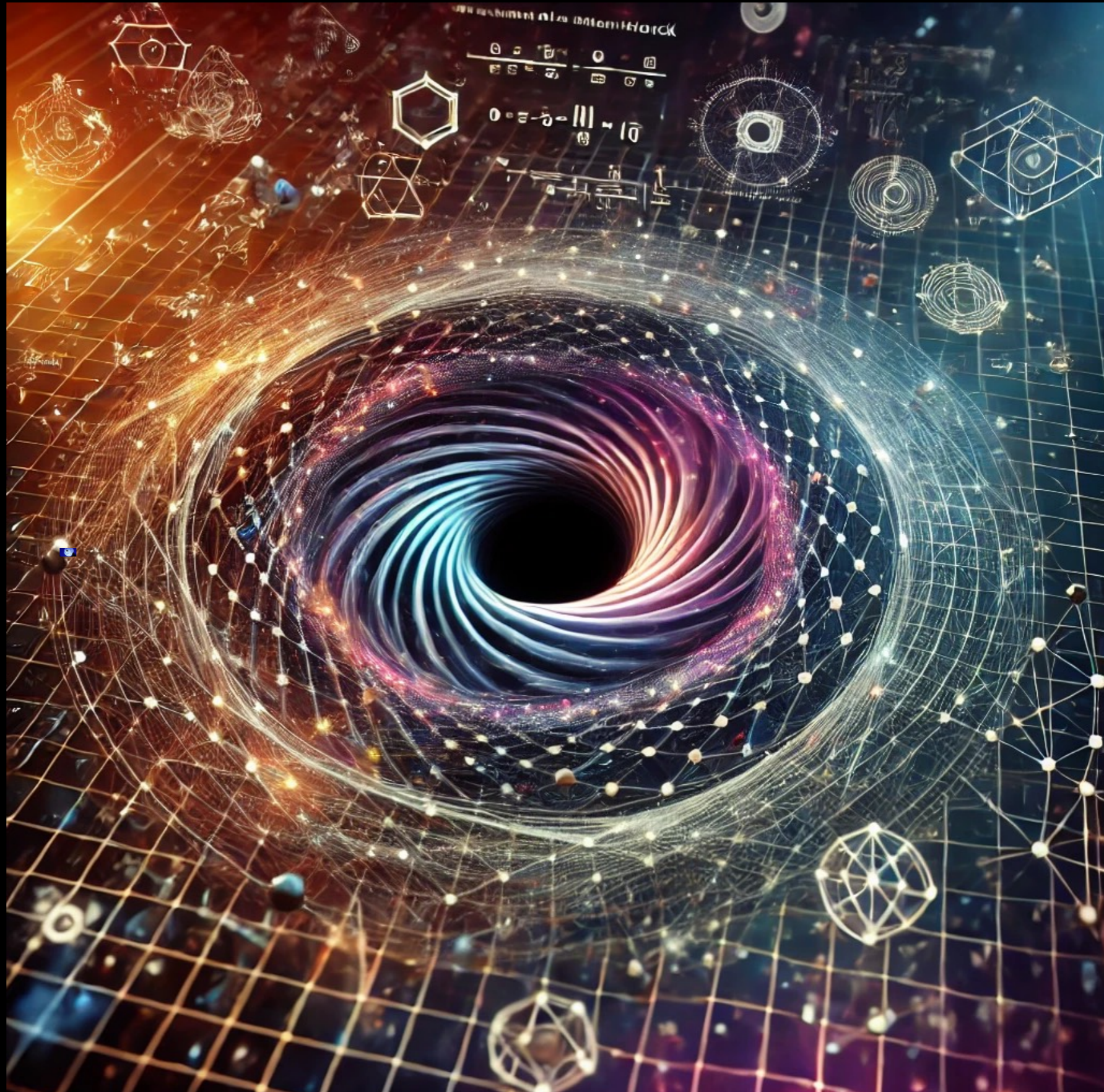


# Matematikens mysterier


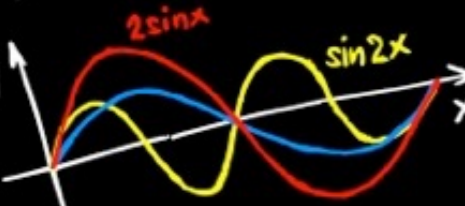
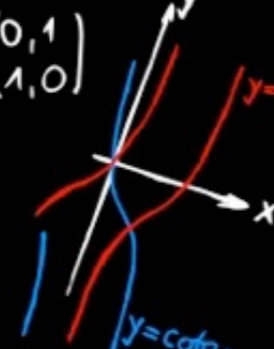

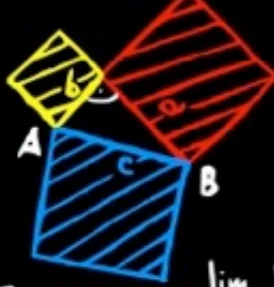
## - från svarta hål till artificiell intelligens -

Daniel Persson  
*Matematiska Vetenskaper*  
*Chalmers Tekniska Högskola*  
*Göteborgs Universitet*

Tisdag 28 okt  
2025

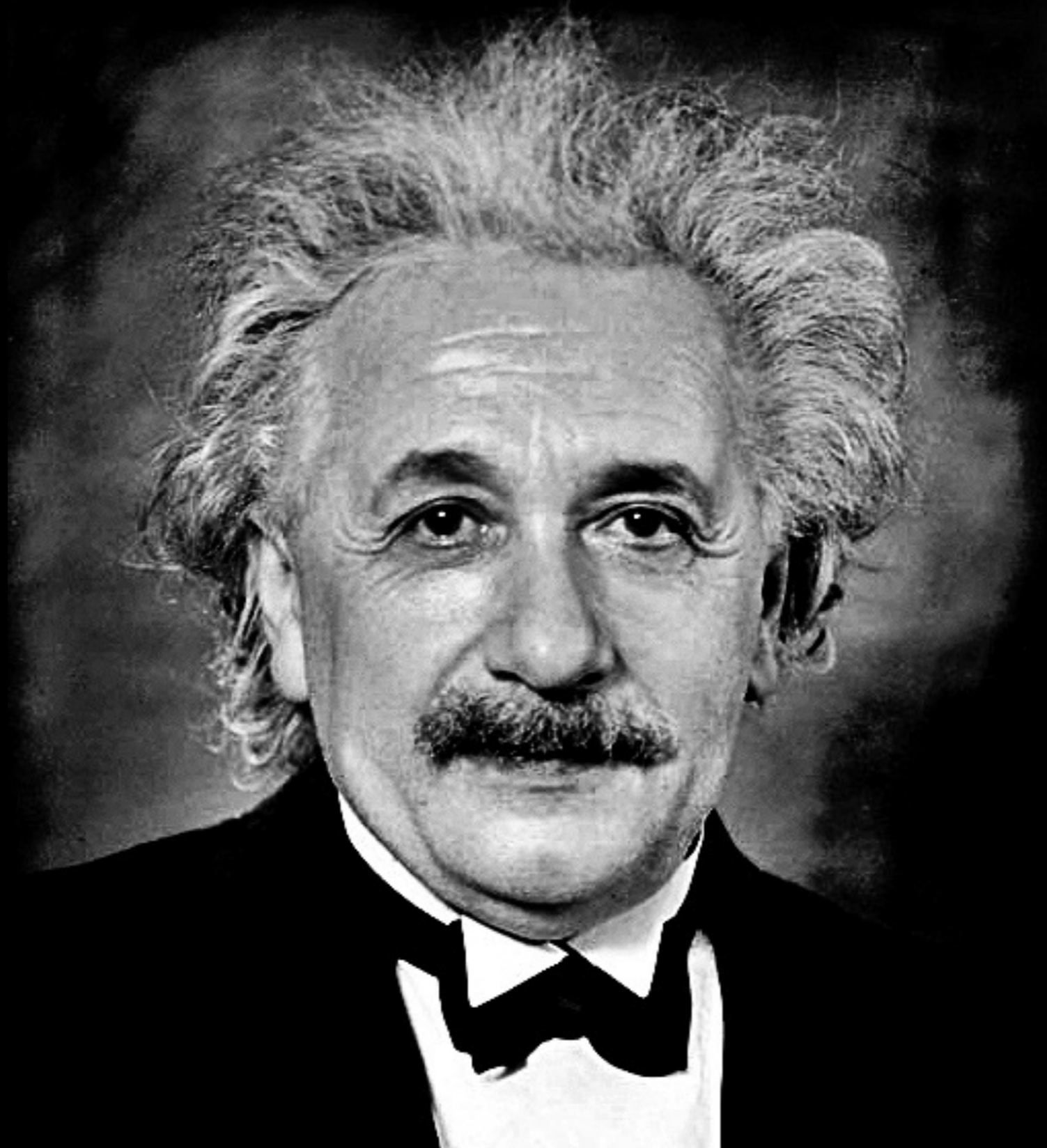


$\nabla f = 0$   
 $\text{grad } f = \left( \frac{\partial f}{\partial x}; \frac{\partial f}{\partial y} \right)$   
 $\text{tg } x \cdot \text{cotg } x = 1$   
 $2x^2 y y' + y^2 = 0$   
 $Y_{i+1} = Y_i + b \cdot k_2$   
 $B = \begin{pmatrix} 2 & 1 & -1 & 0 \\ 3 & 0 & 1 & 2 \end{pmatrix}$   
 $a^2 = b^2 + c^2 - 2bc \cos \alpha$   
 $\sum_{i=0}^n (P_2(x_i) - y_i)^2$   
 $\text{tg } 2x = \frac{2 \text{tg } x}{1 - \text{tg}^2 x}$   
 $\text{tg } x = \frac{\sin x}{\cos x}$   
 $\int_0^{2\pi} \left( \int_0^2 \left( \int_{\frac{1}{2}}^1 r \, dr \right) d\theta \right) d\varphi$   
 $\lim_{n \rightarrow \infty} \frac{\sqrt{n^3+1} + n}{\sqrt[3]{3n^2+2n-1}}$   
 $\lambda x - y + z = 1$   
 $x + \lambda y + z = \lambda$   
 $x + y + \lambda z = \lambda^2$   
 $\frac{a}{\sin \alpha} = \frac{b}{\sin \beta} = \frac{c}{\sin \gamma}$   
 $y = \sqrt[3]{x+1}; x = \text{tg } t$   
 $X_1 = \begin{pmatrix} \alpha + \beta + \gamma \\ \alpha \\ \beta \end{pmatrix}$   
 $\delta(p_2) = \sqrt{0,16}$   
 $c = \begin{pmatrix} 0,1 \\ 1,0 \end{pmatrix}$   
 $a^2 + b^2 = c^2$   
 $\alpha, \beta, \gamma \in \mathbb{C}$   
 $f(x) = 2^{-x} + 1, \epsilon = 0,005$   
 $e^z - xyz = e; A[0; e; 1]$   
 $\lim_{x \rightarrow 0} \frac{e^{2x} - 1}{5x} = \frac{2}{5}$   
 $|x| + |y| \neq 0; y \neq 0$   
 $\frac{2x}{x^2 + 2y^2} = 2 \quad z = \frac{1}{x}$   
 $\sin(x+y) = \sin x \cos y + \cos x \sin y$   
 $y' - \frac{\sqrt{y}}{x+2} = 0$   
 $\frac{\partial f}{\partial x} = 16 - x^2 + 16y^2 - 4z > 0$   
 $A = \begin{pmatrix} x & 1+x^2 & 1 \\ y & 1+y^2 & 1 \\ z & 1+z^2 & 1 \end{pmatrix}; x=0, y=1, z=2$   
 $y' - \frac{\sqrt{y}}{x+2} = 0$   
 $\int 3x^7 + 166x^{-0,17} dx$   
 $\lim_{n \rightarrow \infty} (1 + \frac{3}{n})^n$   
 $A = [1; 0; 3]$   
 $\cos \varphi =$


***How can it be that mathematics, being after all a product of human thought which is independent of experience, is so admirably appropriate to the objects of reality?***

***- A. Einstein***





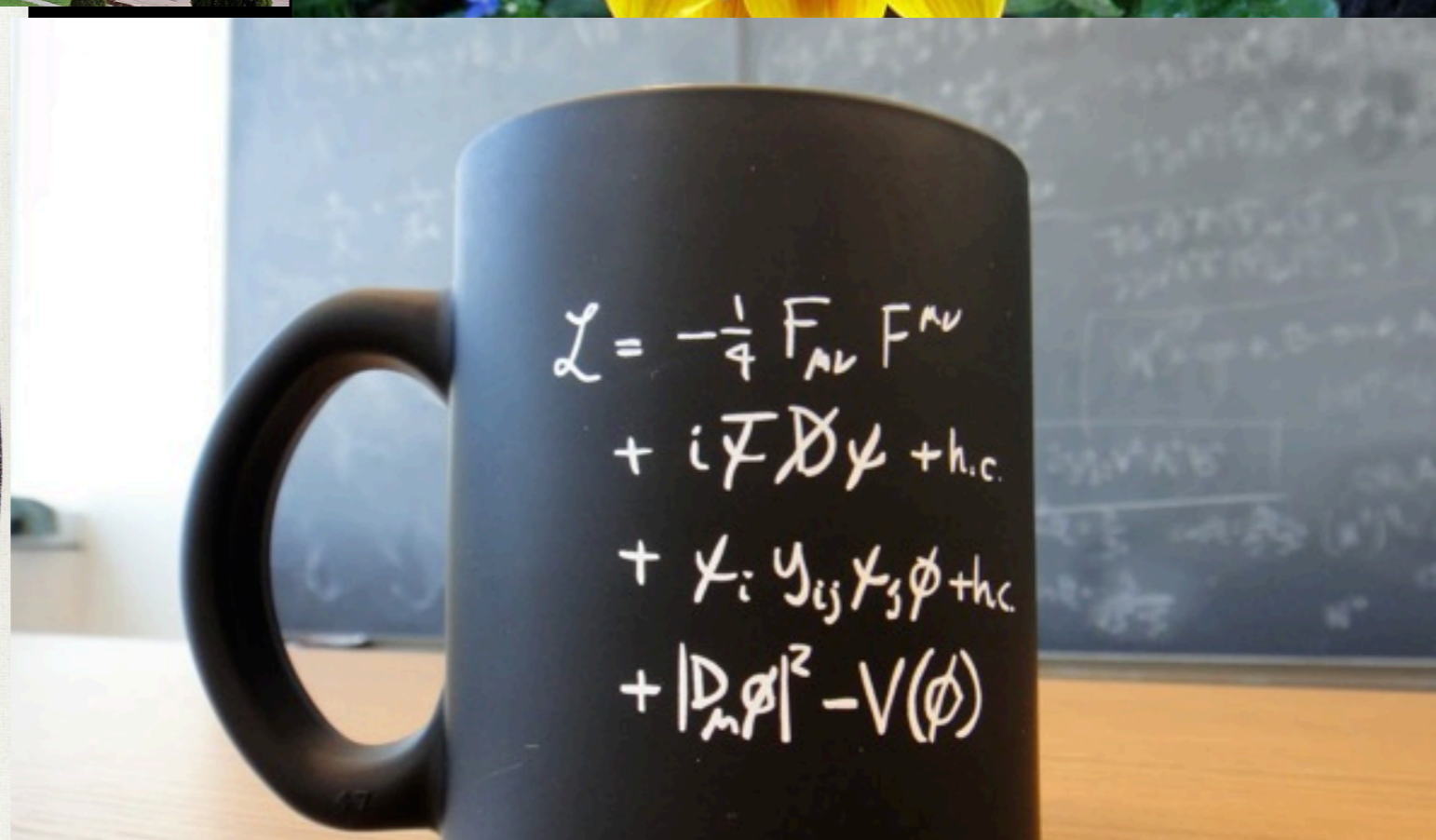
WORKING  
CLASS  
HERO

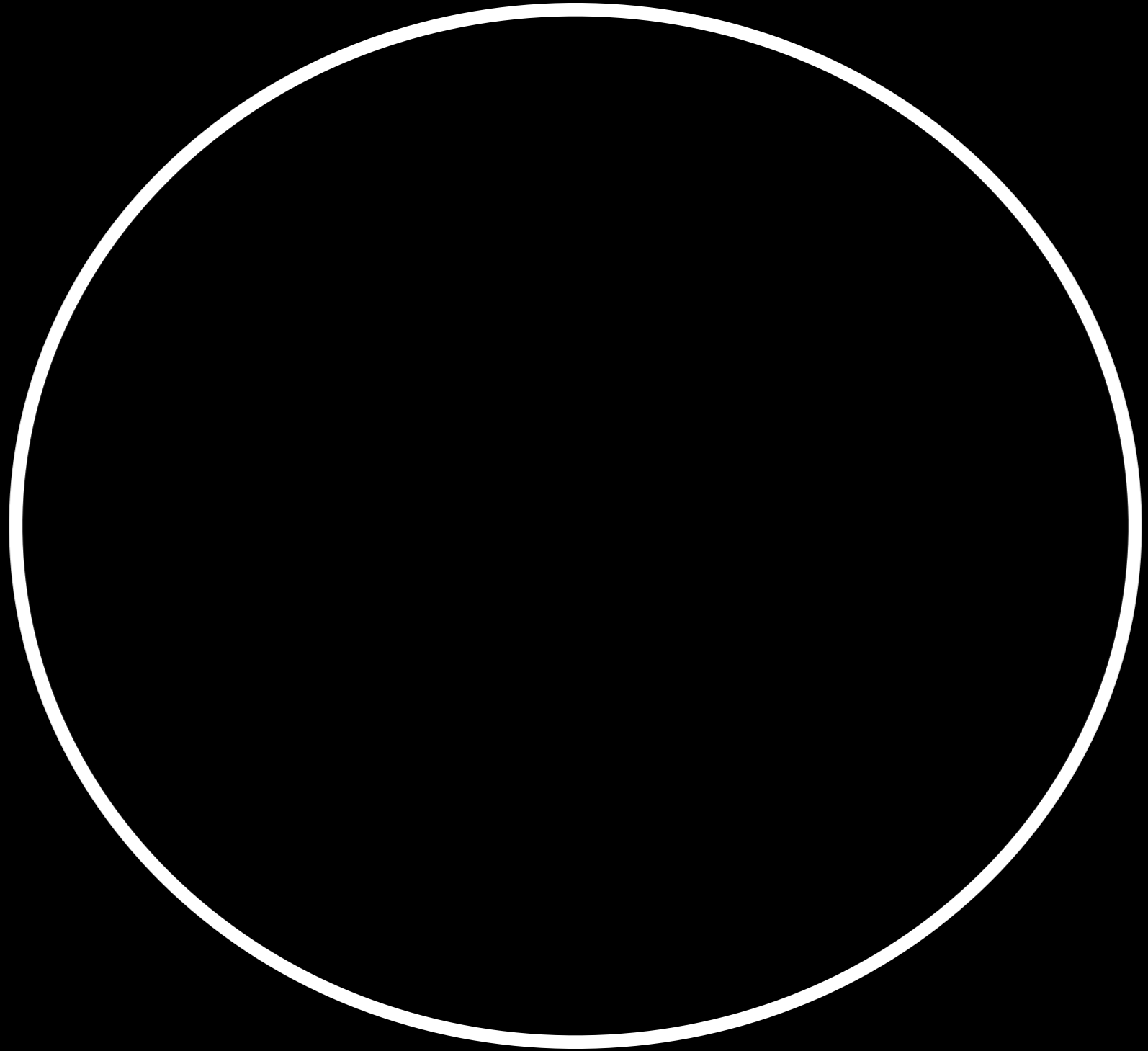
$$\Psi_{g,h}(\sigma, \tau, z) := \exp \left[ \sum_{L=1}^{\infty} p^L \mathcal{T}_L^\alpha \phi_{g,h}(\tau, z) \right]$$

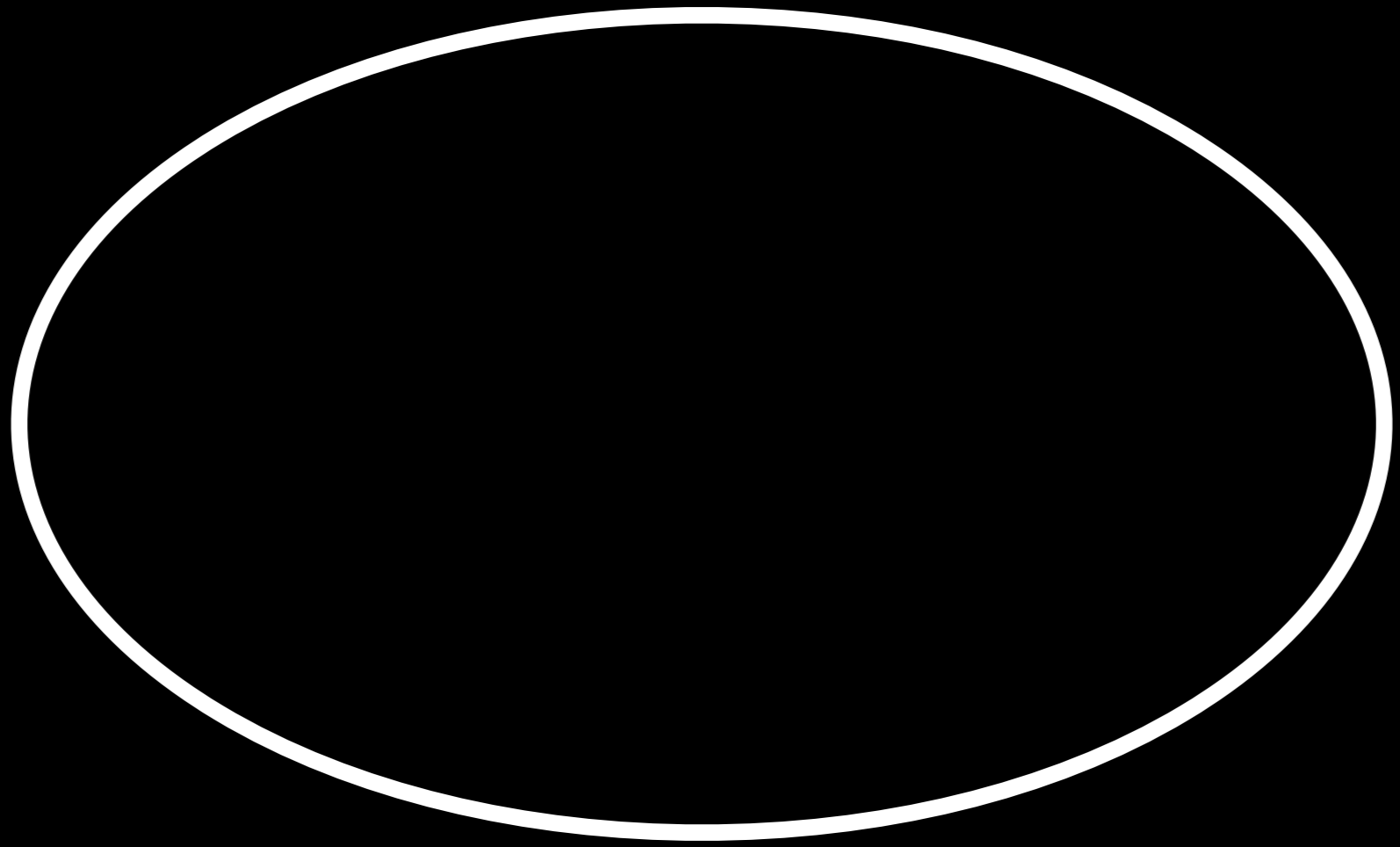
$$\chi(K3; \tau, z) = \frac{\vartheta_1(\tau, z)^2}{\eta(\tau)^3} \left( 24\mu(\tau, z) + q^{-1/8} \left( -2 + \sum_{n=1}^{\infty} A_n q^n \right) \right)$$

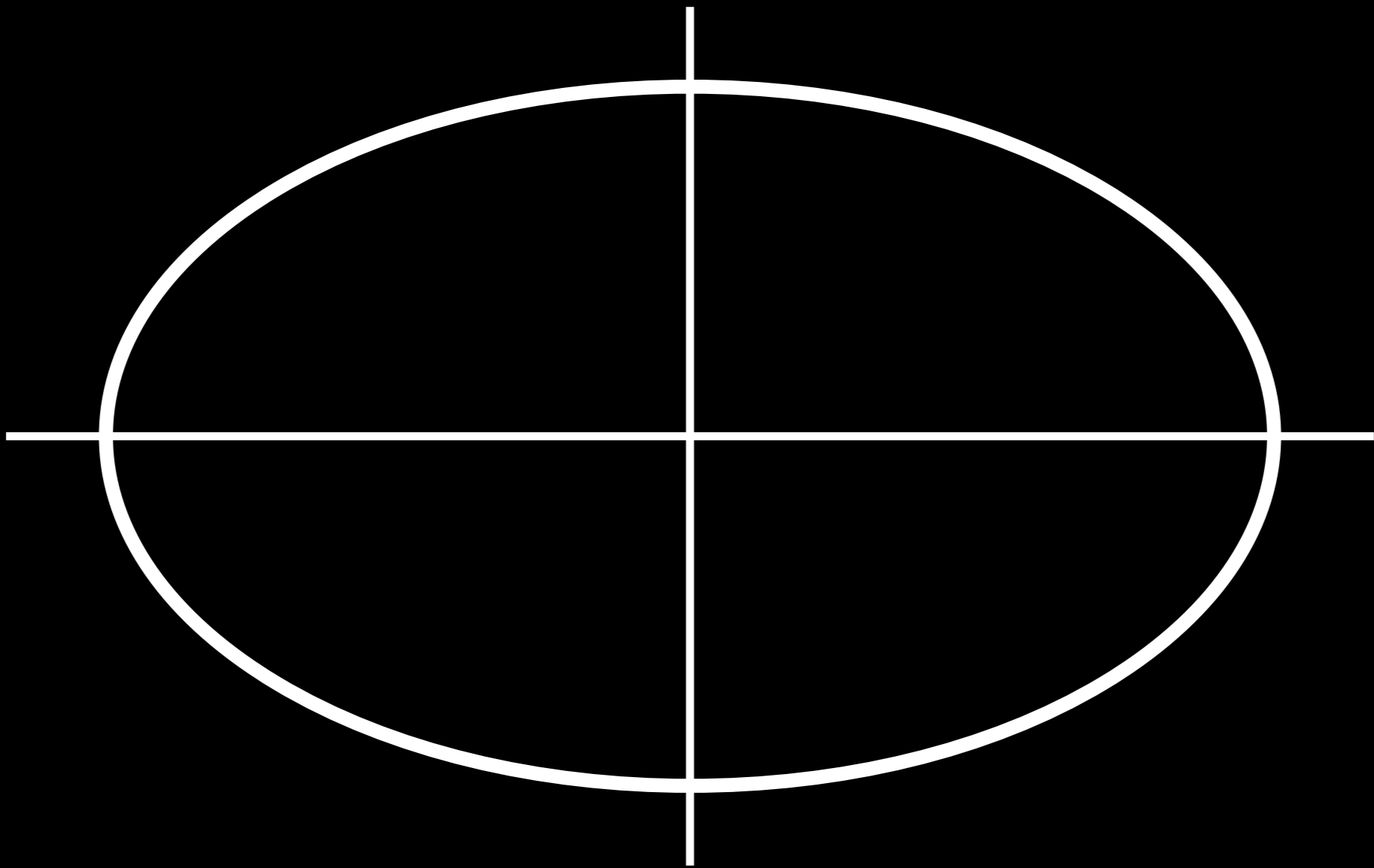
$$\text{gdim } V^\natural = \sum_{n=-1}^{\infty} (\text{dim } V_n^\natural) q^n = q^{-1} + 196884q + \dots = J(\tau)$$

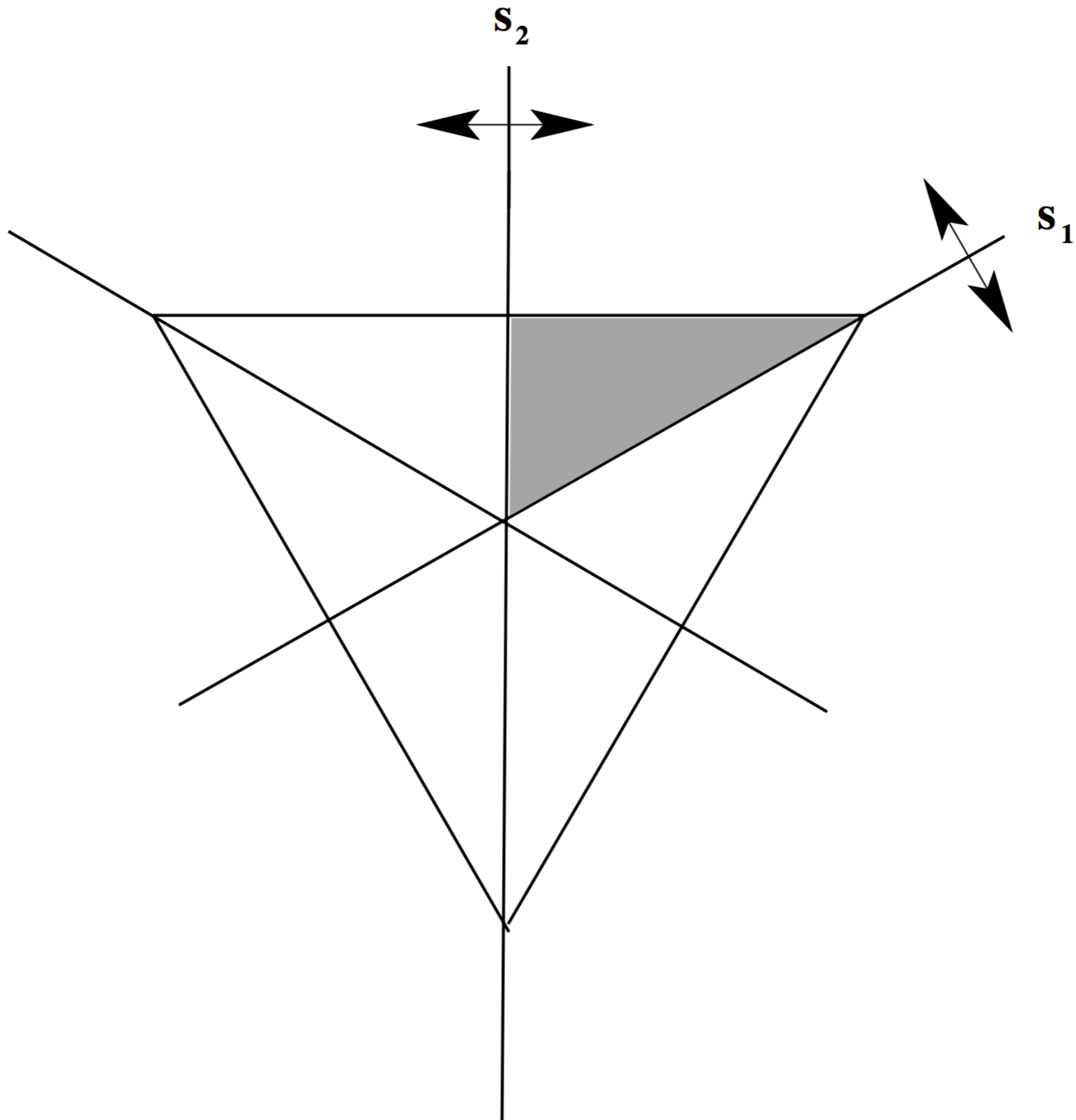
# Naturen har inbyggda symmetrier

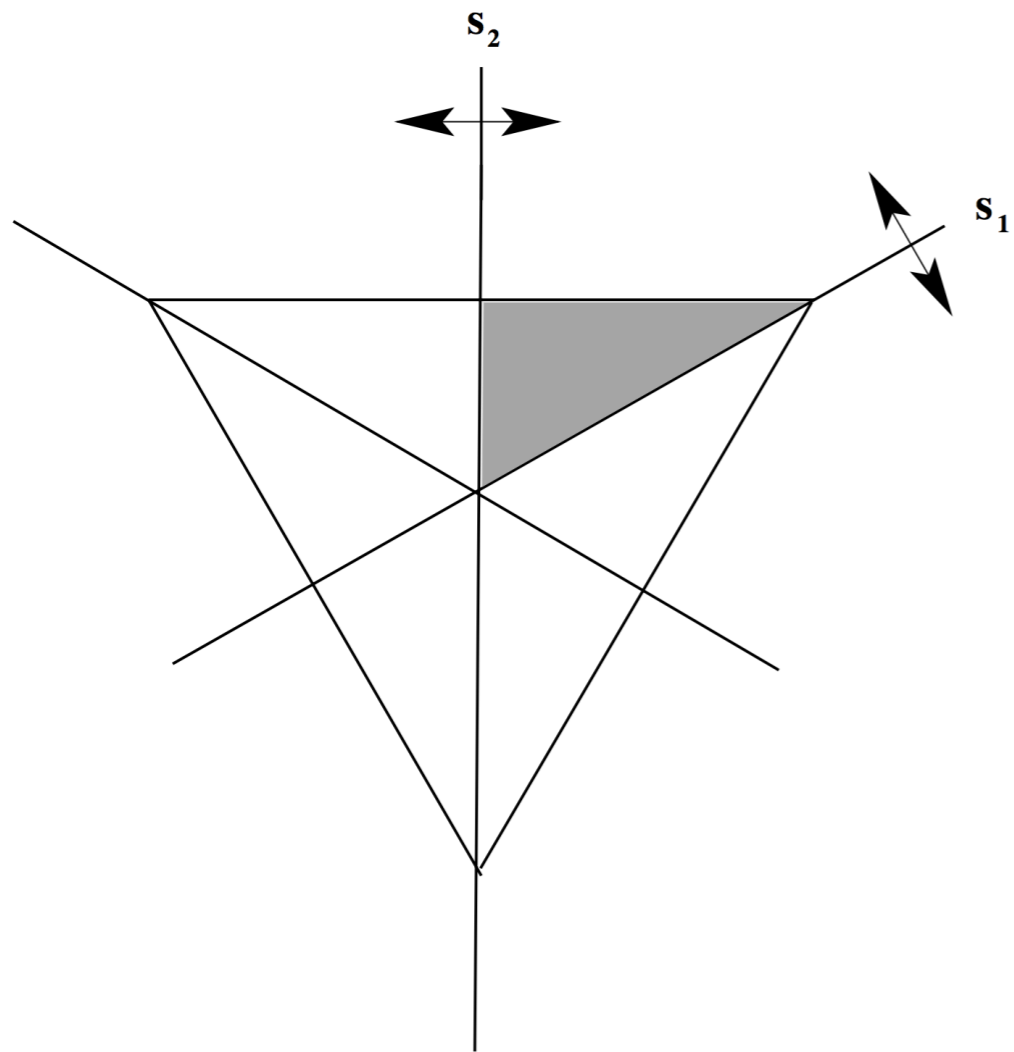










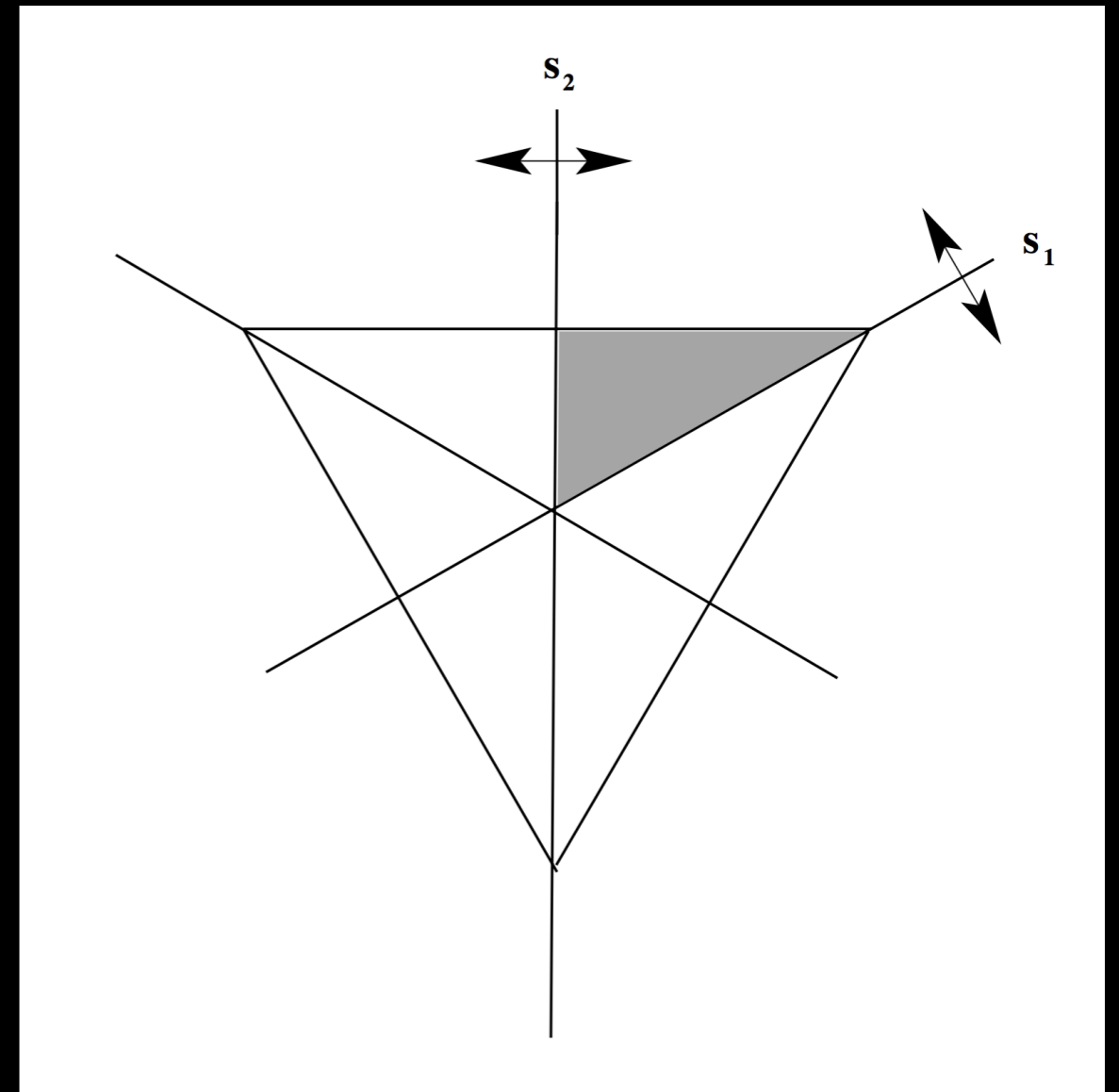


Symmetritransformationer bildar  
ett matematisk objekt  
som kallas ***grupp***

Kombination av två transformationer  
måste också vara en symmetri

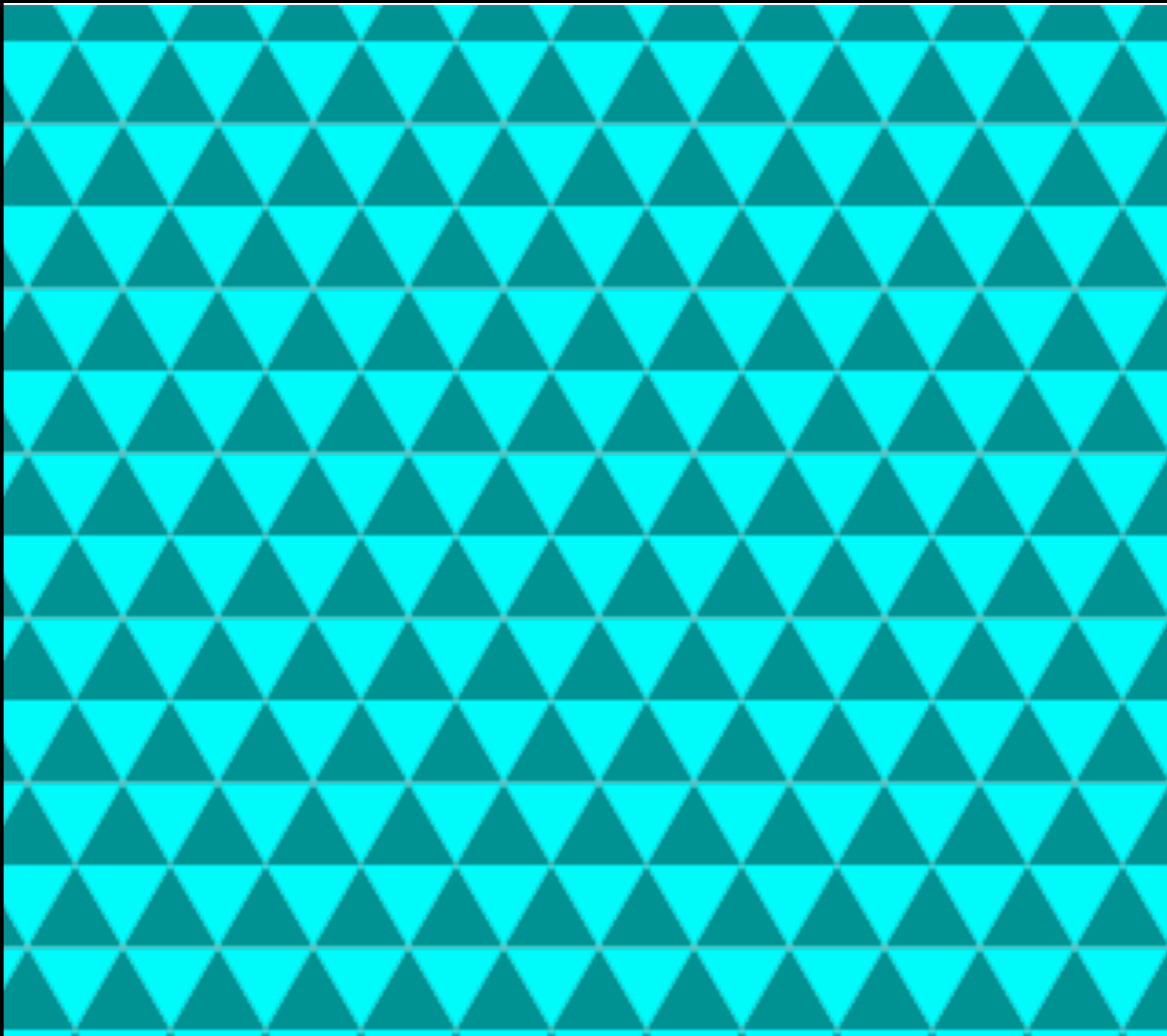
Symmetritransformationer bildar  
ett matematisk objekt  
som kallas **grupp**

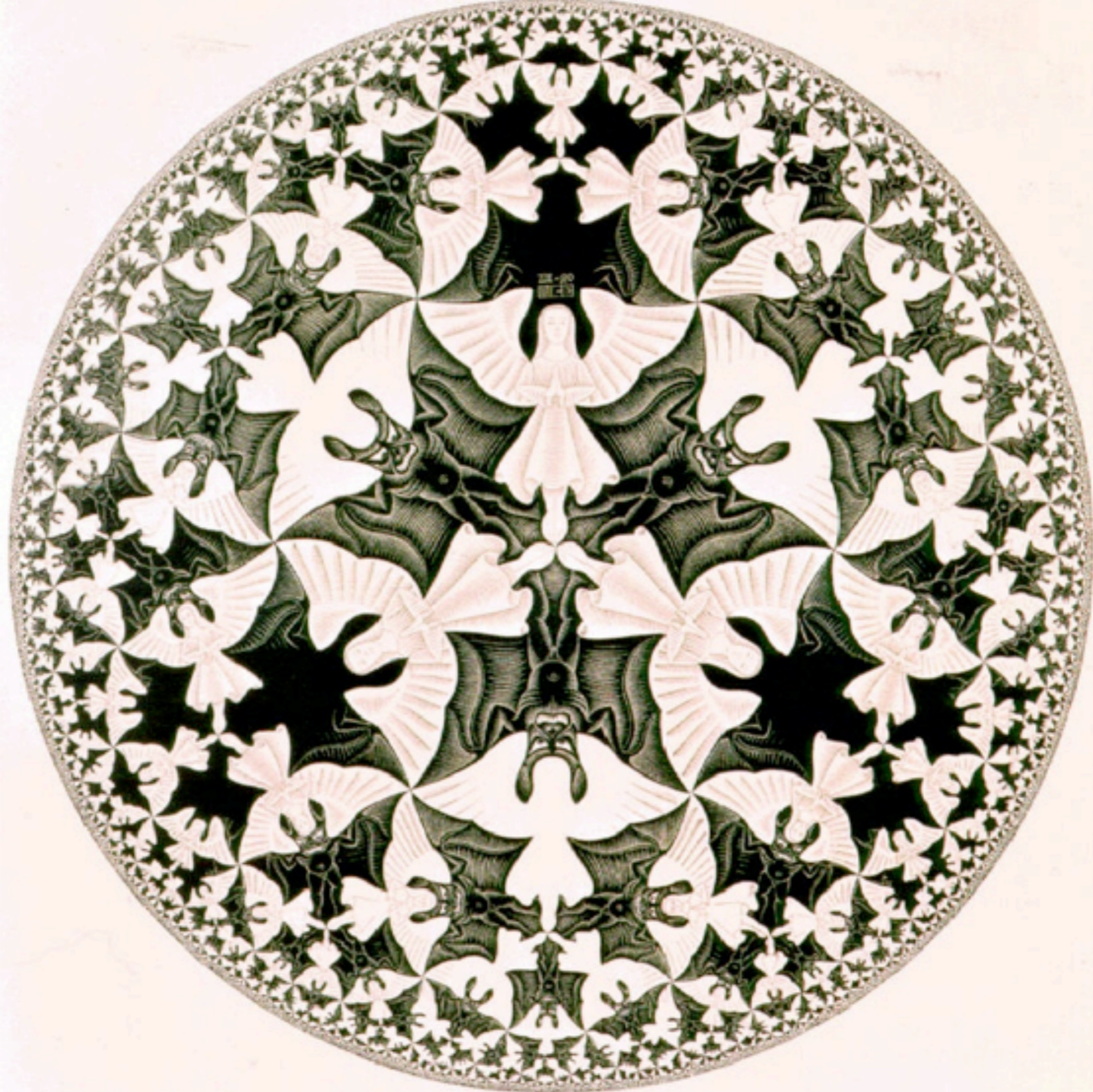
Kombination av två transformationer  
måste också vara en symmetri



**Men vad händer om vi flyttar triangeln?**

Men en “tesselering” av planet med trianglar har oändlig symmetri!







**Naturens fundamentala lagar bestäms av symmetrier!**



starka kärnkraften



gravitation

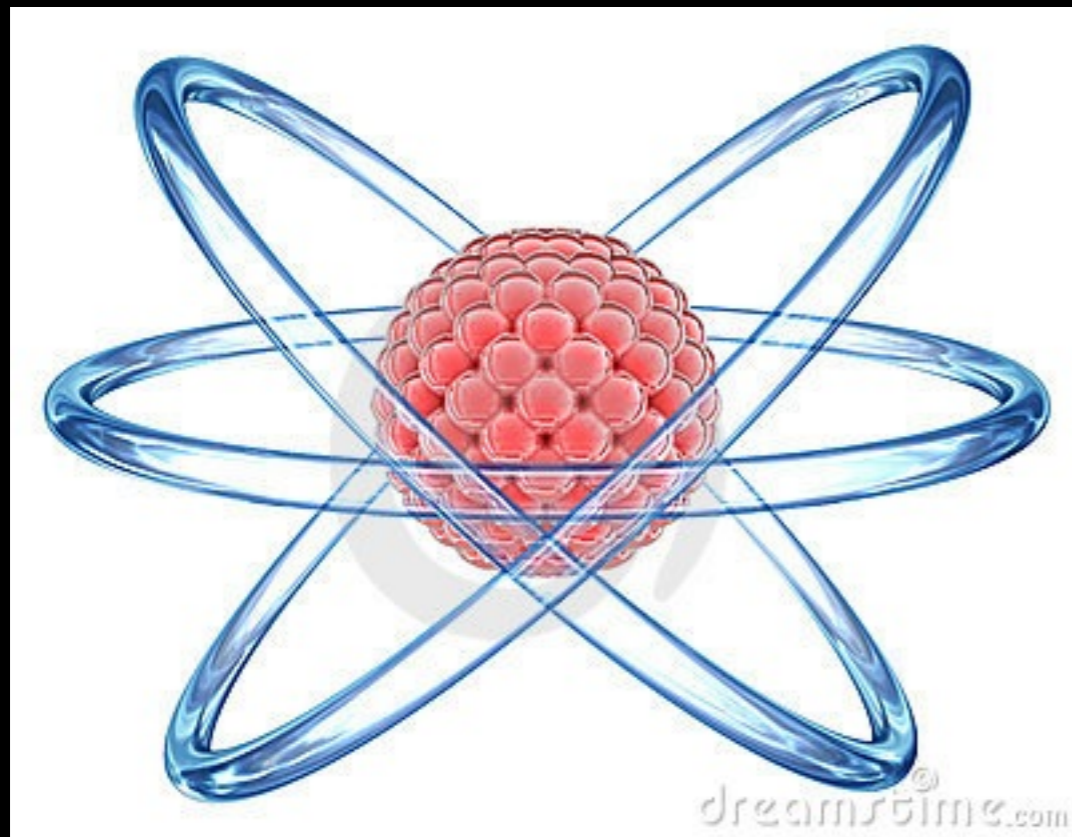


elektromagnetism

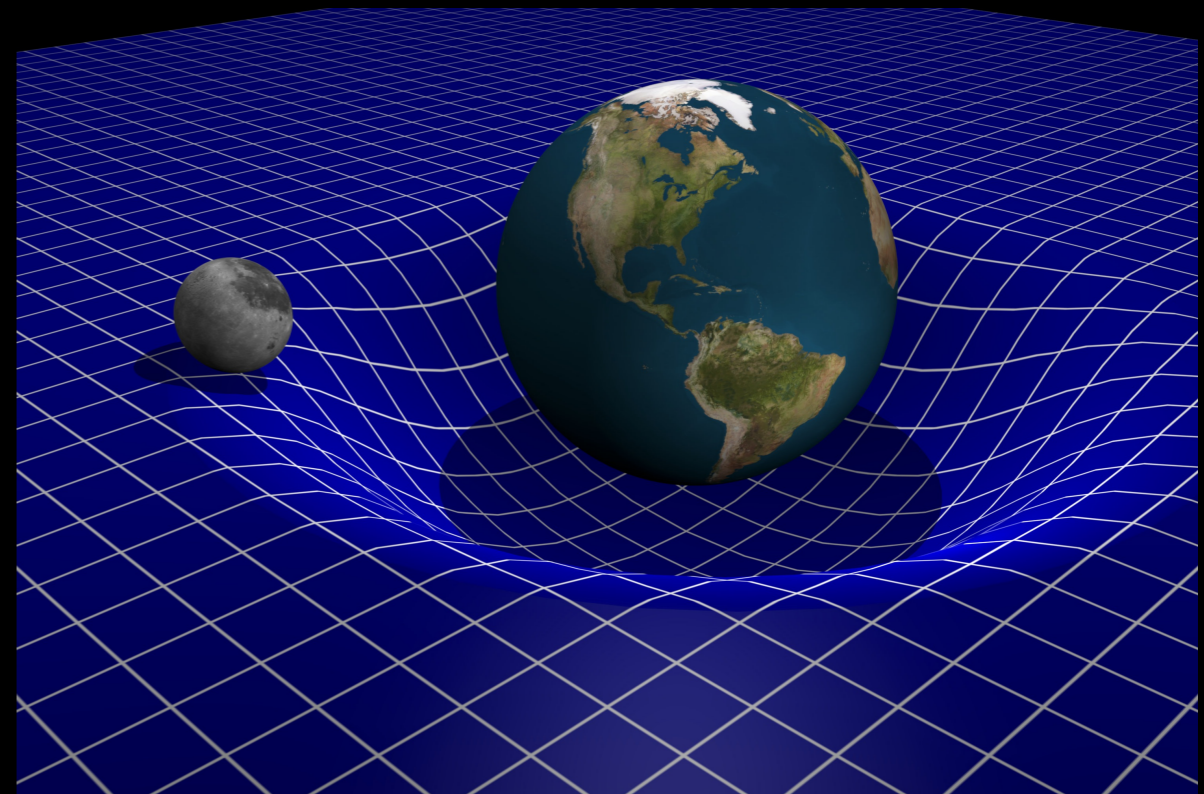


svaga kärnkraften



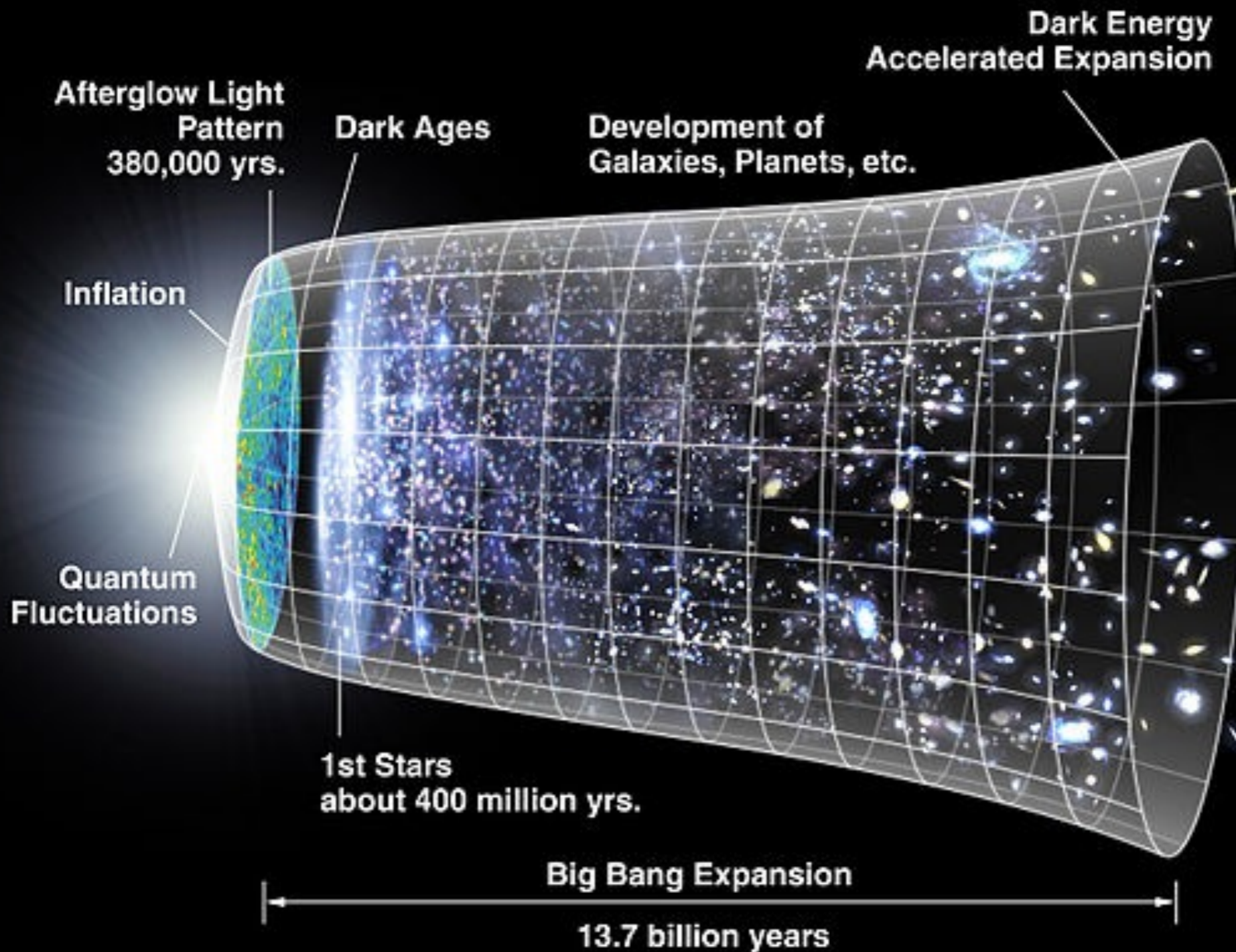


kvantmekanik



allmän relativitetsteori

Det finns regioner i universum där kvantmekanik och allmän relativitetsteori måste kombineras



# The Milky Way

DIGITAL IMAGE OF THE MILKY WAY BY PIKAIA IMAGING (WWW.PIKAIA-IMAGING.CO.UK)



OUTER ARM

NORMA ARM

Sagittarius Dwarf  
Elliptical Galaxy

Source of 2004  
magnetar burst

Giant star V354 Cephei

Cygnus X-1

CRUX-SCUTUM ARM

Central black hole

Most distant  
known planet

Eagle Nebula

Giant star  
KW Sagittarii

Scorpius X-1

Lagoon Nebula

Trifid Nebula

Cat's Paw Nebula

Ring Nebula

Cat's Eye Nebula

Stingray Nebula

First known pulsar

Twin Jet Nebula

Giant star Mu Cephei

Witch's Broom Nebula

Butterfly star cluster

North America Nebula

Dumbell Nebula

Ant Nebula

Helix Nebula

Polaris

Pulsar planetary system

HD 209458 Hot Jupiter

Planetary system 51 Pegasi

Hourglass Nebula

Omega Centauri  
globular cluster

Pleiades star cluster

**SOLAR SYSTEM**  
You are here

Jewel Box  
star cluster

Keyhole Nebula

Horsehead Nebula

Eta Carinae

Spirograph  
Nebula

Giant star  
VY Canis Majoris

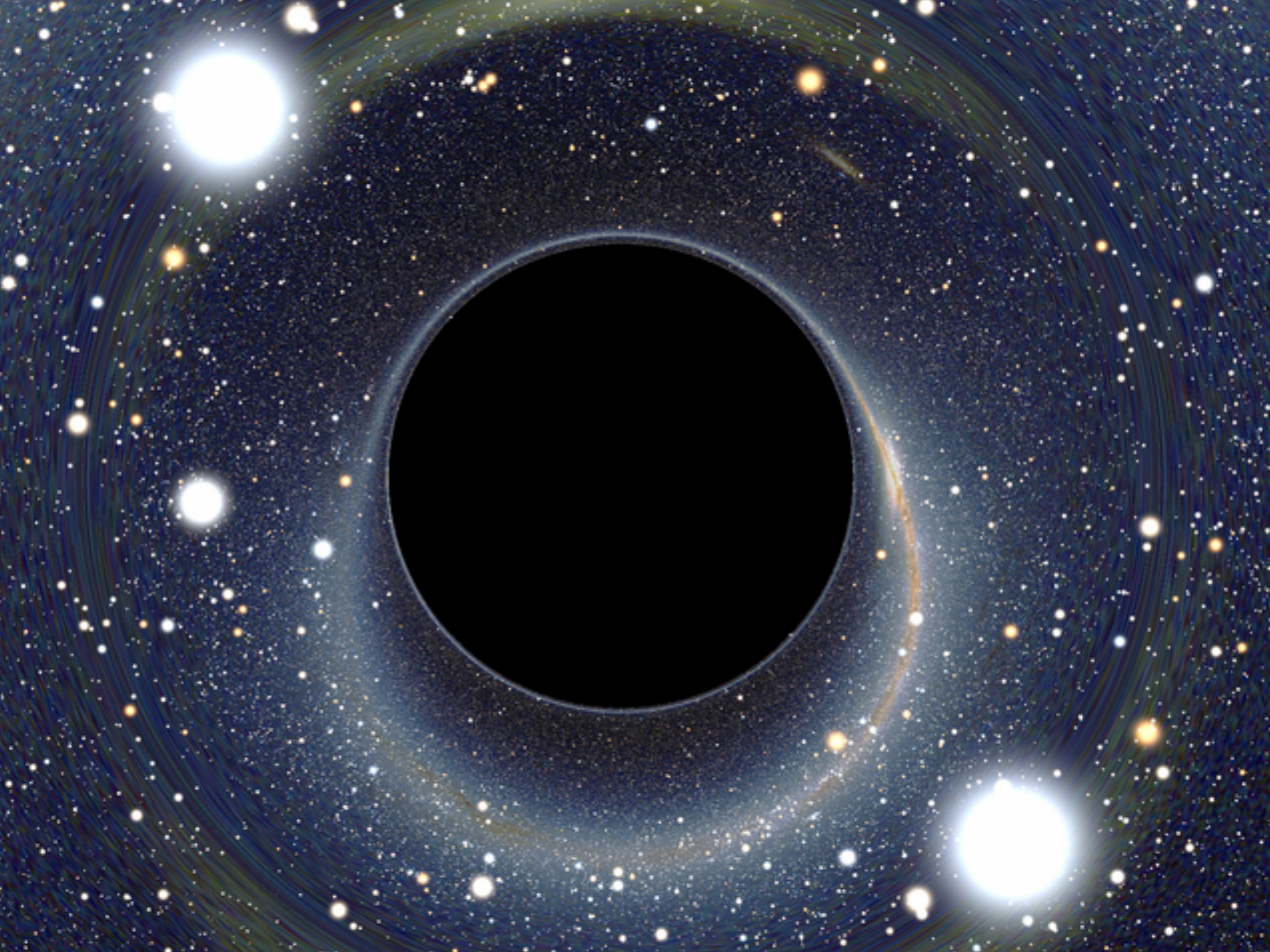
Rotten Egg  
Nebula

Eskimo Nebula

PERSEUS ARM

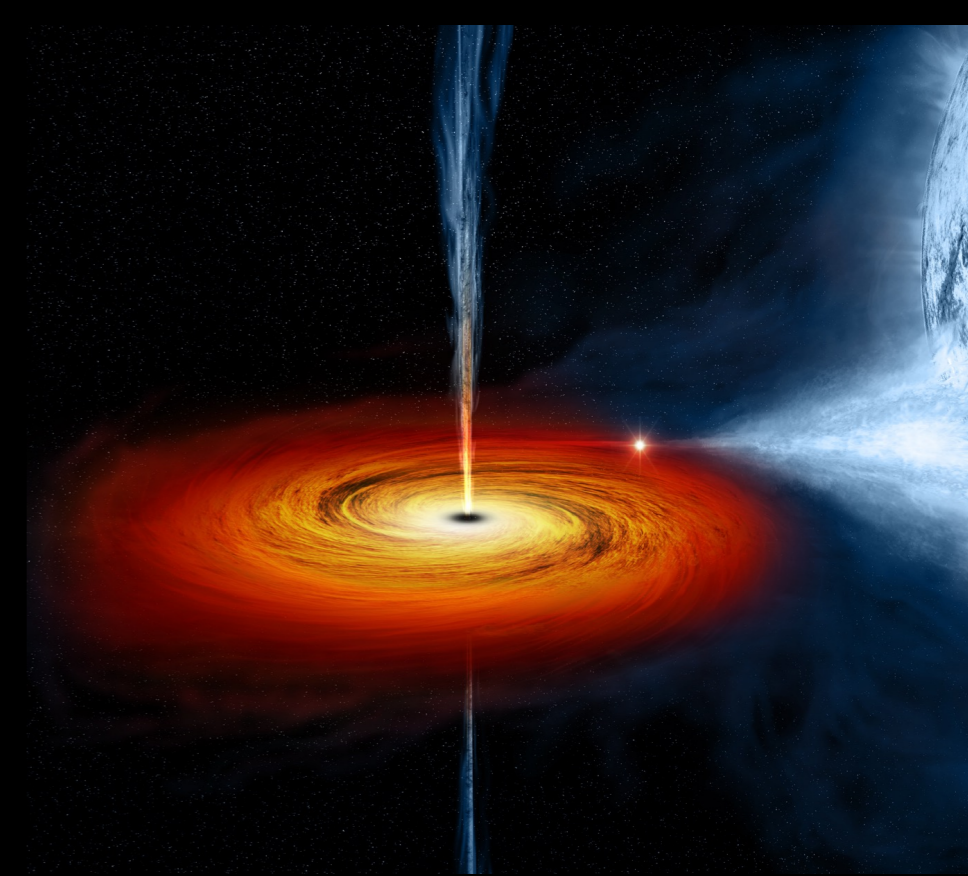
Rosette Nebula

Crab Nebula

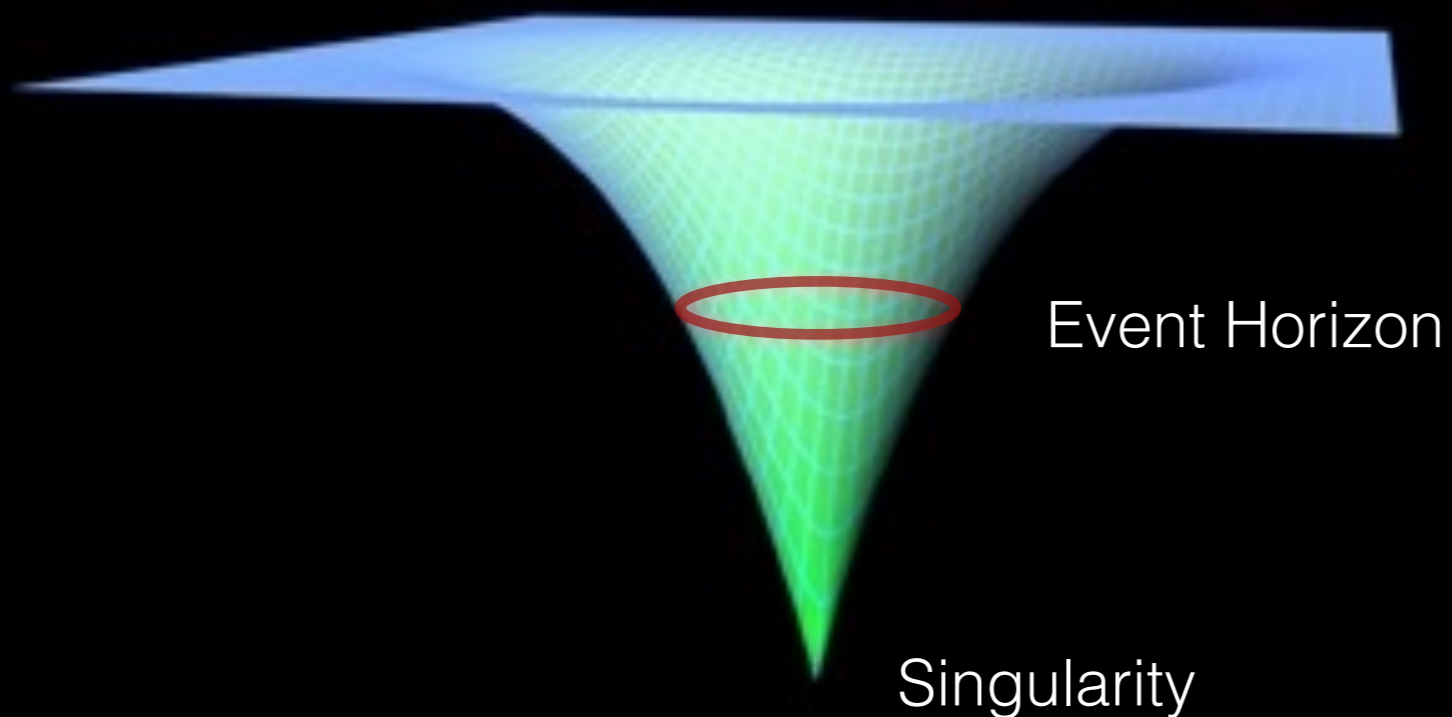




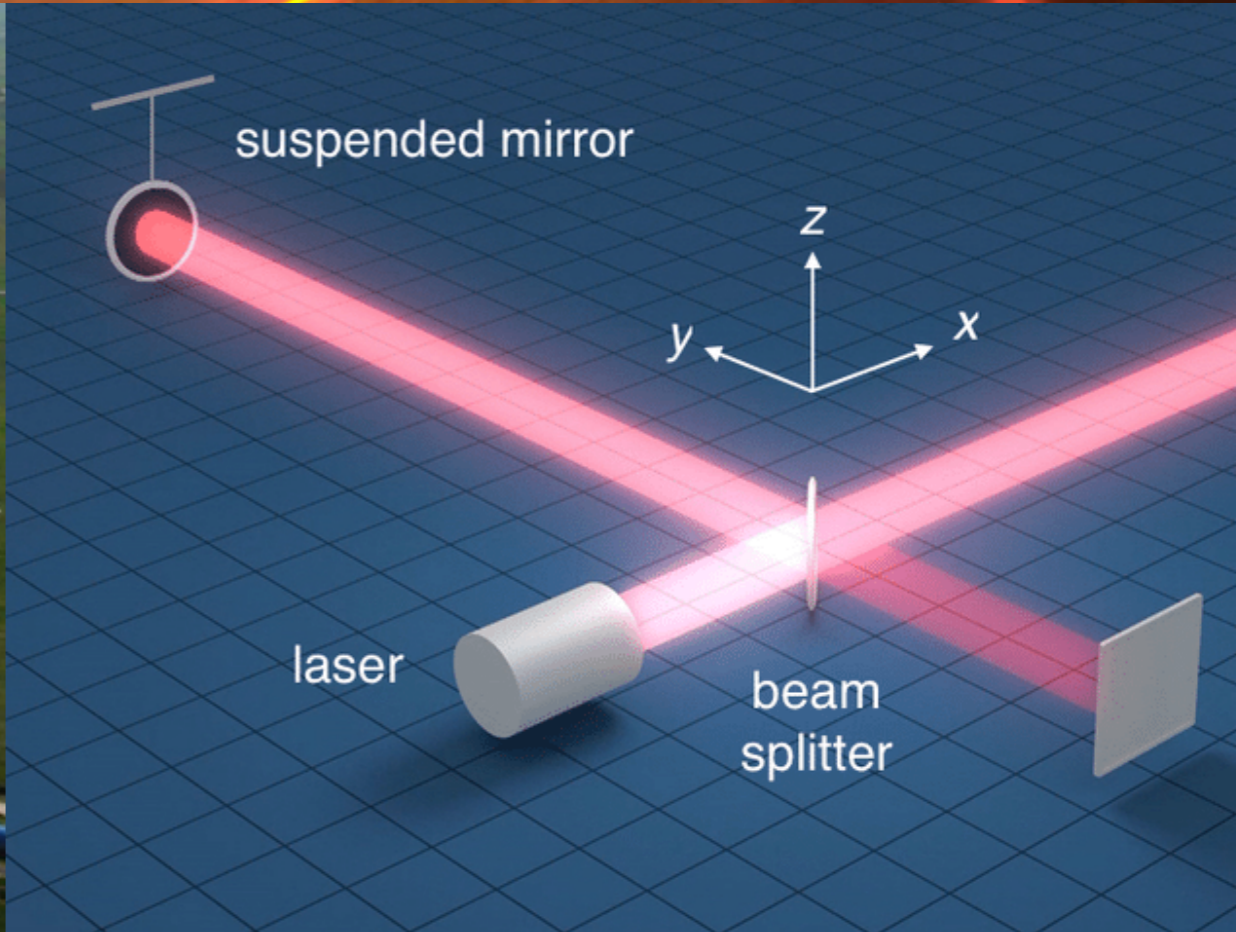
Ett svart hål bildas när en tillräckligt stor stjärna kollapsar och dör



I mitten av ett svart hål bryts rumtiden sönder



**Vad händer inuti ett svart hål?**

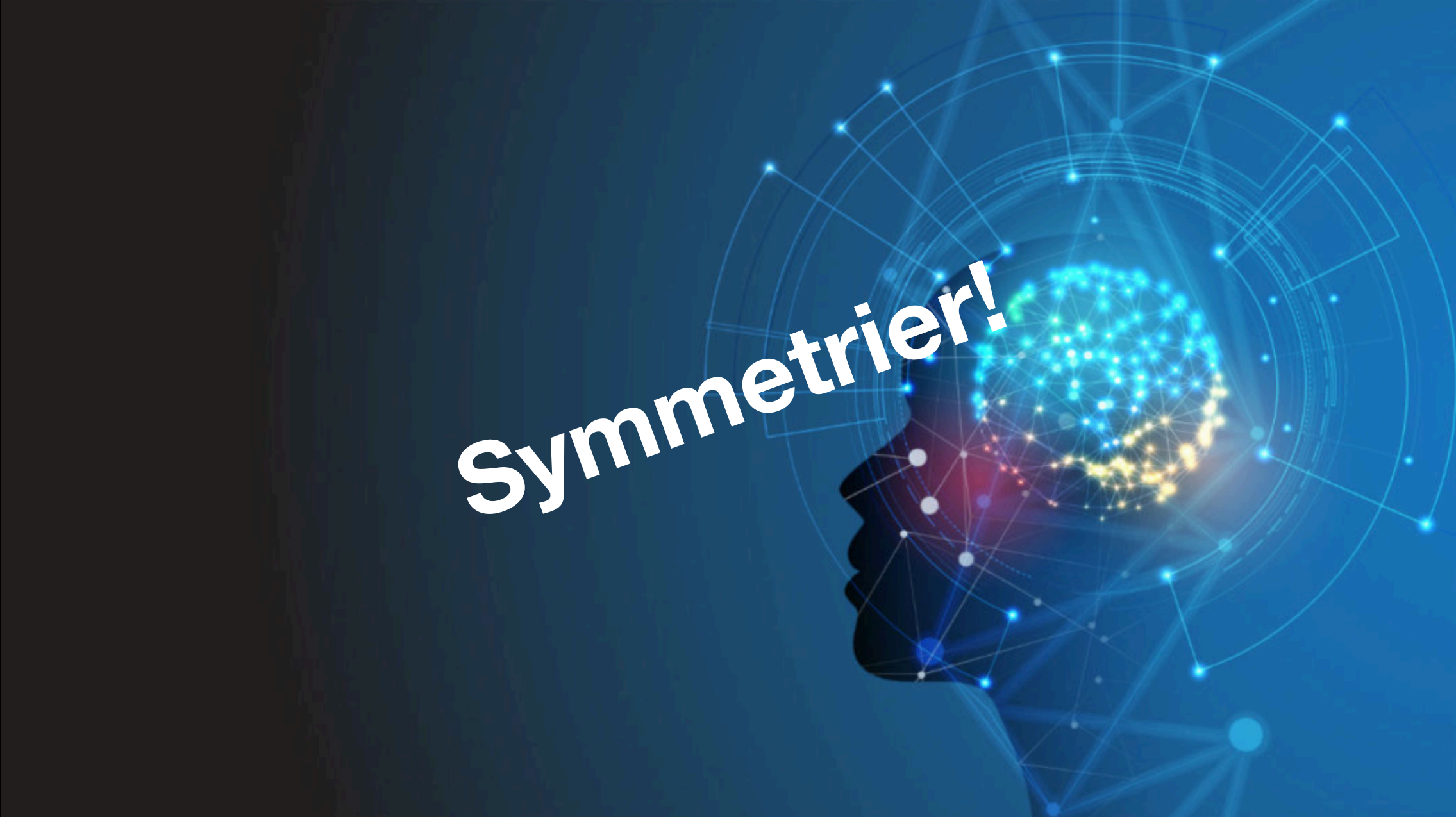


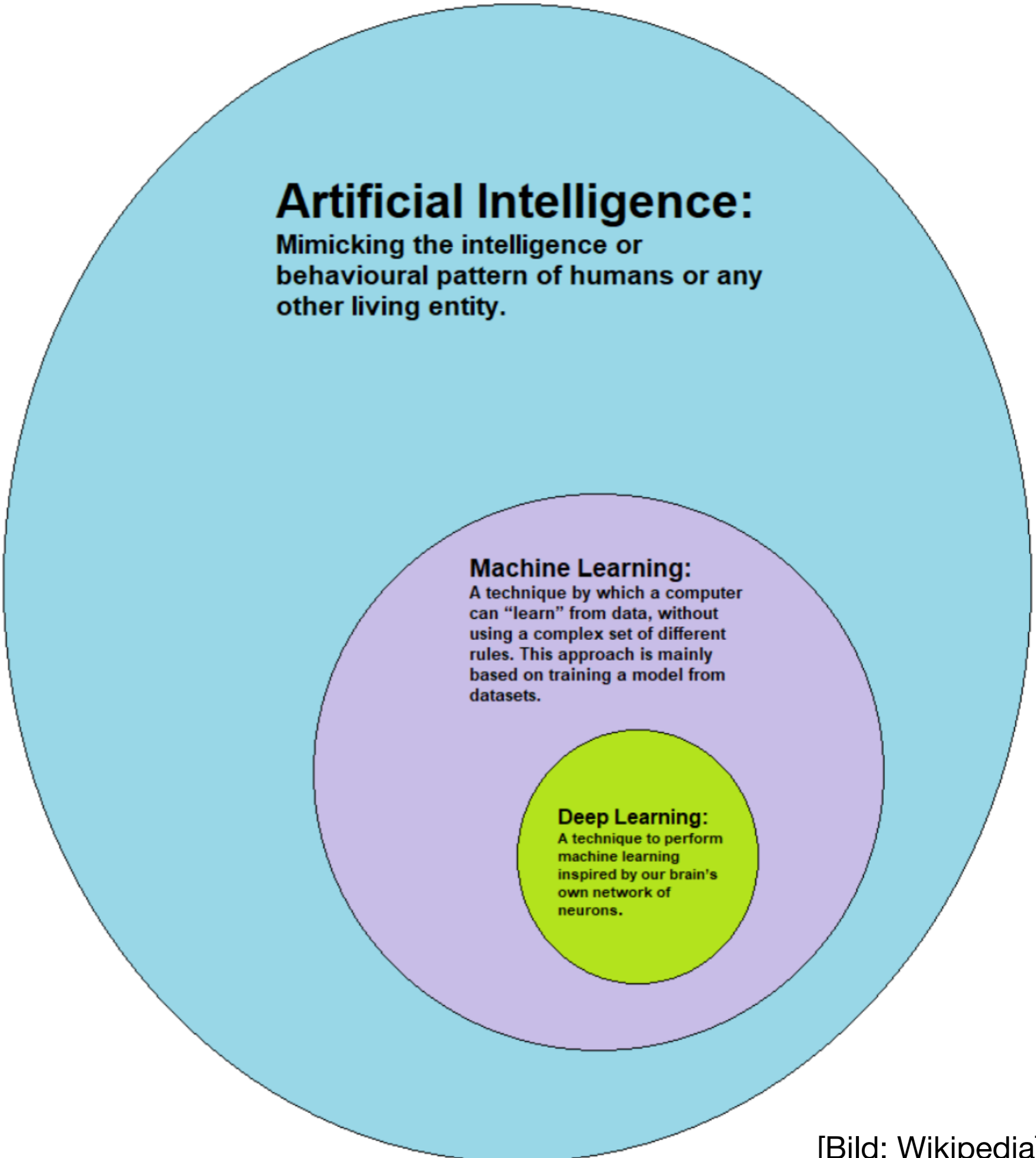
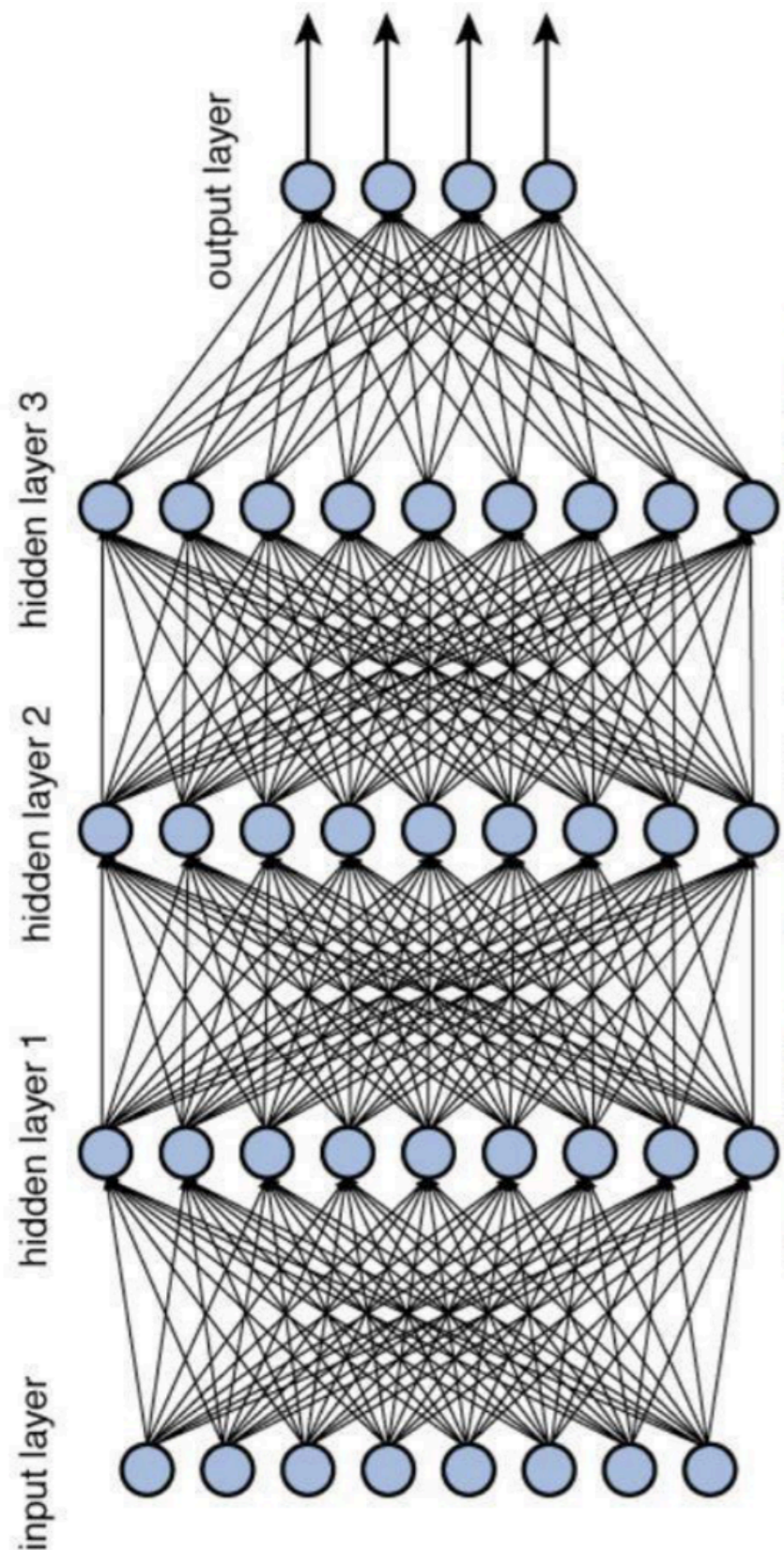
# Vad har allt detta med AI att göra?



**Vad har allt detta med AI att göra?**

**Symmetrier!**





### Classification



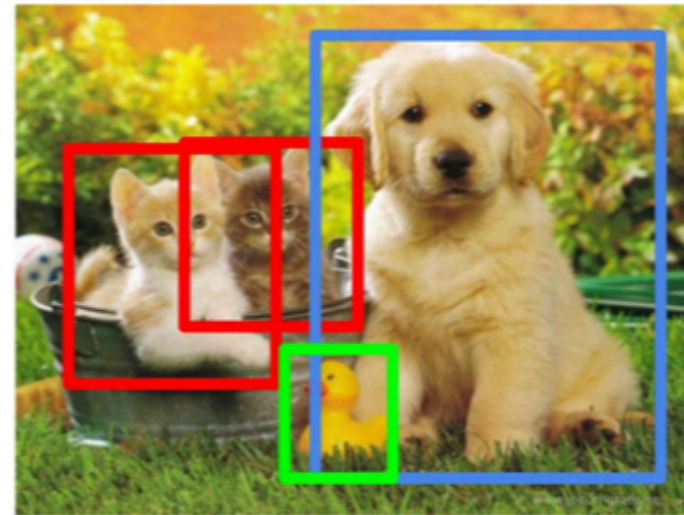
CAT

### Classification + Localization



CAT

### Object Detection



CAT, DOG, DUCK

### Instance Segmentation



CAT, DOG, DUCK

Single object

Multiple objects







[Bild från [thispersondoesnotexist.com](http://thispersondoesnotexist.com)]



## What can I help with?

Ask anything

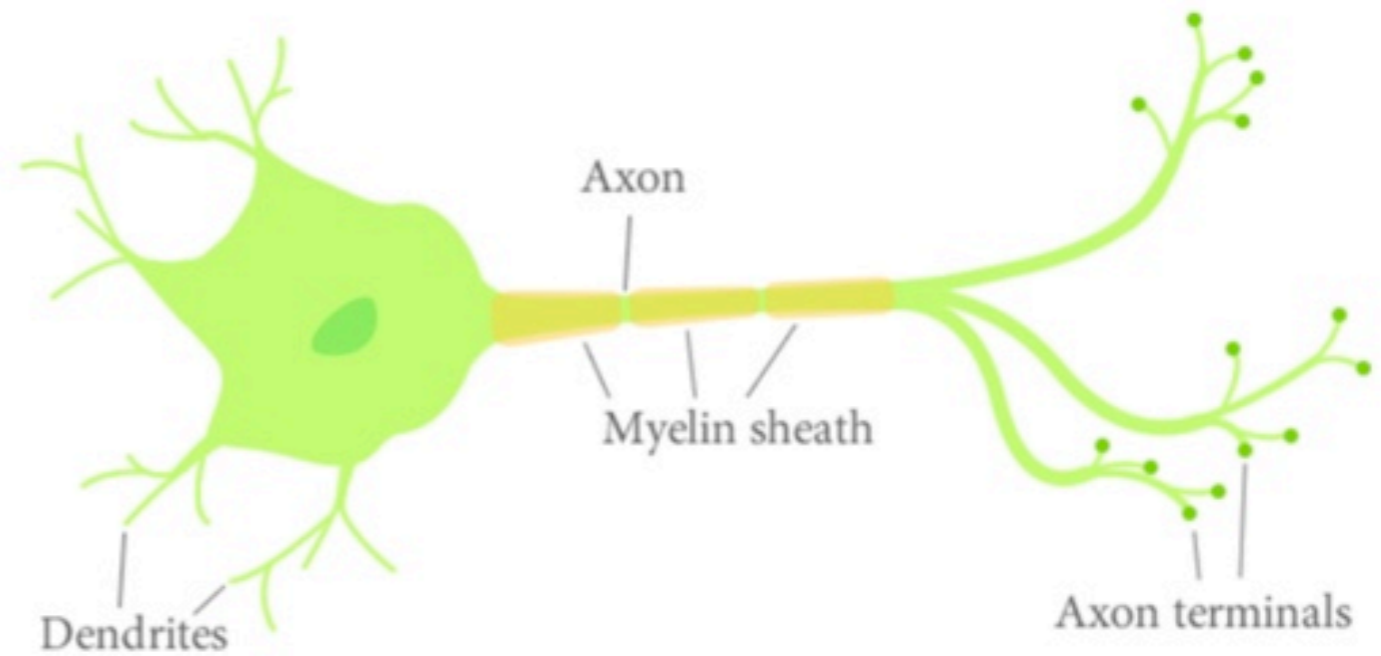


Search

Deep research



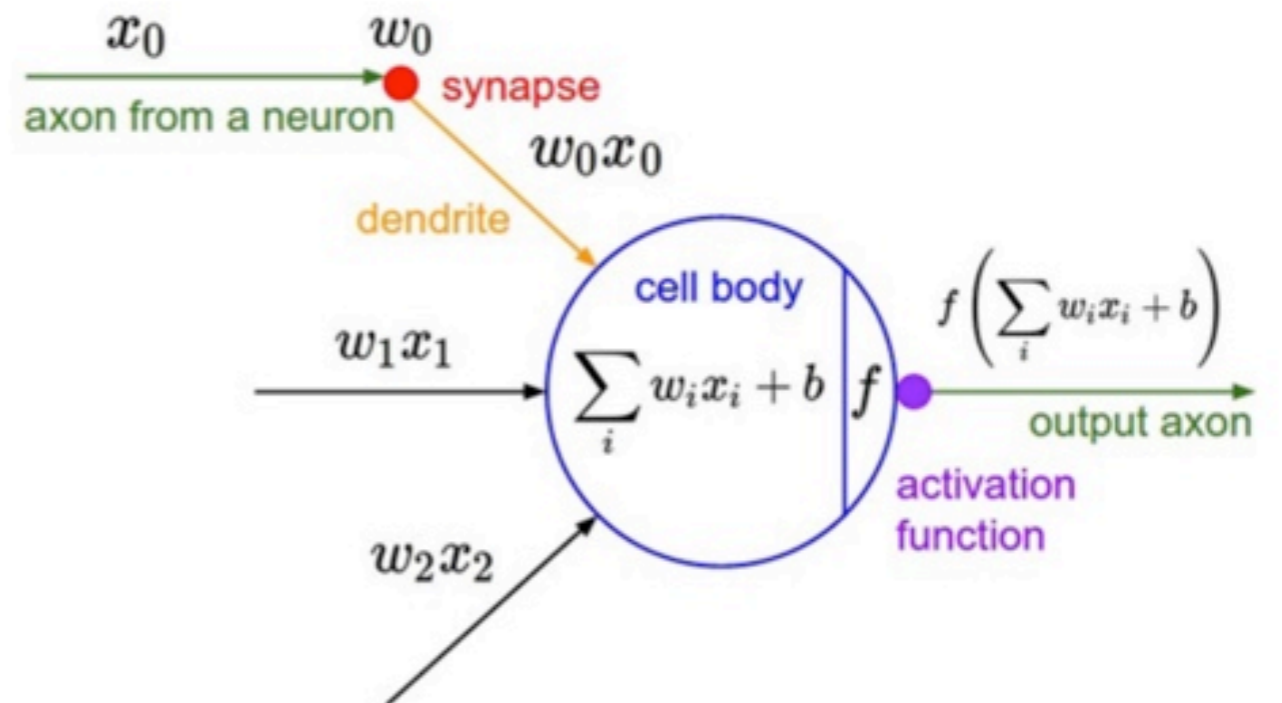
## Real Neuron



## Artificial Neuron

Artificiell neuron:

1. Input lager
2. Dolda lager
3. Output lager



**Att känna igen bilder**

# Att känna igen bilder

“skateboard”



“capybara”

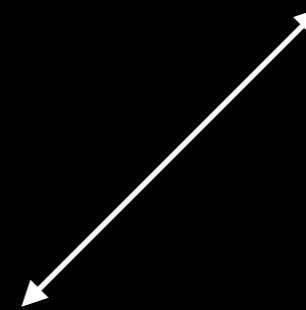
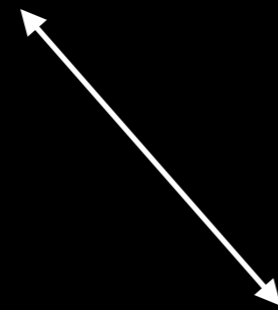


“boxhandskar”

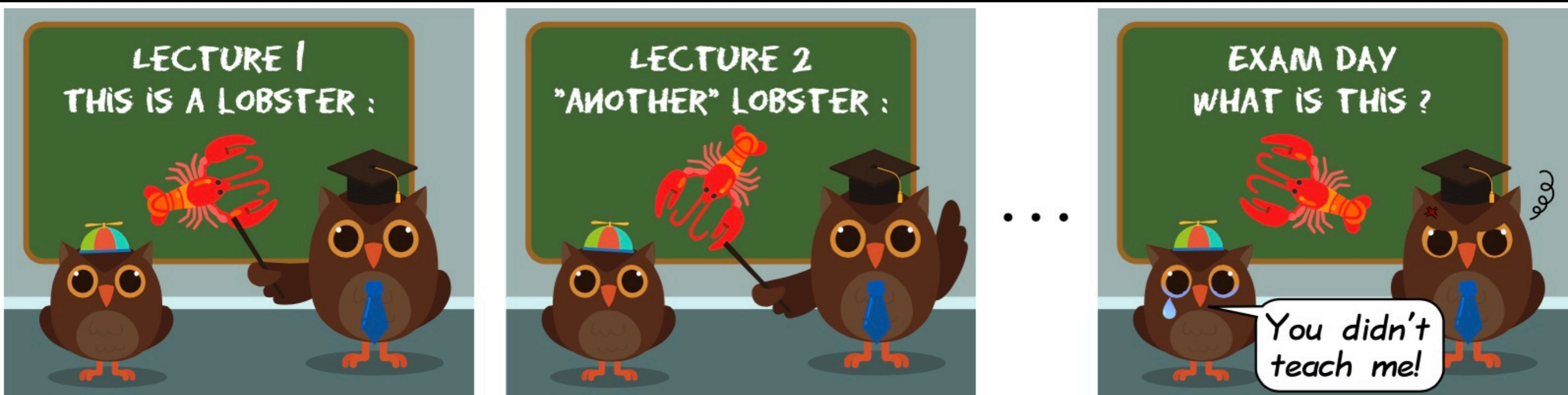
# Reflektionssymmetri



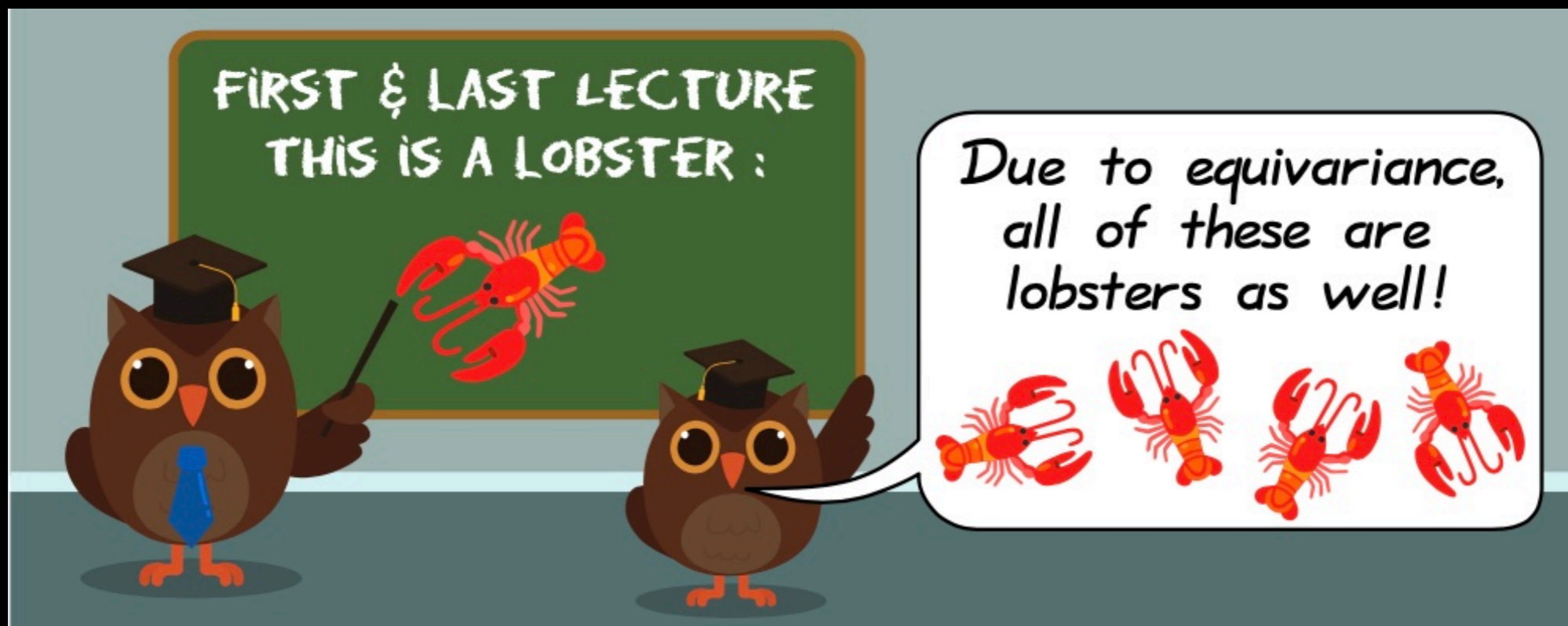
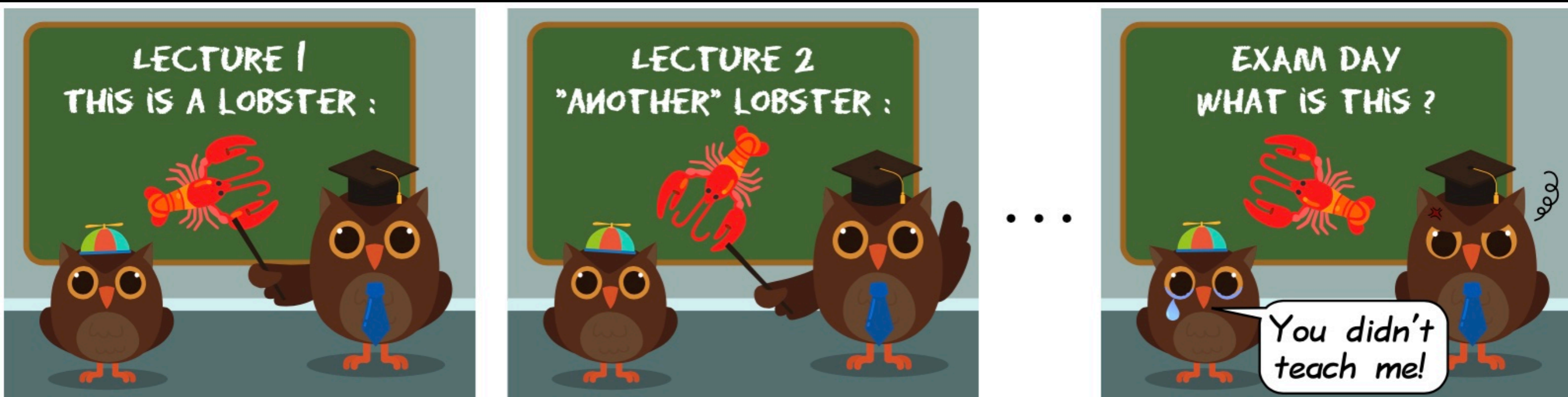
reflektera



“boxhandske”



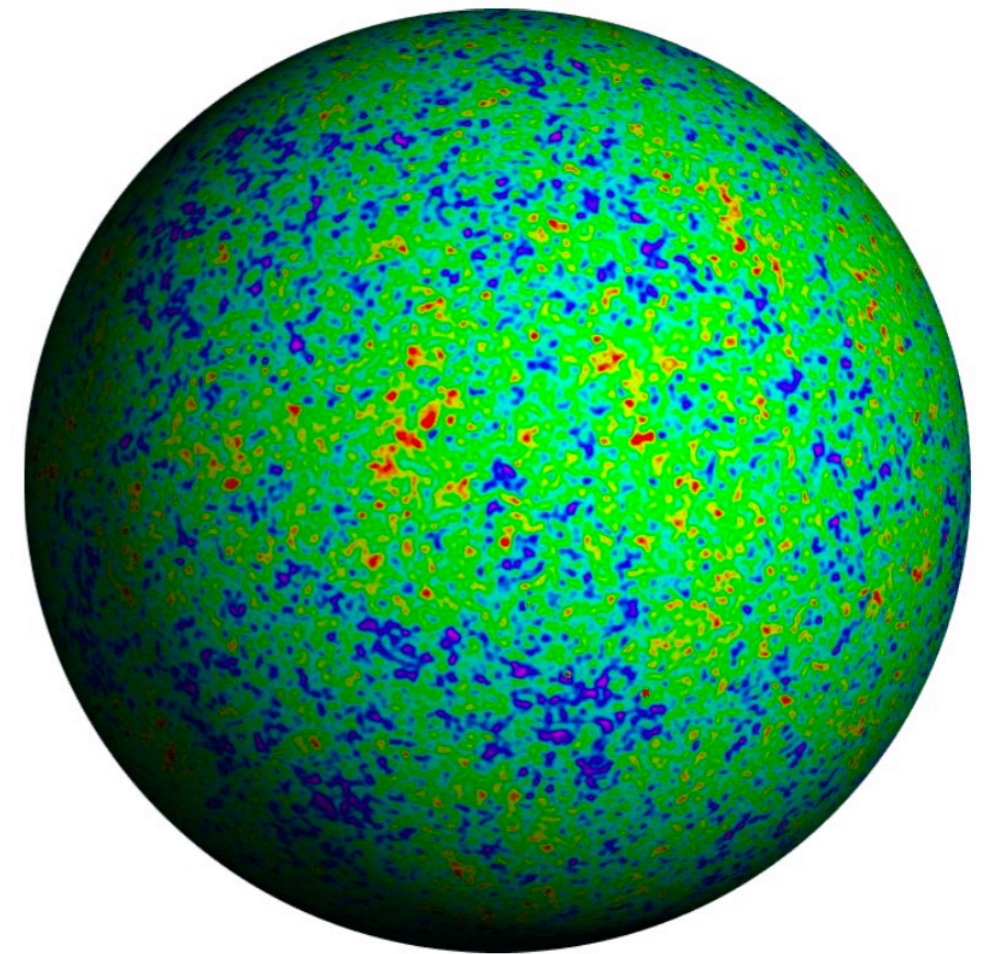
[Bilder från: Weiler, Forré, Verlinde, Welling (2023)]



# Vad händer om datan är “krökt”?



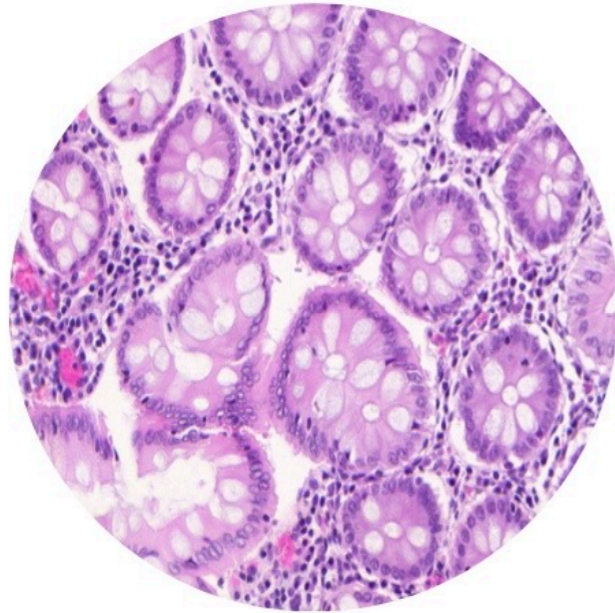
[Bild från Woodscape dataset, projected onto a sphere]



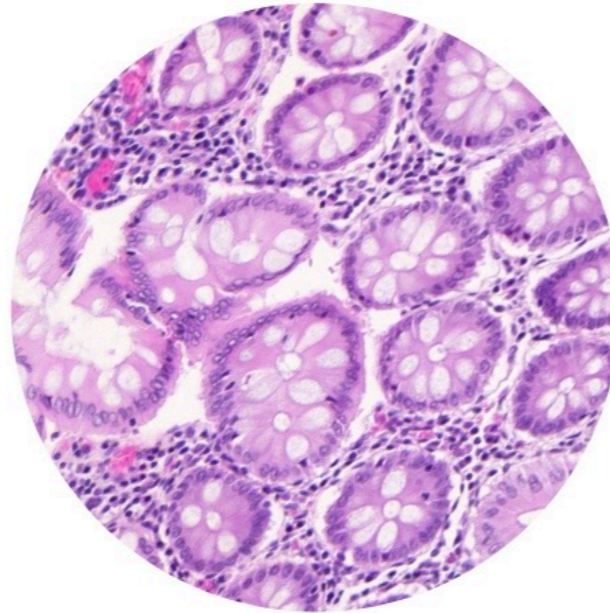
**Kosmiska bakgrundsstrålningen**

[Bild från Weiler et al]

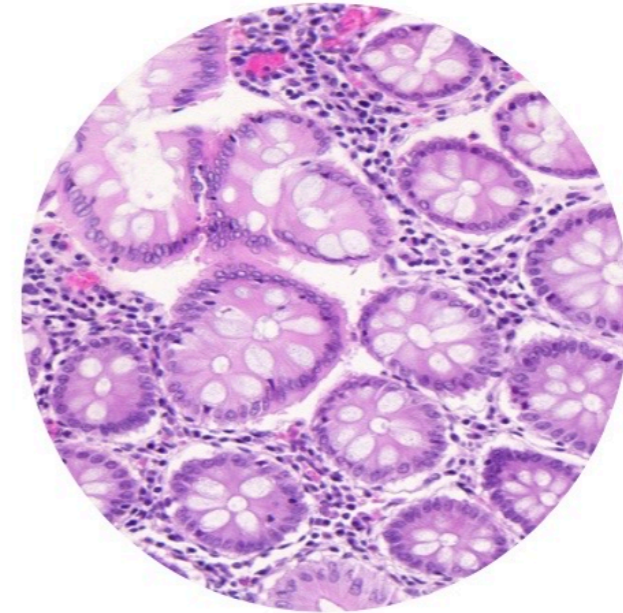
# Medicinska bilder av tumörer



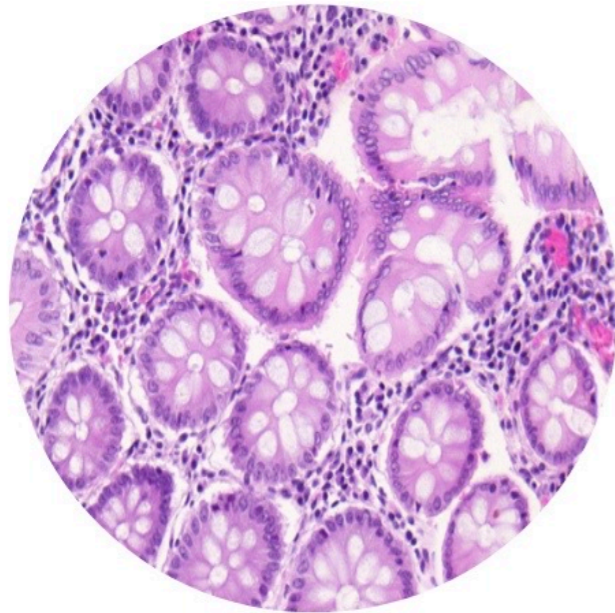
Original



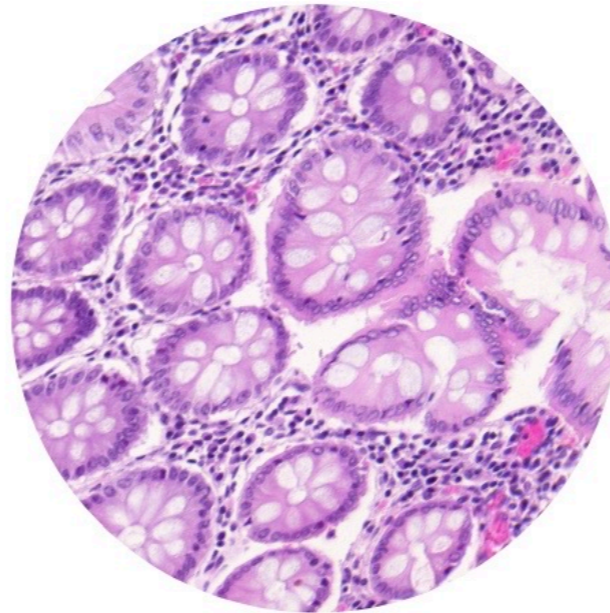
45° rotation



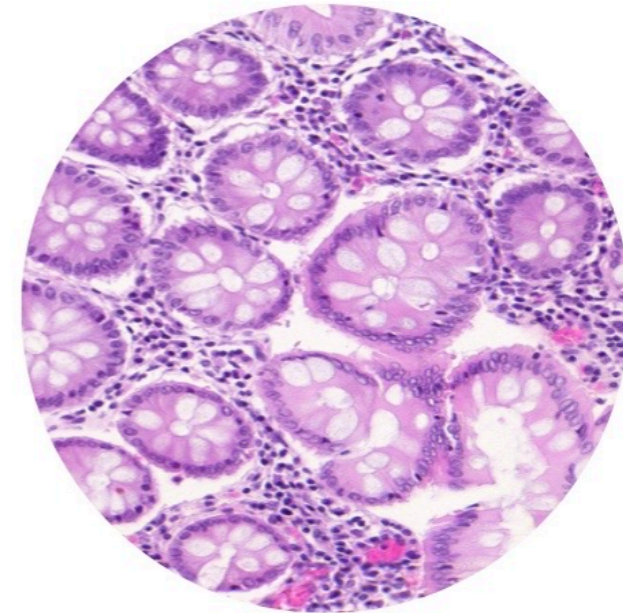
90° rotation



180° rotation

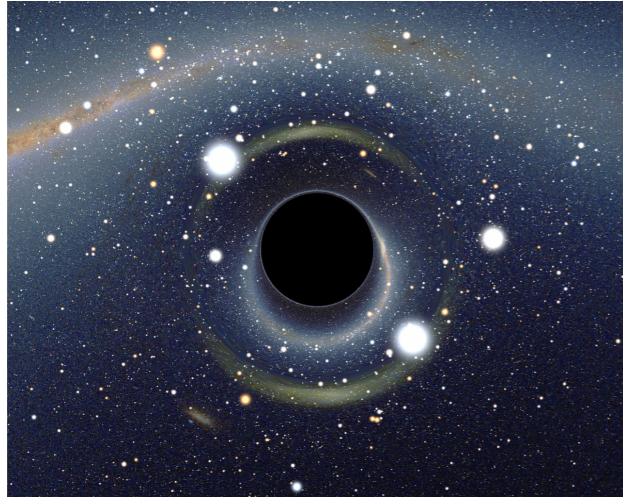


225° rotation

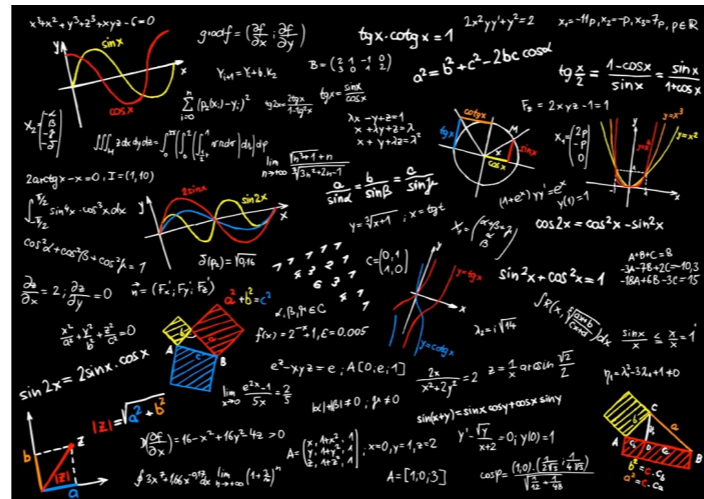
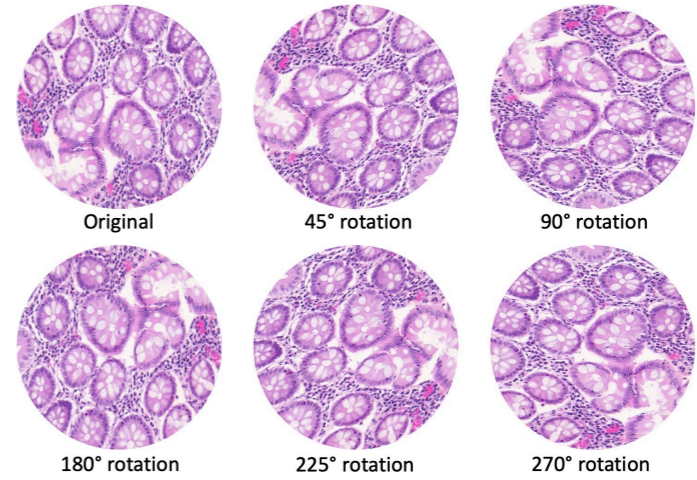


270° rotation

# Fysik



# AI



# Matematik





**TACK!**