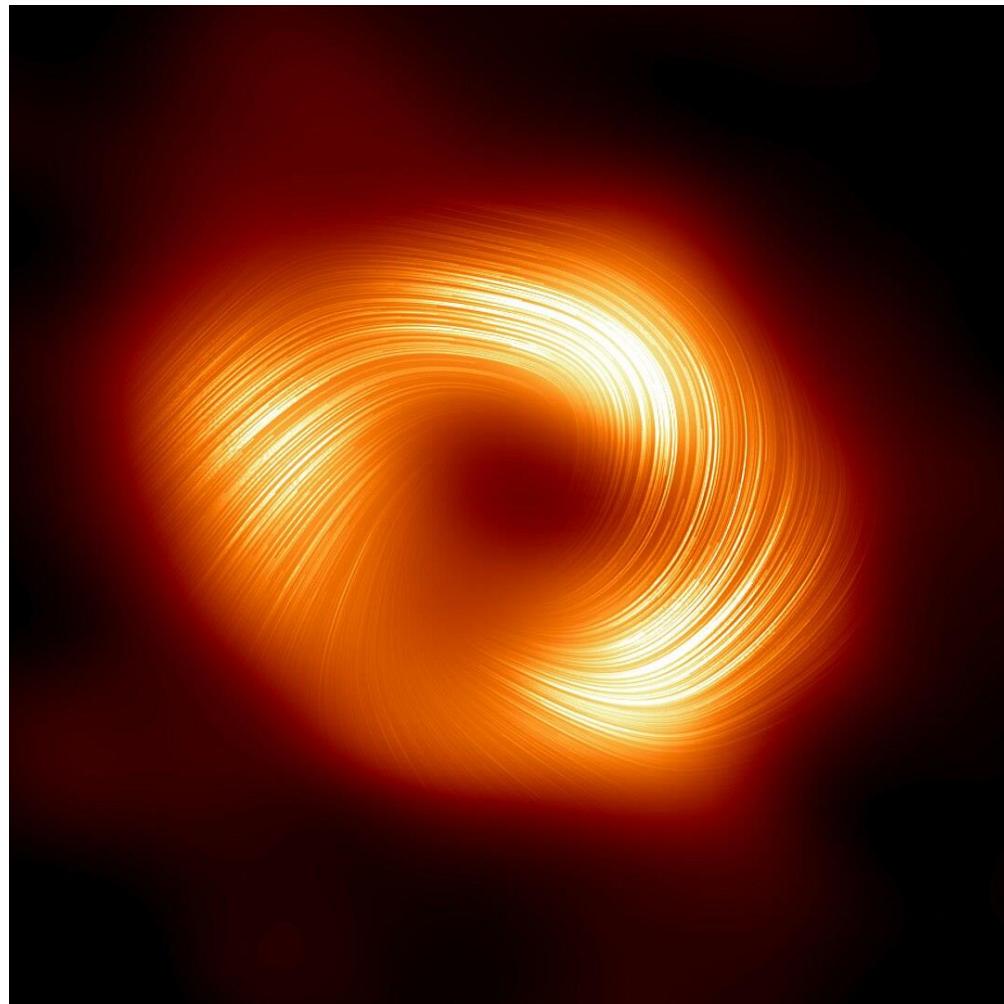
Eyðast svarthol einhverntíman, eiga þau eftir að soga allt í heiminum í sig?



EÐLISFRÆÐI: Í DAGLEGU LÍFI

Hversu lengi endast svarthol?

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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

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

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

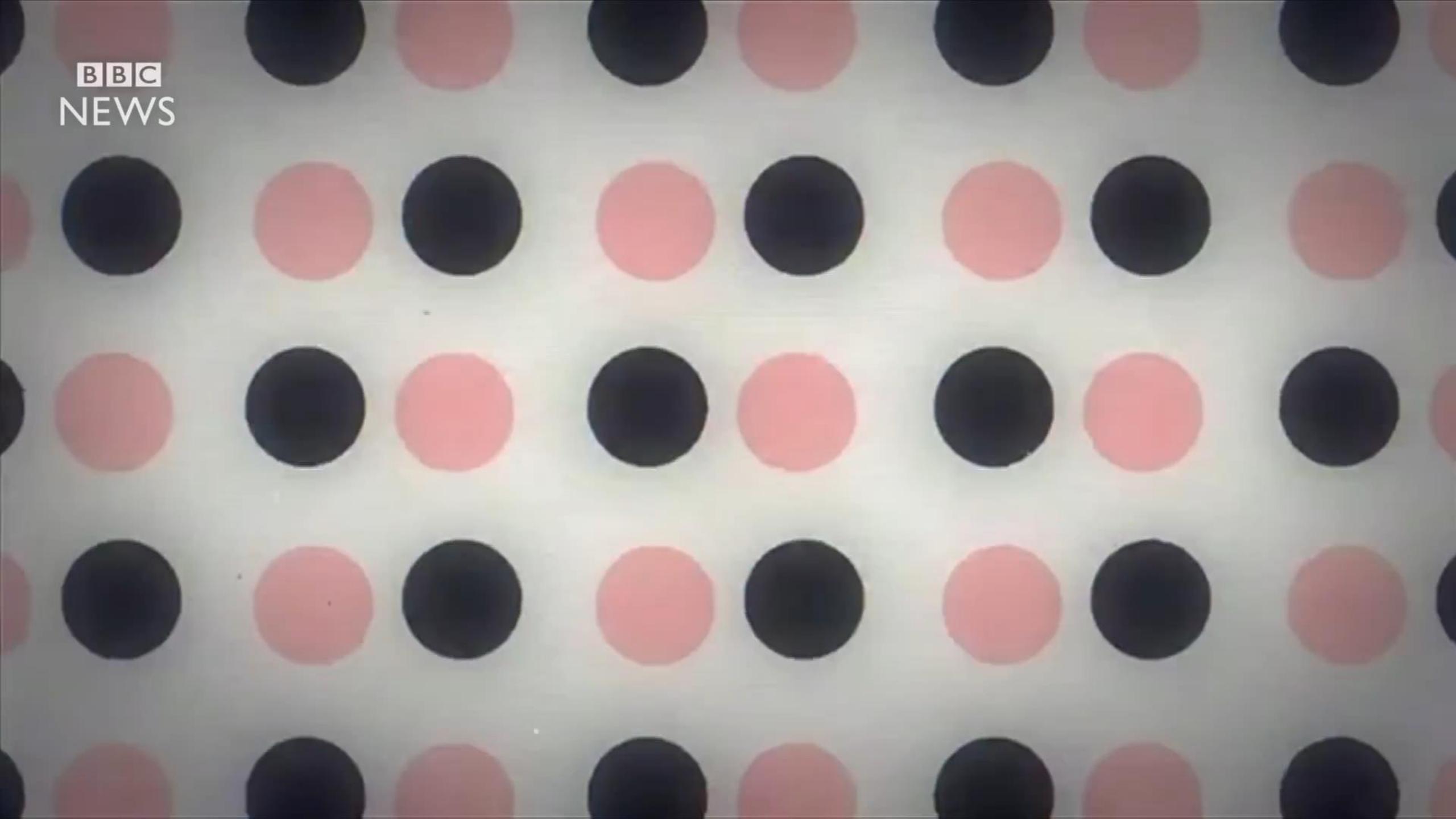
$$T_H = 9,8 \cdot 10^{45} \text{ K}$$

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

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?