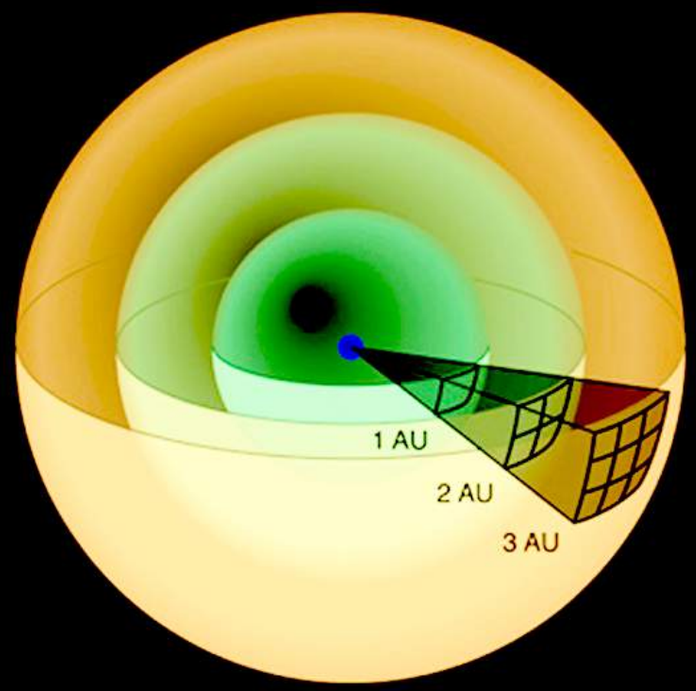
VIVA FYSICA
AMSTERDAM
27 januari 2017

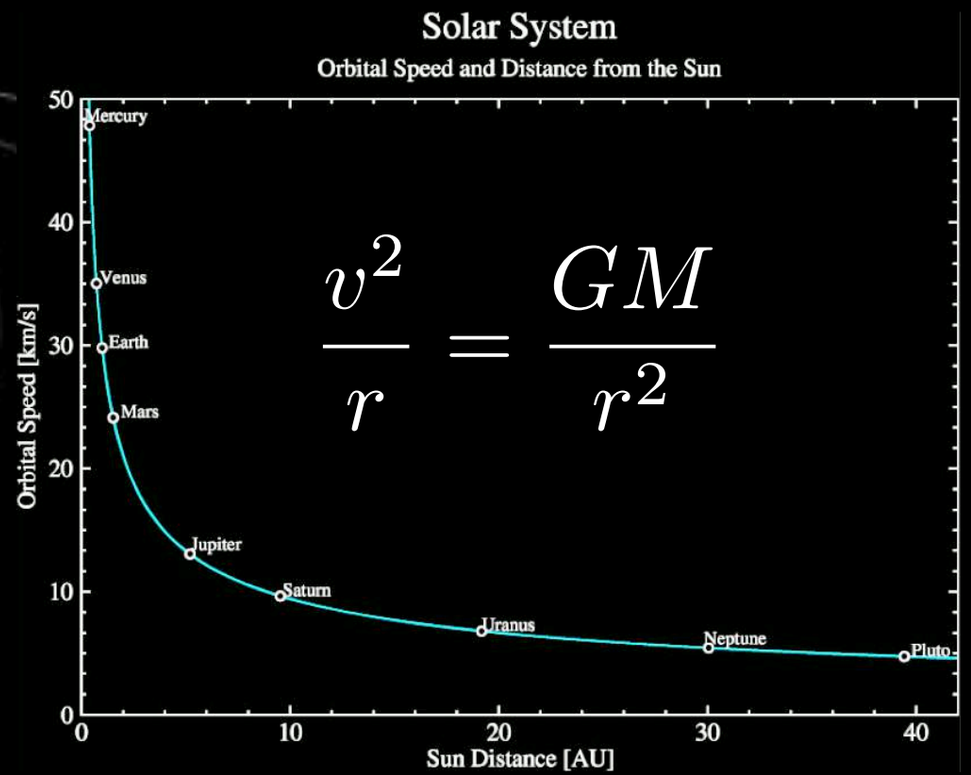
EMERGENTE ZWAARTEKRACHT
EN HET DONKERE HEELAL

Erik Verlinde

Newton's wet van de zwaartekracht

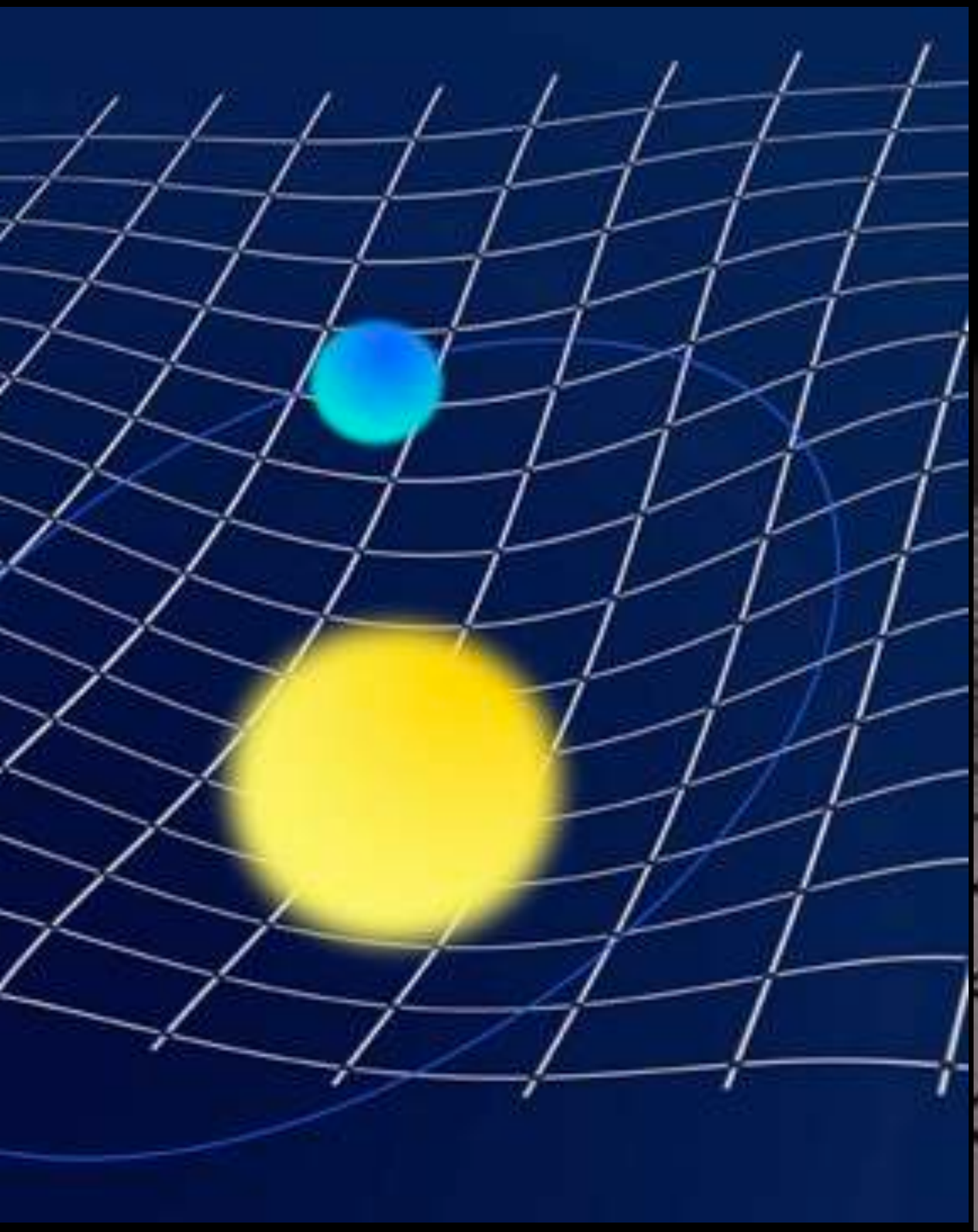
$$F = \frac{GMm}{r^2}$$

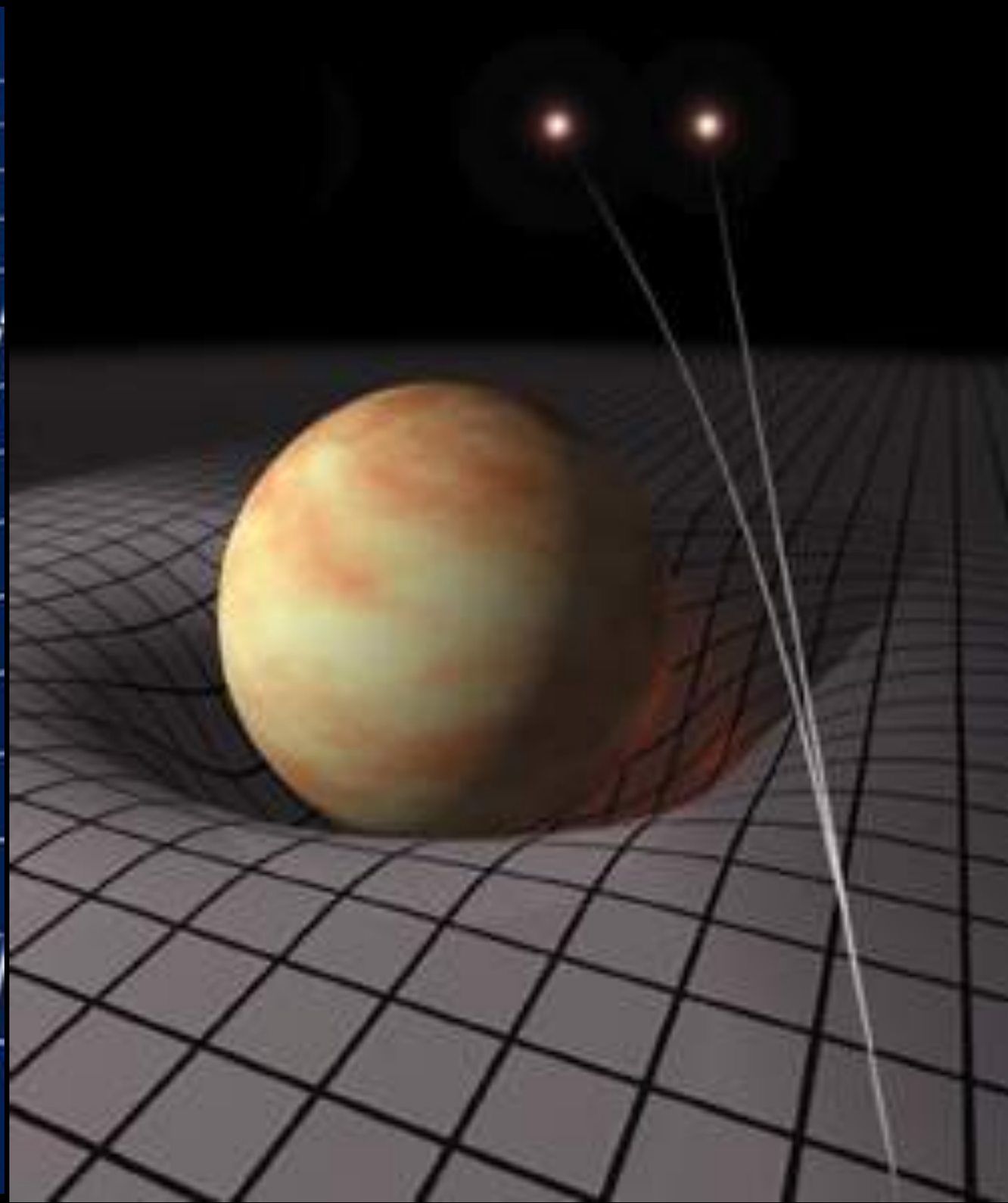




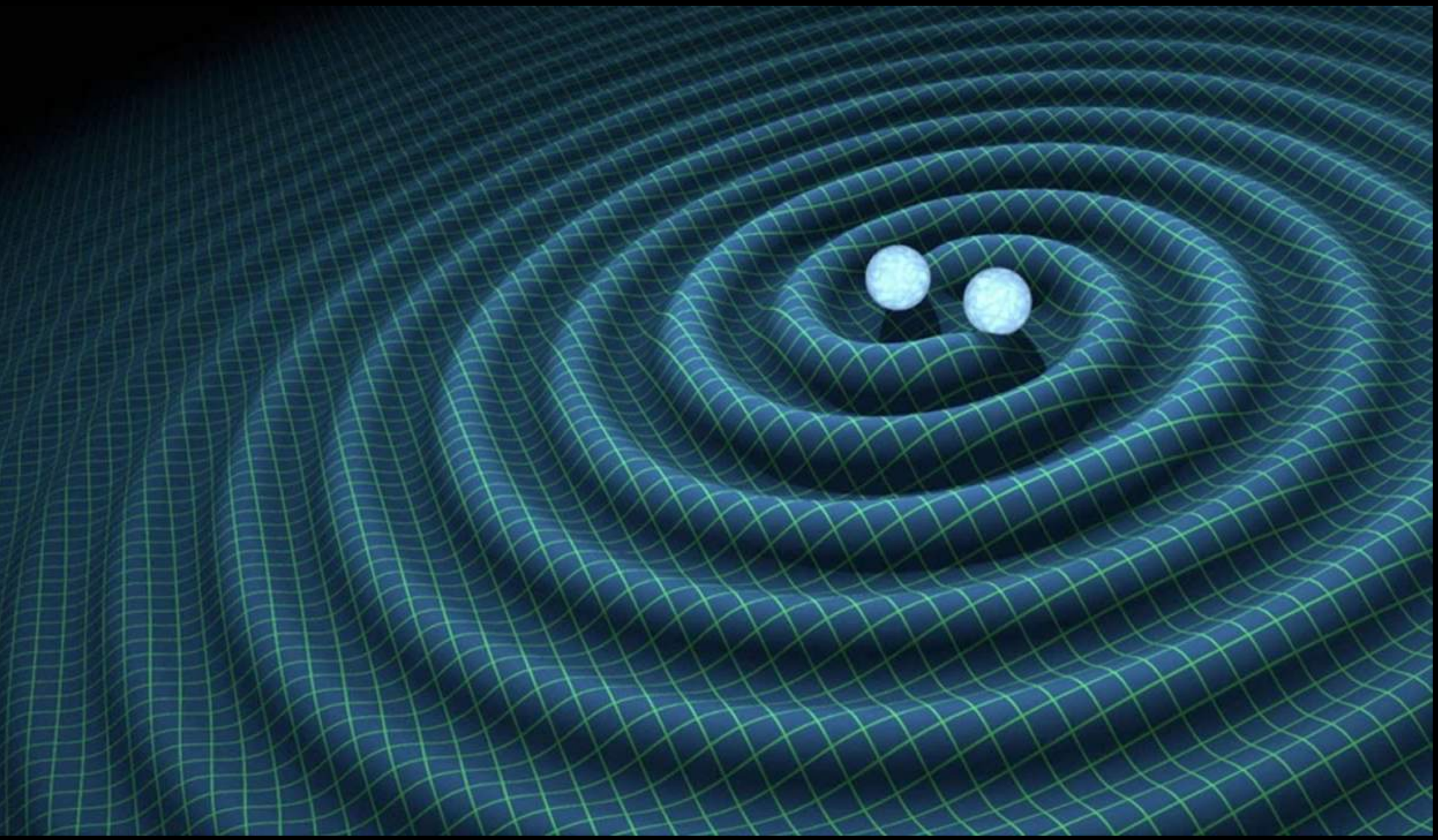
$$\frac{v^2}{r} = \frac{GM}{r^2}$$

Einstein's Algemene Relativiteitstheorie

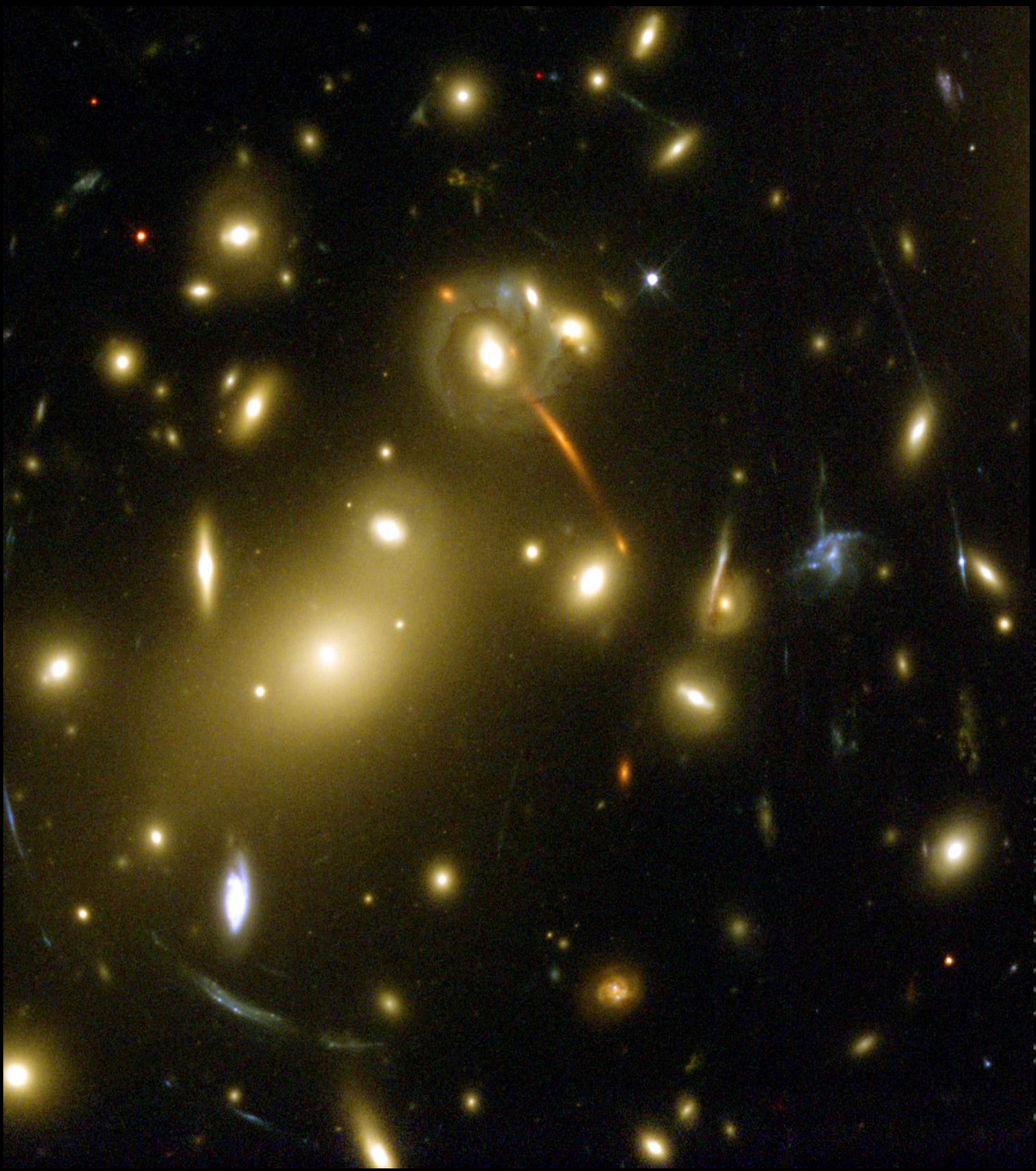


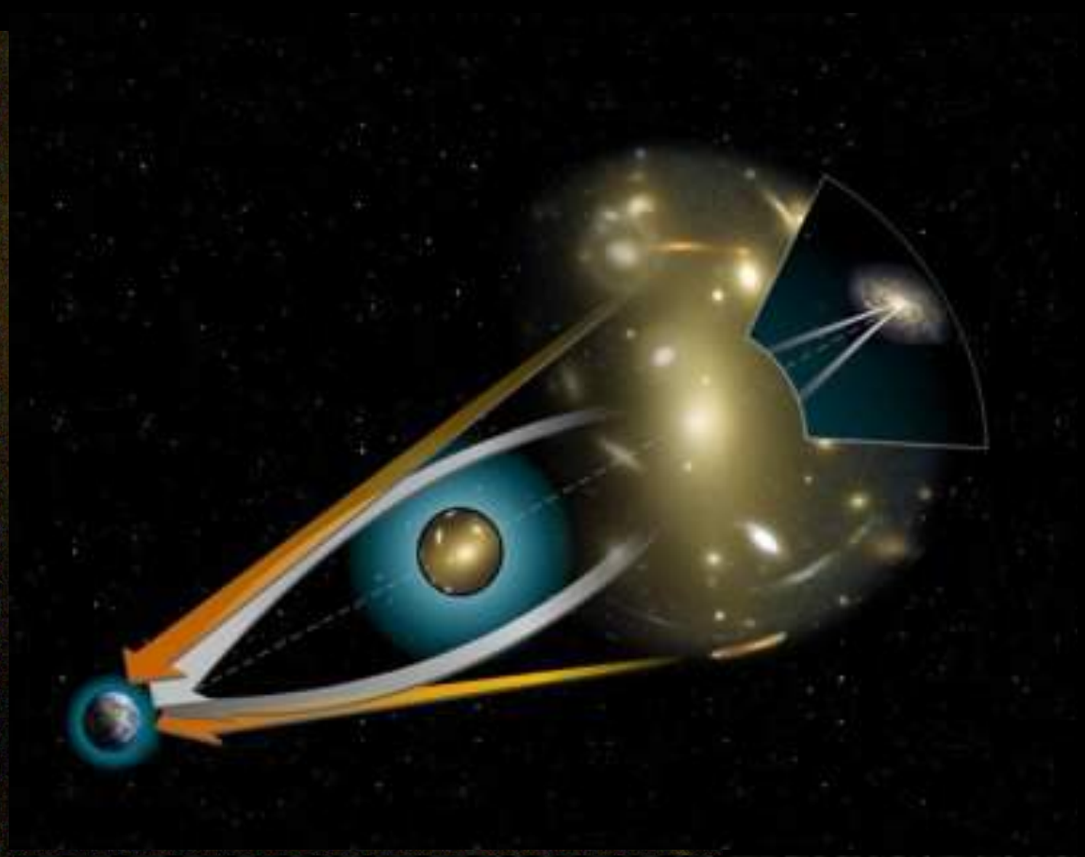


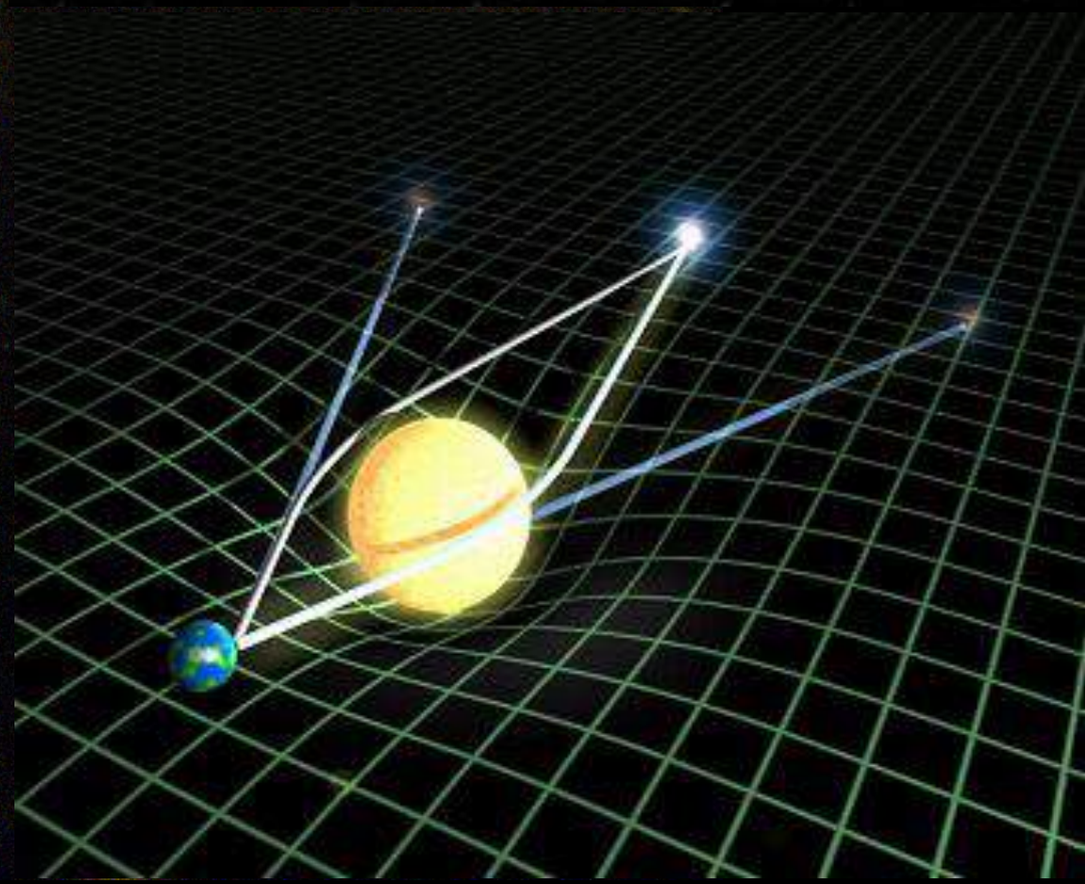
Zwaartekrachtsgolven



Zwaartekracht-lens

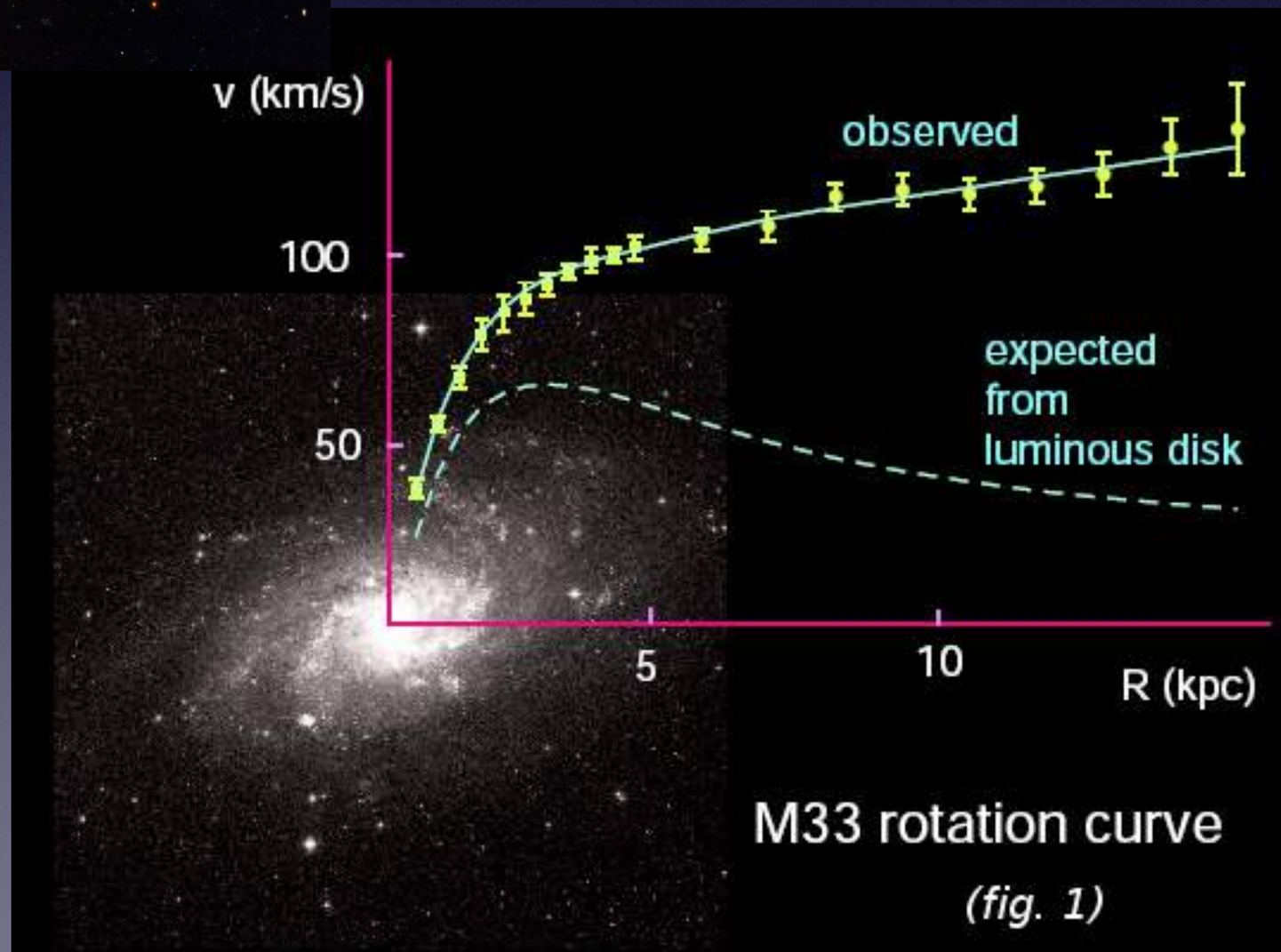


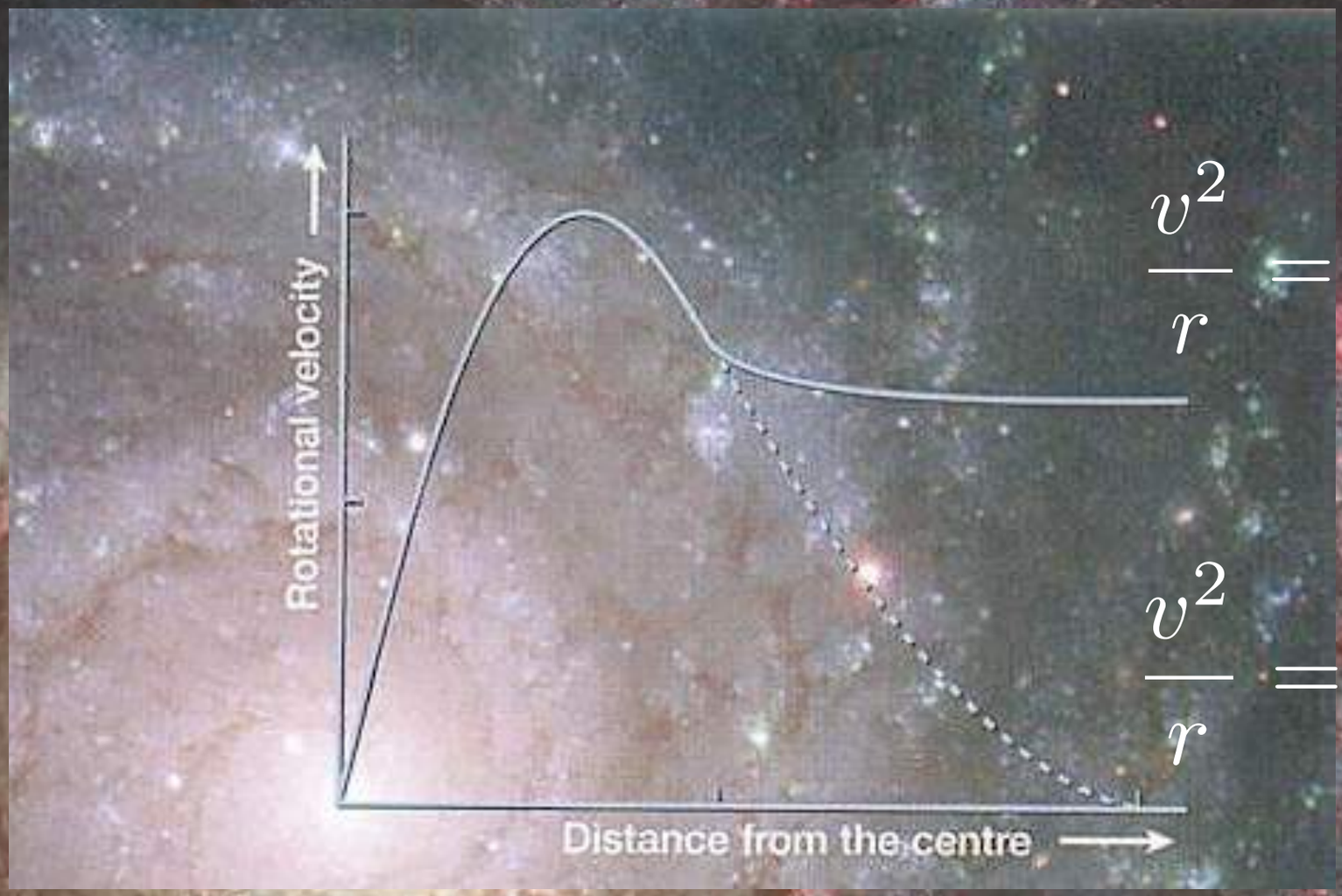




Rotatiekromme van sterrenstelsel

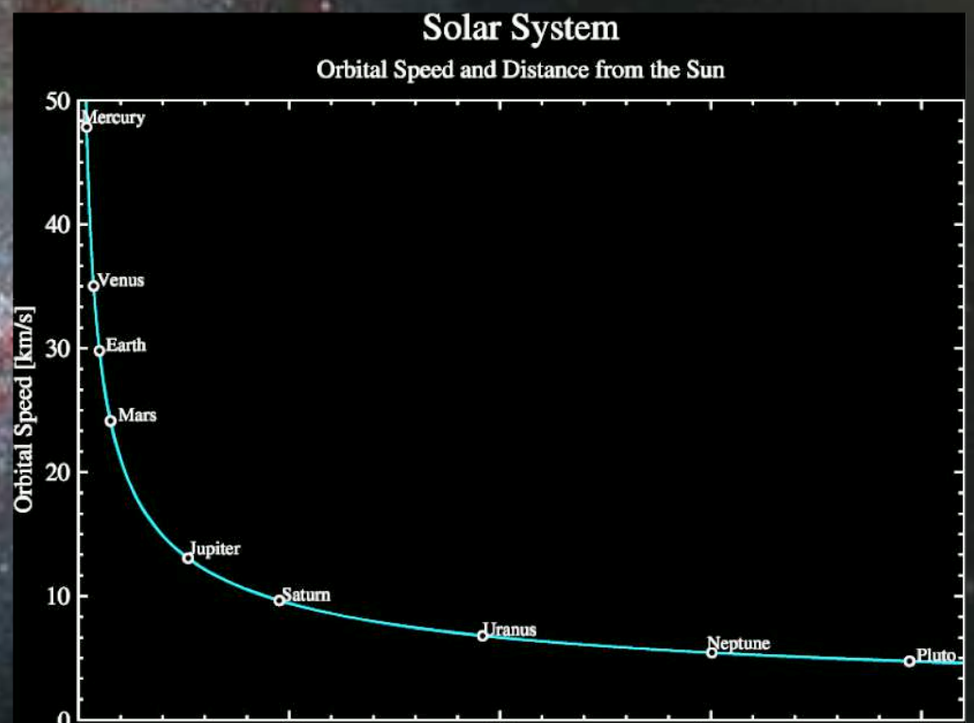
Afwijking van wetten van Newton en Einstein





$$\frac{v^2}{r} = \frac{GM_B}{r^2} + \frac{GM_D}{r^2}$$

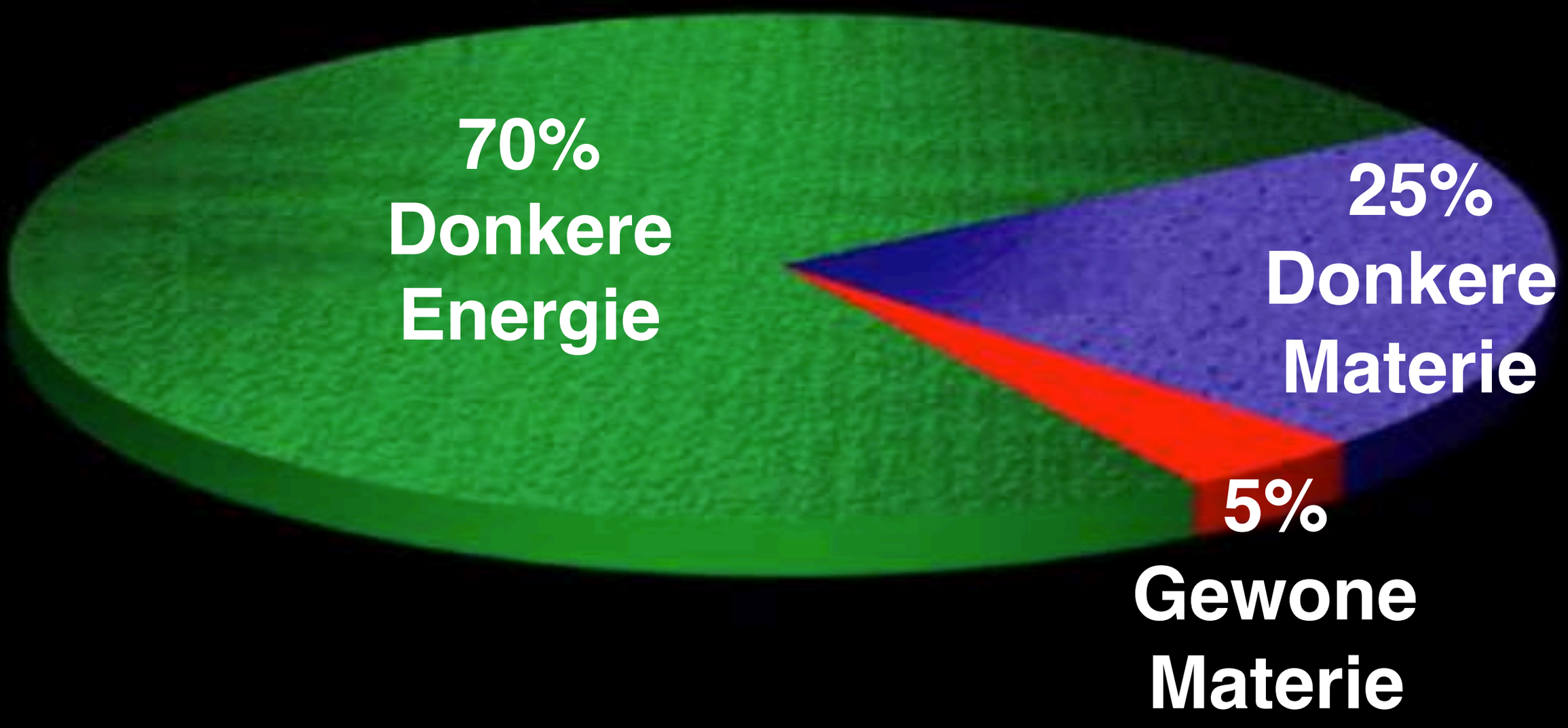
$$\frac{v^2}{r} = \frac{GM_B}{r^2}$$



Donkere materie: onzichtbare deeltjes

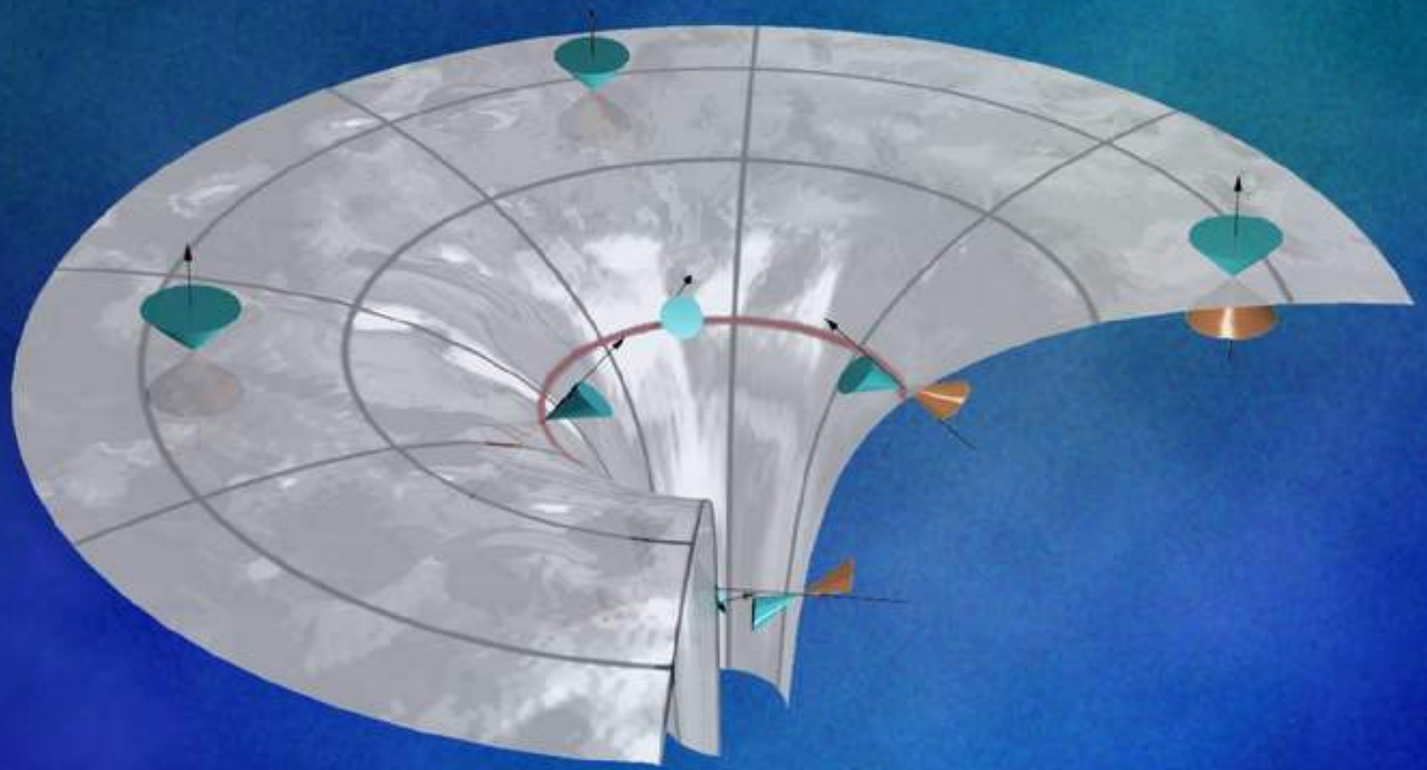
Of is er een andere verklaring?

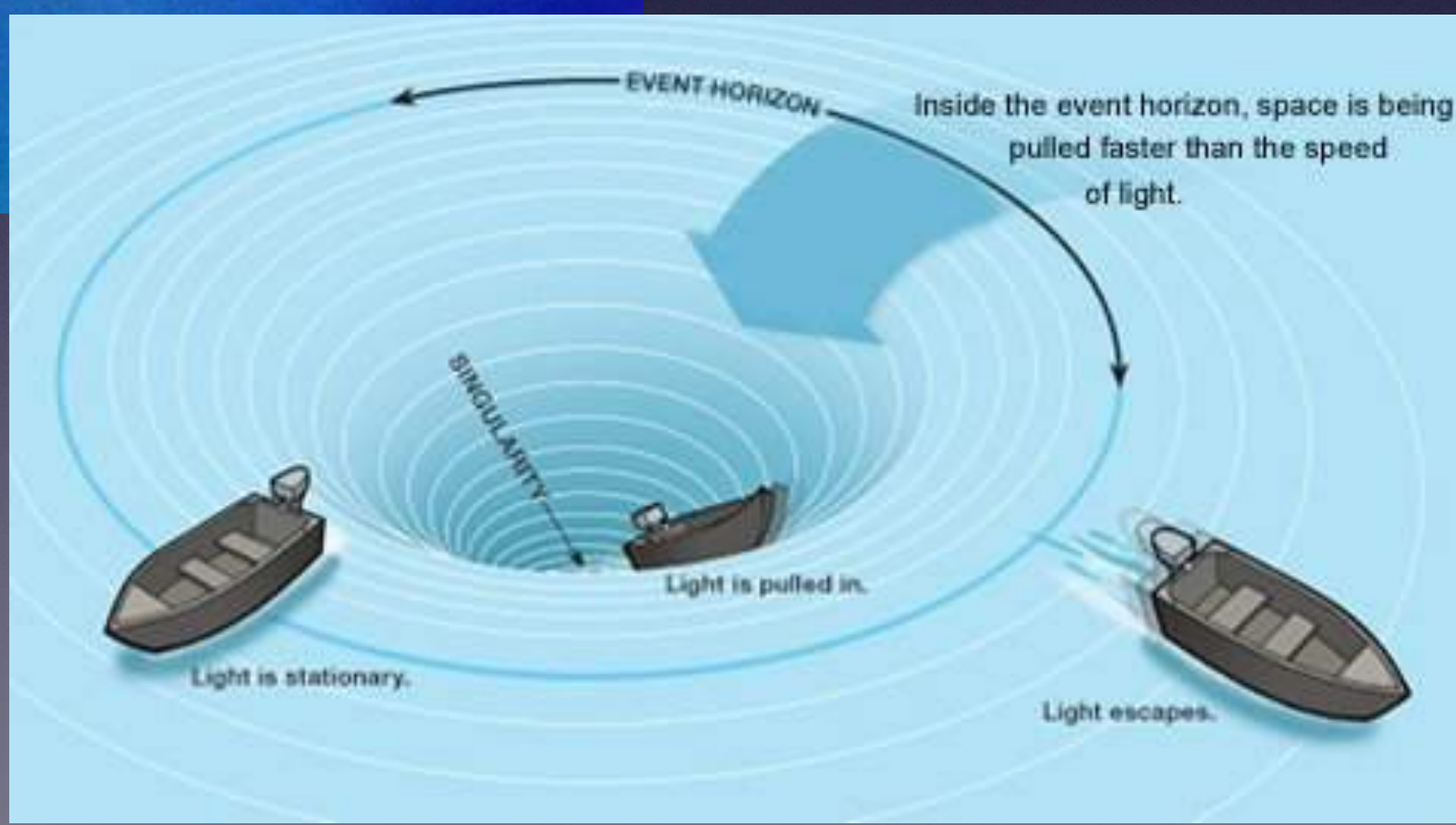
Samenstelling van het universum



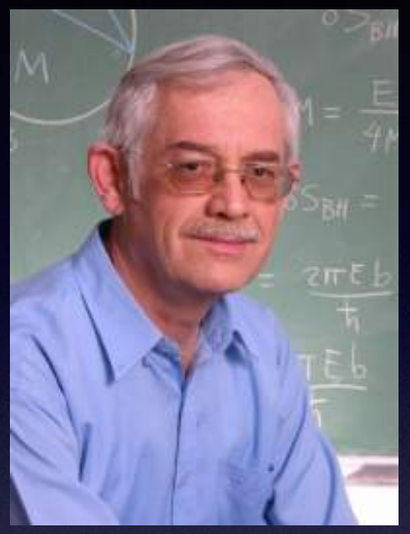
95% = donkere universum

Zwarte gaten

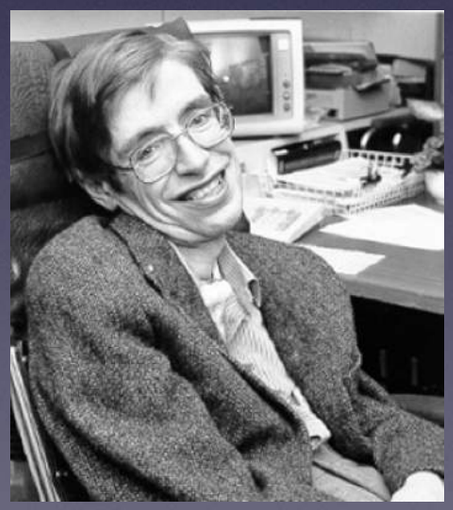



EVENT HORIZON
Inside the event horizon, space is being pulled faster than the speed of light.
SINGULARITY
Light is pulled in.
Light is stationary.
Light escapes.

Zwarte gaten verbergen informatie.



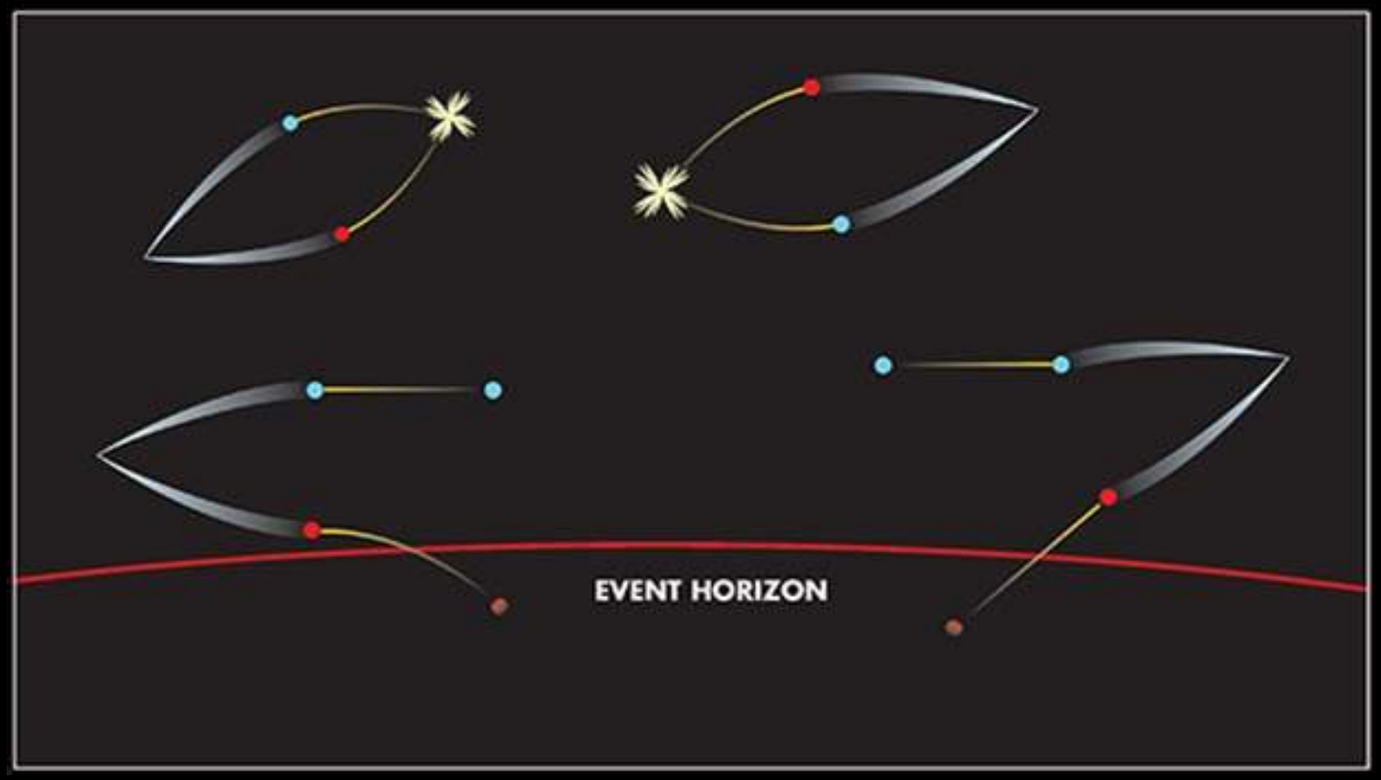
Bekenstein



Hawking

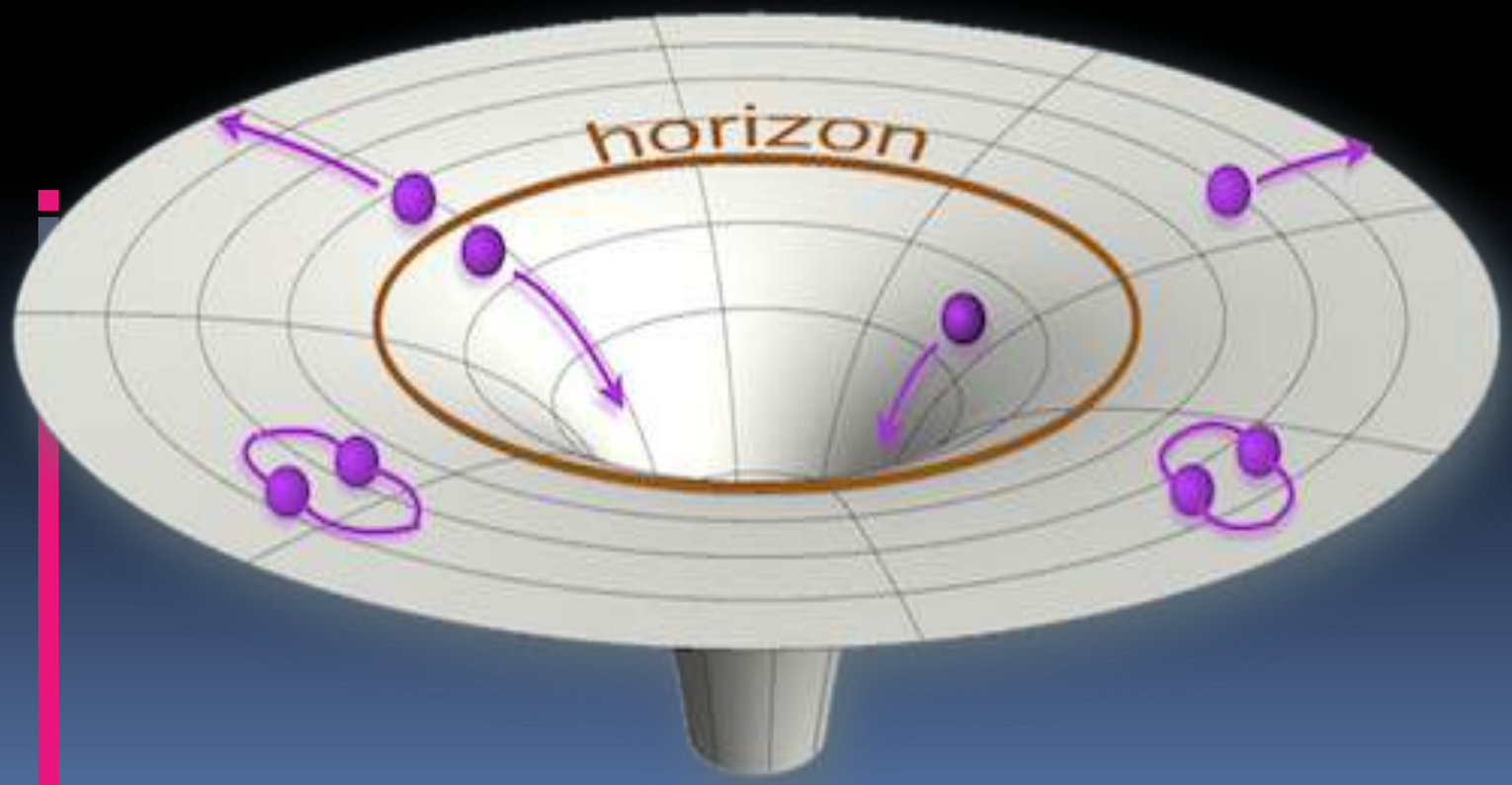
Oppervlak van horizon bepaalt
de hoeveelheid verborgen informatie

Zwarte gaten zenden warmtestraling uit

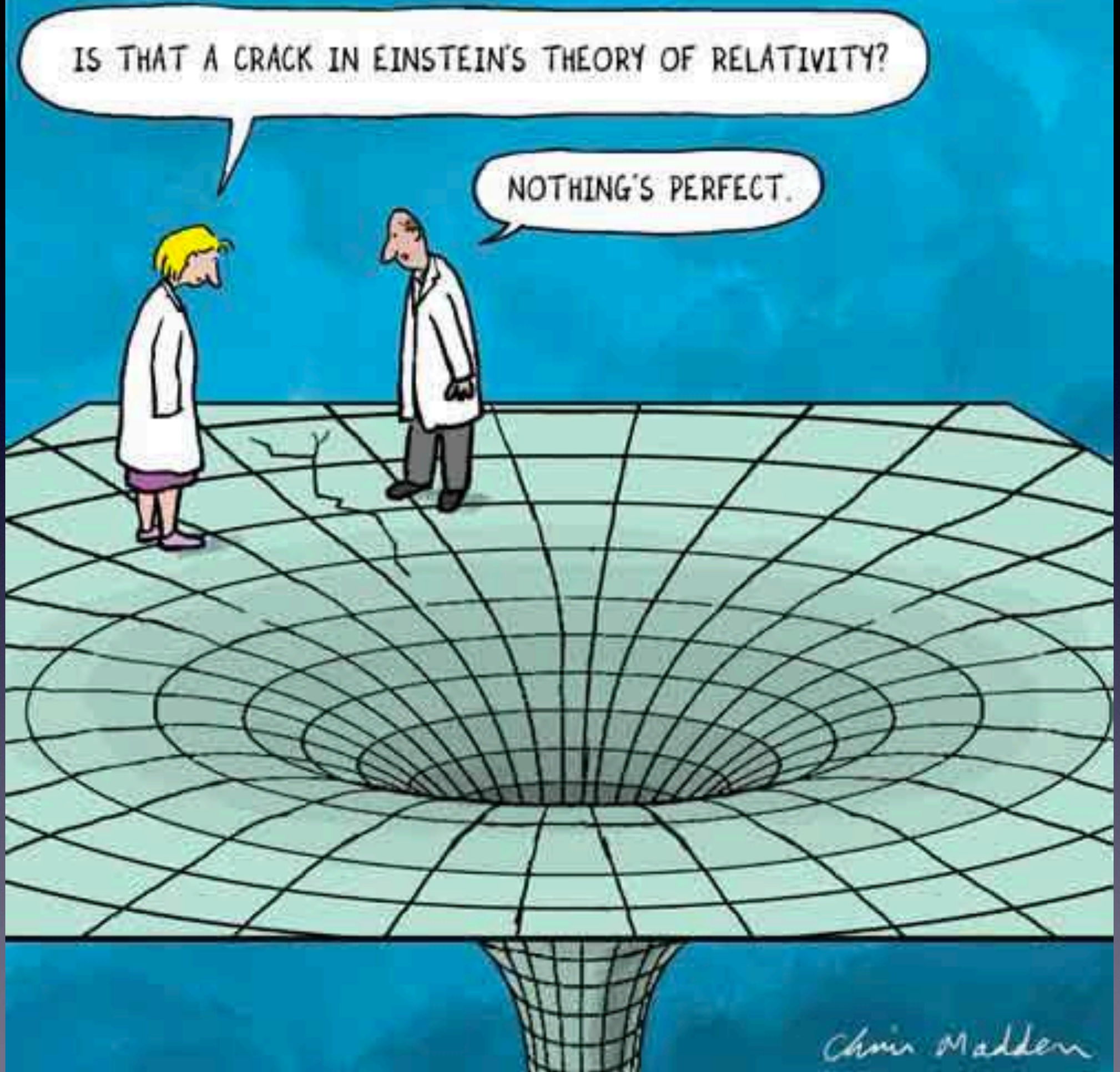


Hawking temperatuur

$$T = \frac{1}{2\pi} \frac{\hbar g}{k_B c}$$



$$g = \frac{GM}{R^2}$$

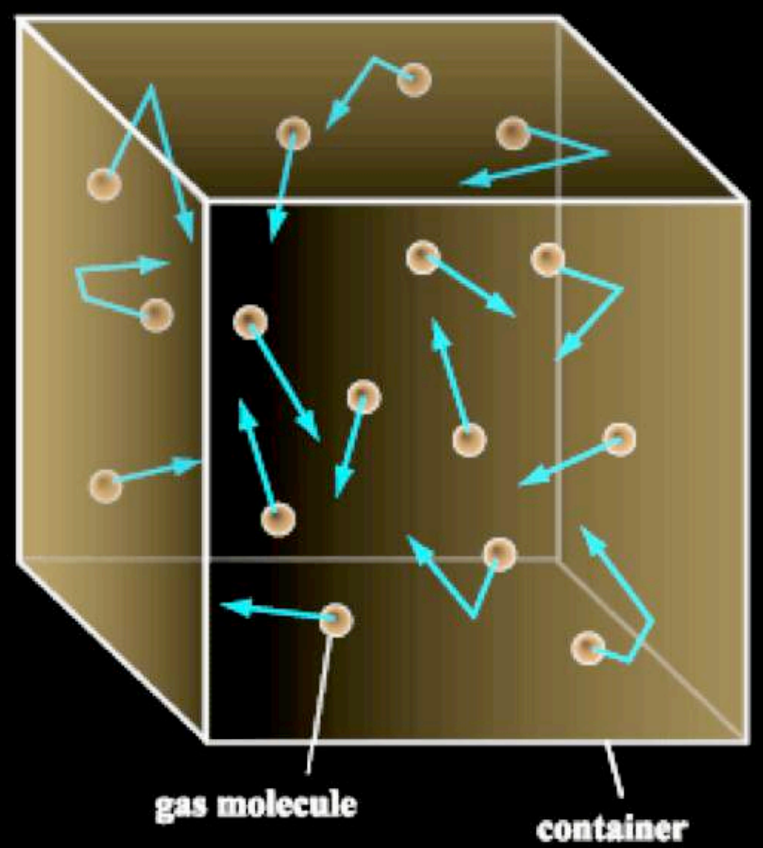

IS THAT A CRACK IN EINSTEIN'S THEORY OF RELATIVITY?
NOTHING'S PERFECT.
Chris Madden

EMERGENTIE

Als mens nemen we verschijnselen waar en gebruiken begrippen op macroscopische schaal.

Voorbeeld: temperatuur

Maar deze begrippen zijn afgeleid uit een microscopisch wereld waarin deze geen betekenis hebben.



Emergente Zwaartekracht

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Zwaartekracht komt te voorschijn uit informatie.

JHEP

PUBLISHED FOR SISSA BY SPRINGER

RECEIVED: *October 22, 2010*
ACCEPTED: *March 19, 2011*
PUBLISHED: *April 7, 2011*

On the origin of gravity and the laws of Newton

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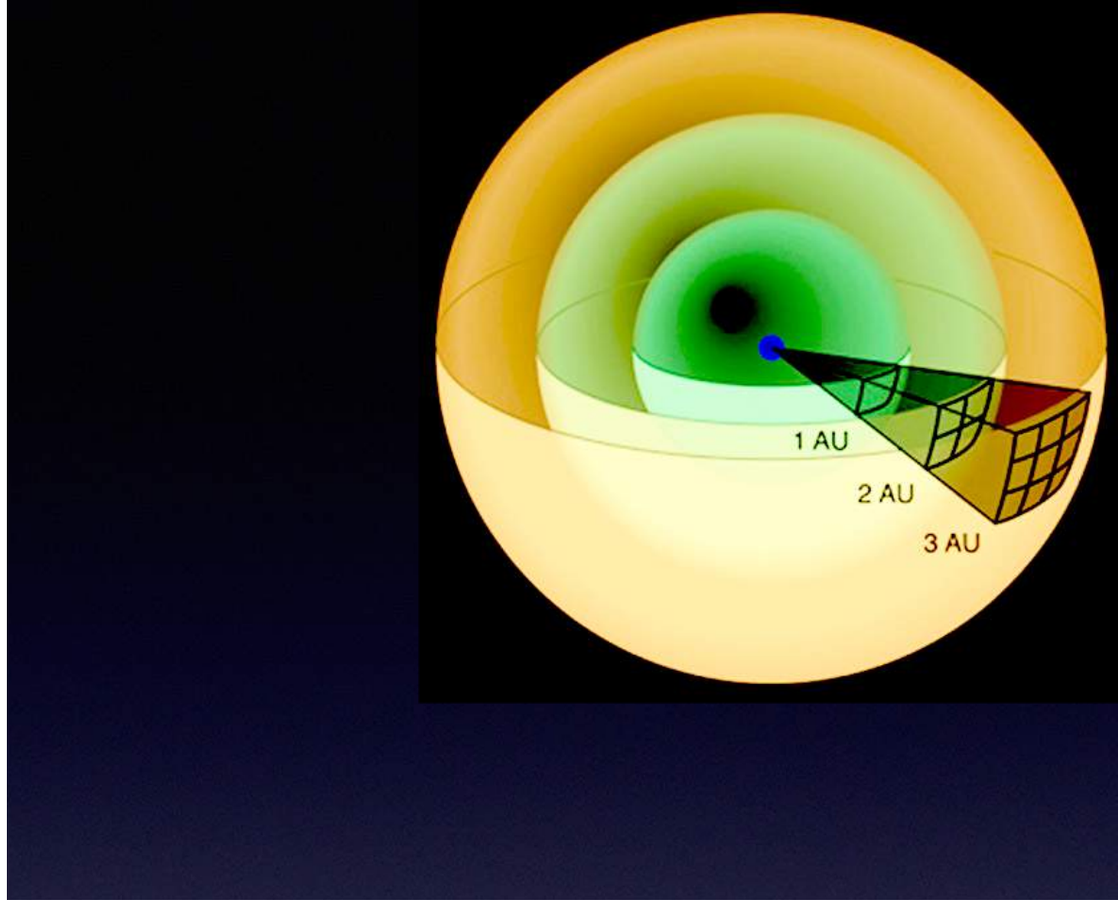
ABSTRACT: Starting from first principles and general assumptic
argument that shows that Newton's law of gravitation naturally a
space emerges through a holographic scenario. Gravity is identifi
caused by changes in the information associated with the positic
relativistic generalization of the presented arguments directly le
tions. When space is emergent even Newton's law of inertia ne
equivalence principle auggests that it is actually the law of inertia



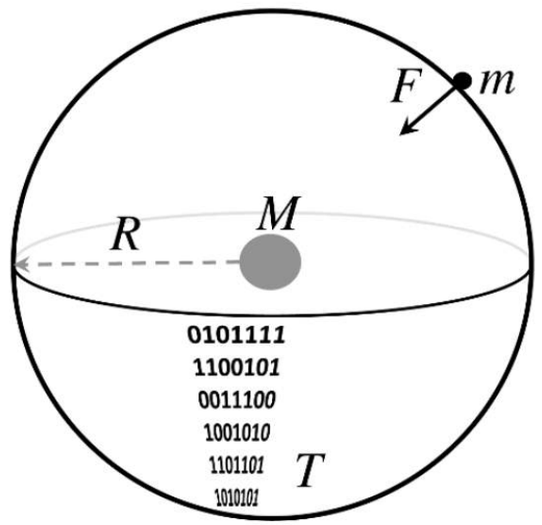


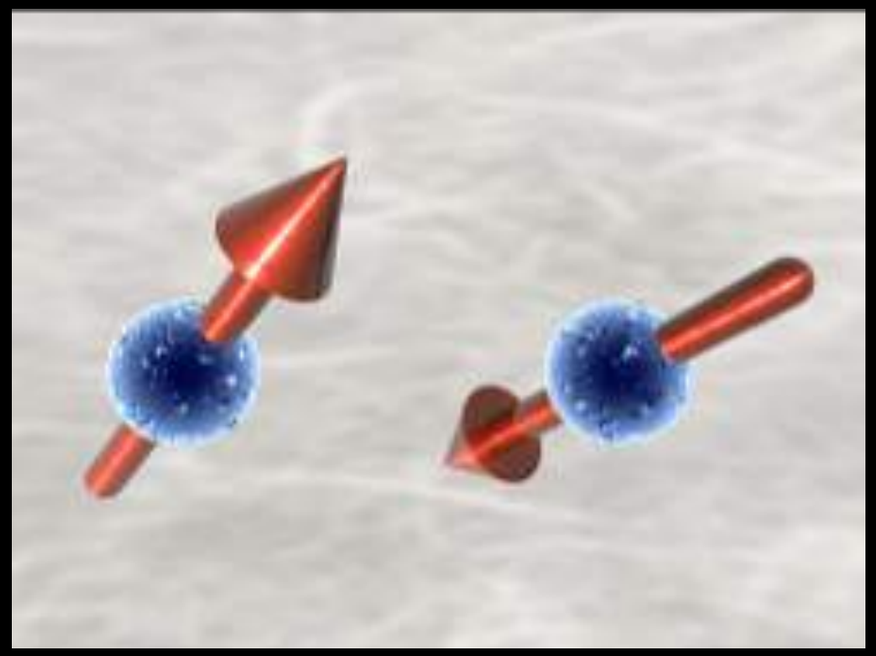
Figure 3. A particle with mass m near a spherical holographic screen. The energy is evenly distributed over the occupied bits, and is equivalent to the mass M that would emerge in the part of space surrounded by the screen.

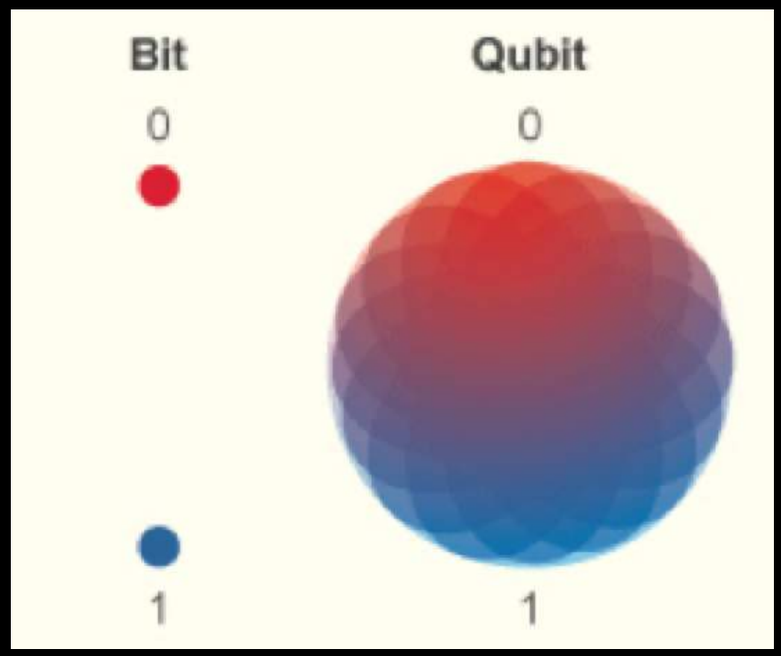
and one obtains the familiar law:

$$F = G\frac{Mm}{R^2}. \tag{3.9}$$

We have recovered Newton's law of gravitation, practically from first principles!

Quantum-informatie

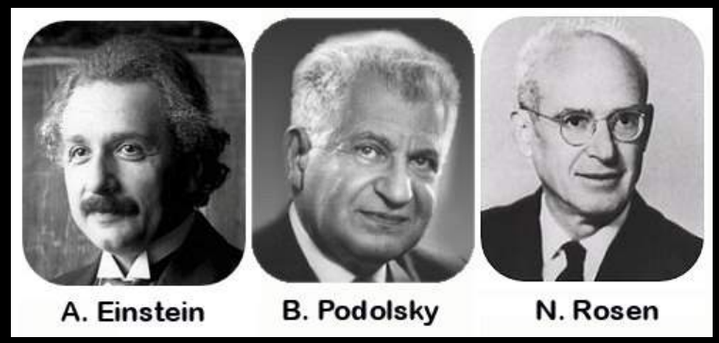




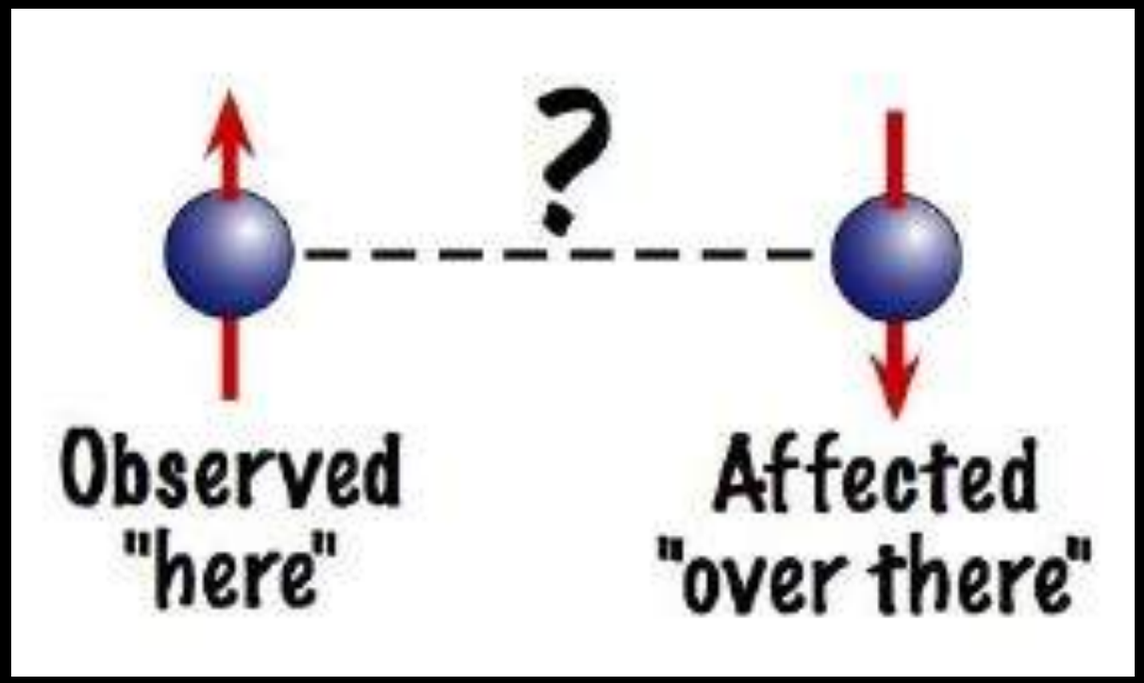
Qubits: superpositie van 0 en 1

$$\alpha|0\rangle + \beta|1\rangle$$

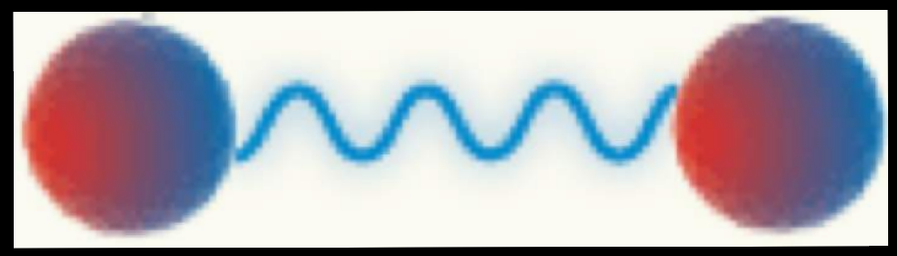
Quantumverstrengeling.



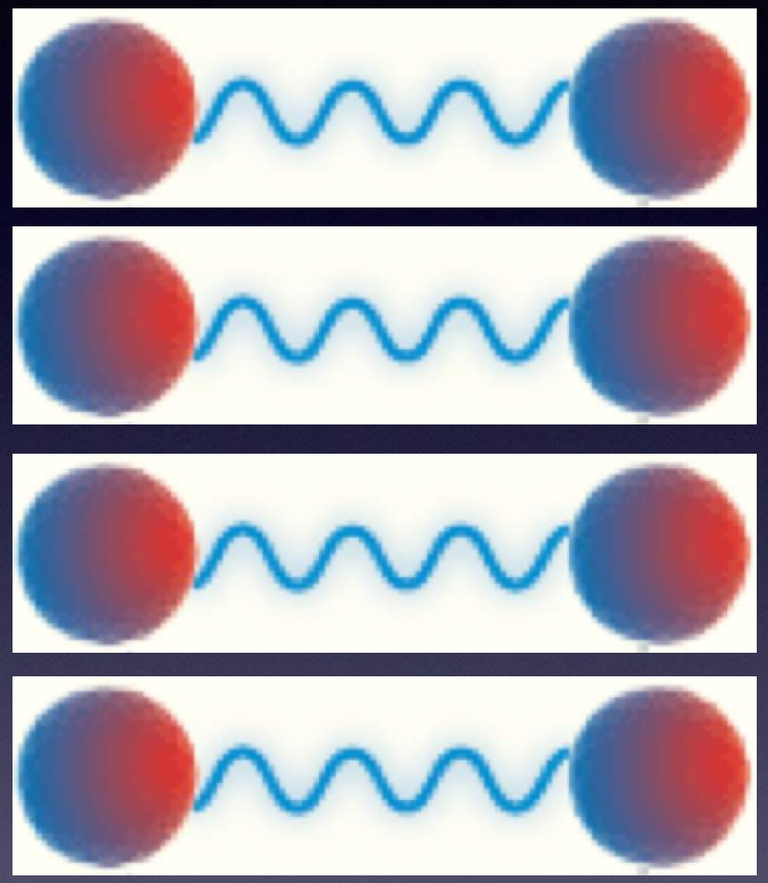
At the instant at which the left-hand electron is observed, the state of the right-hand electron is determined.



Verstrengelde qubits zijn niet onafhankelijk

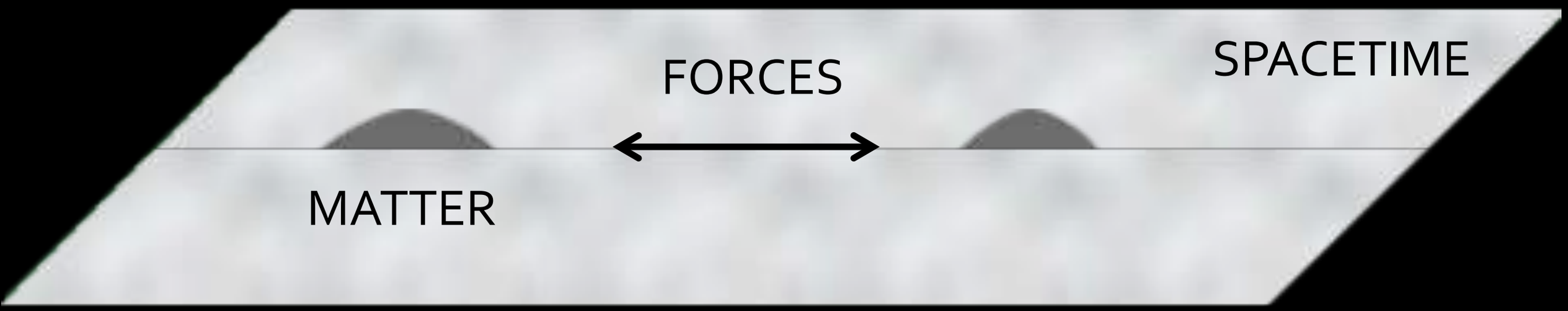


Bouwstenen van de ruimte-tijd
= Verstrengelde qubits



Zwaartekracht komt te voorschijn door verandering van de hoeveelheid verstrengelde quantuminformatie

EMERGENT



DARK
MATTER

DARK
ENERGY

EMERGENT

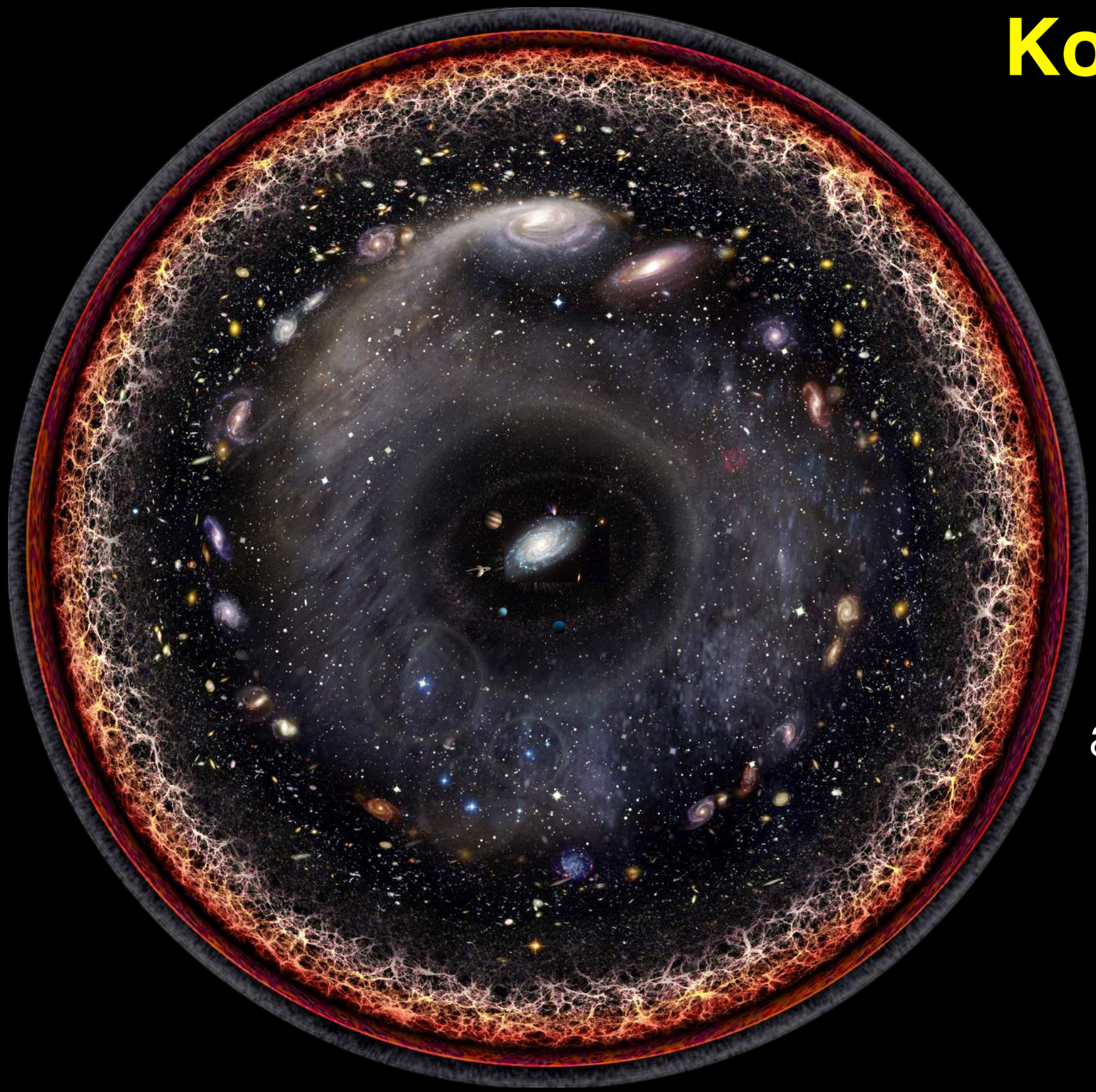
SPACETIME

FORCES

MATTER

DARK
MATTER

DARK
ENERGY



Kosmologische Horizon

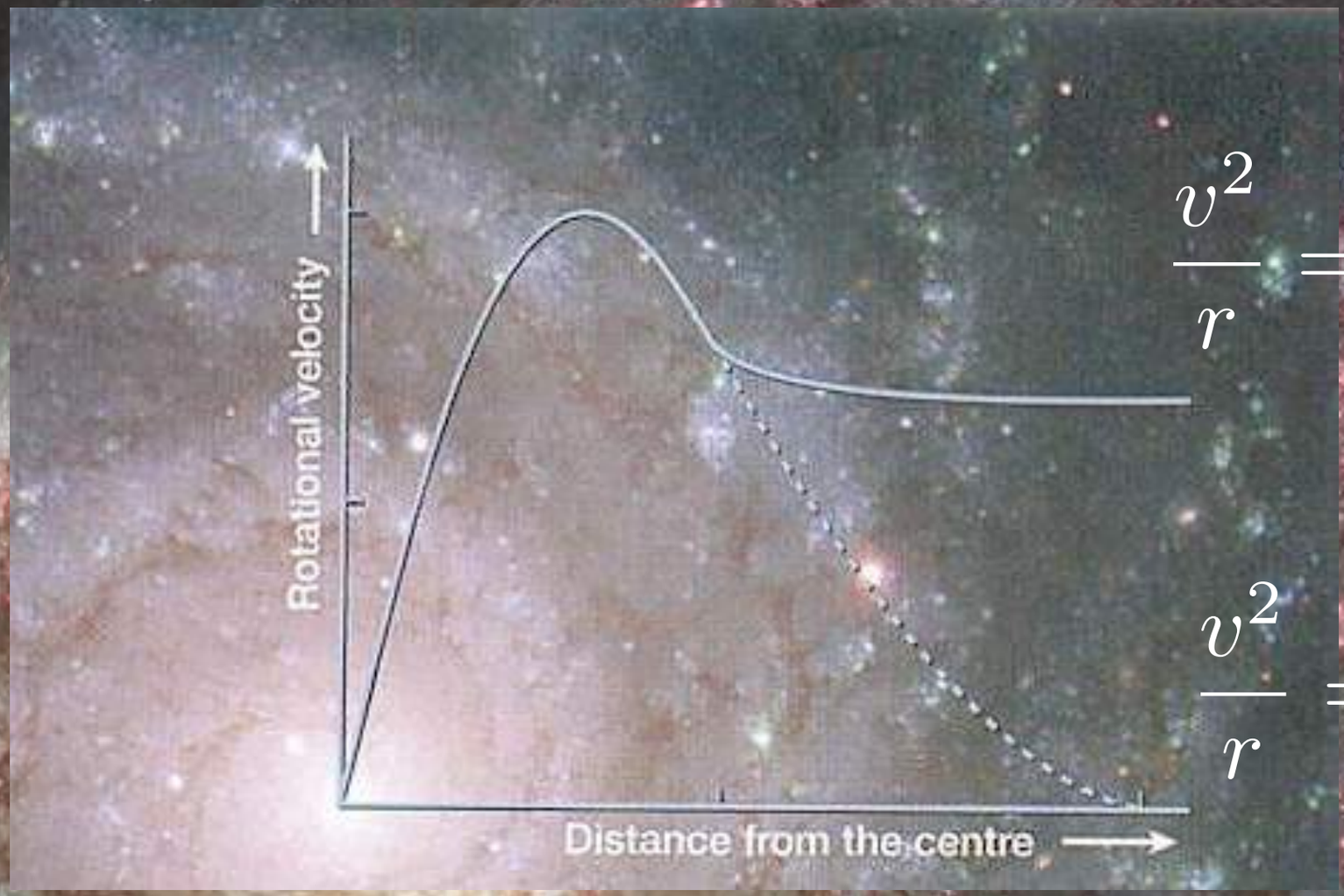
wet van Hubble

$$v = H_0 d$$

afstand tot de horizon

$$d_{hor} = \frac{c}{H_0}$$

$H_0 =$ Hubble constante

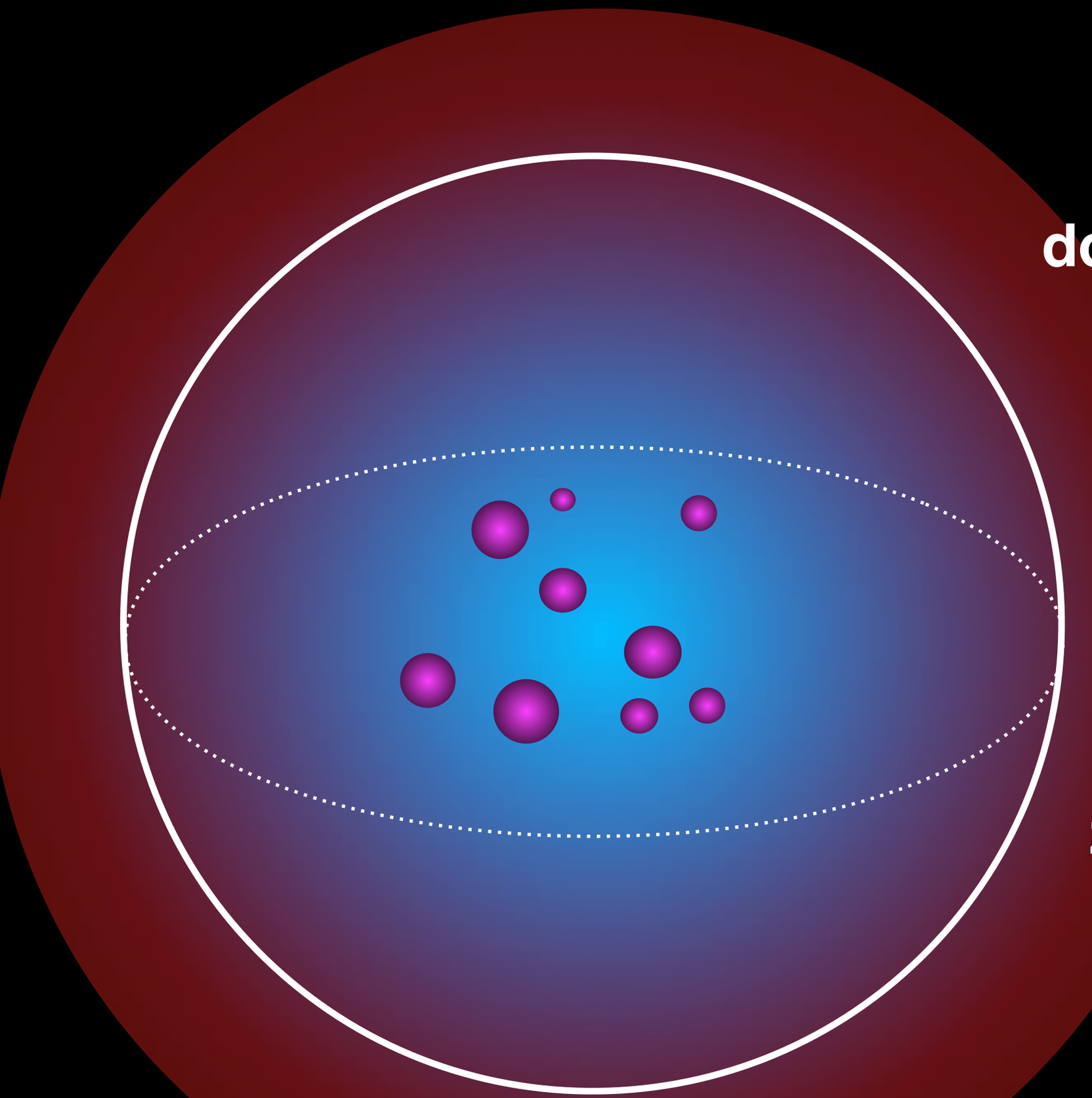


$$\frac{v^2}{r} = \frac{GM_B}{r^2} + \frac{GM_D}{r^2}$$

$$\frac{v^2}{r} = \frac{GM_B}{r^2}$$

Donkere Materie is alleen nodig bij een heel lage zwaartekracht-versnelling

$$\frac{GM_B}{r^2} < \frac{cH_0}{2}$$

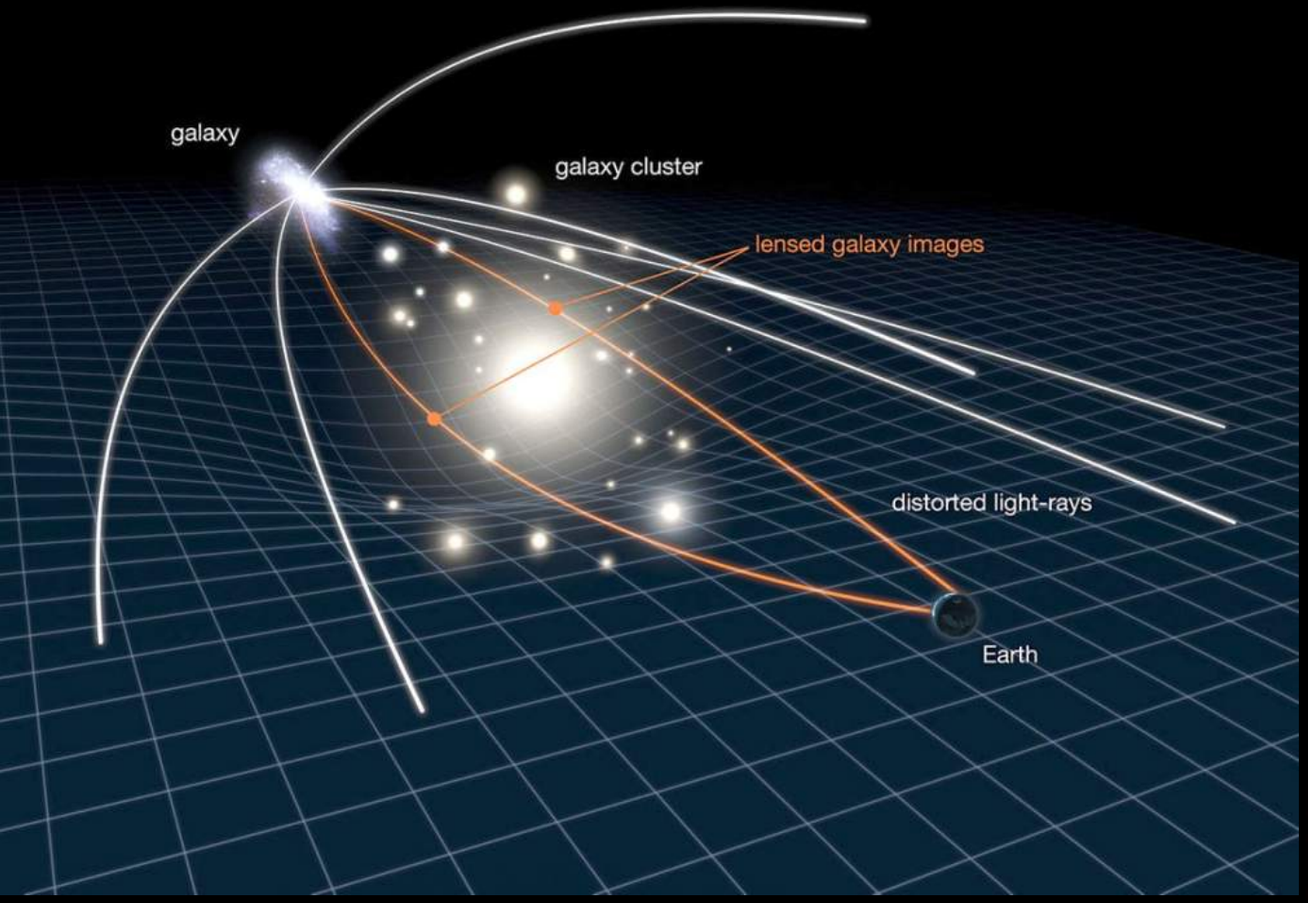


Materie verwijdert informatie en duwt donkere energie weg

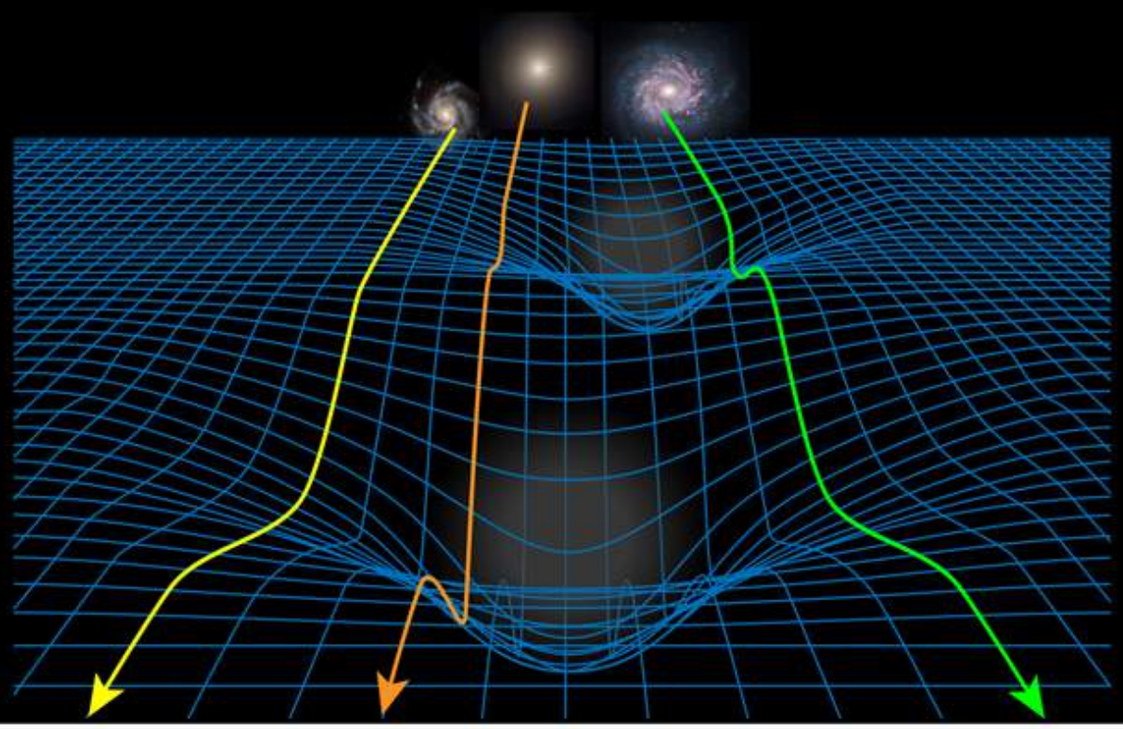
De donkere energie duwt terug en veroorzaakt een extra kracht .

Deze lijkt op de zwaartekracht door donkere materie.

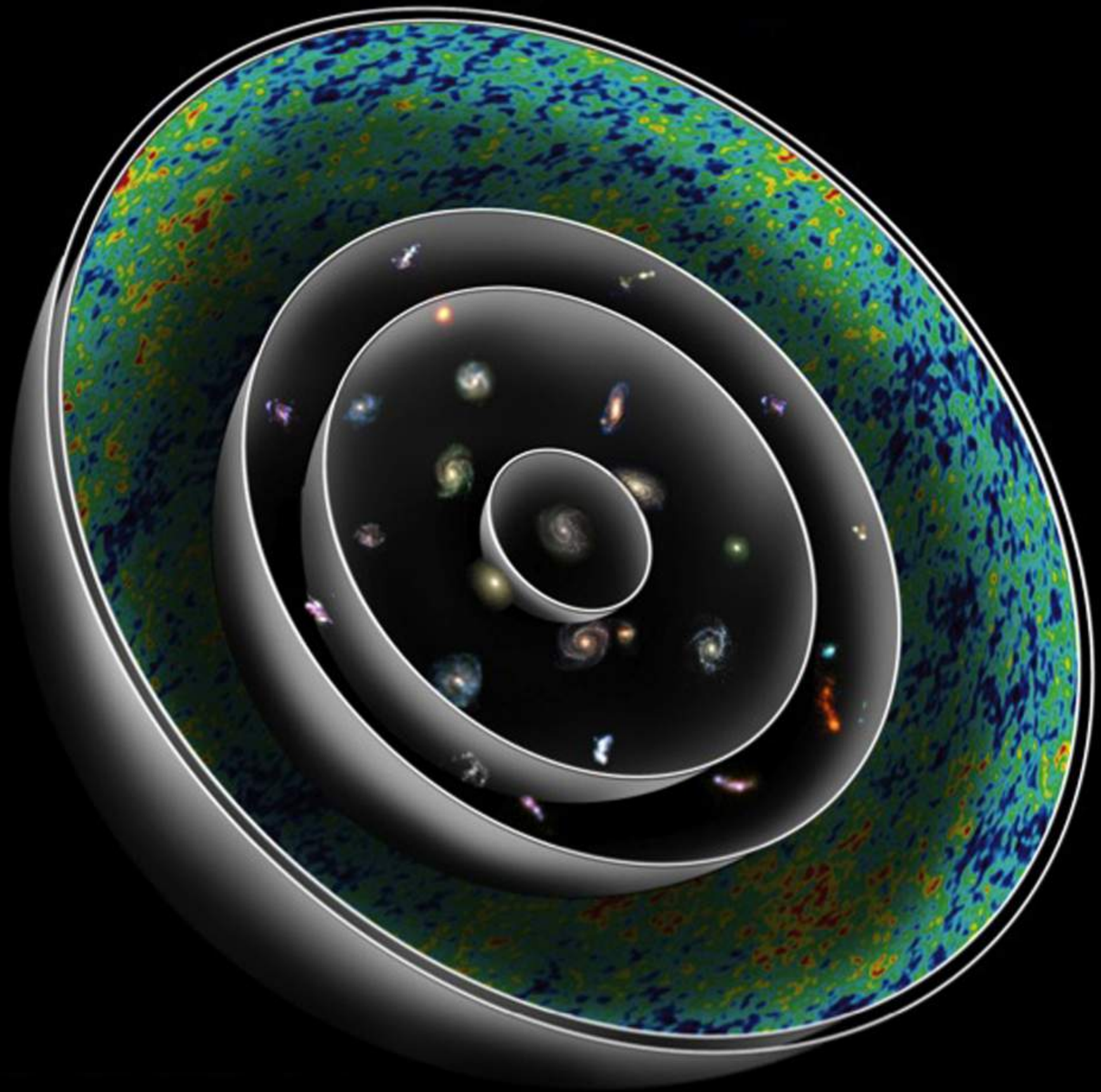
Donkere materie bestaat niet!

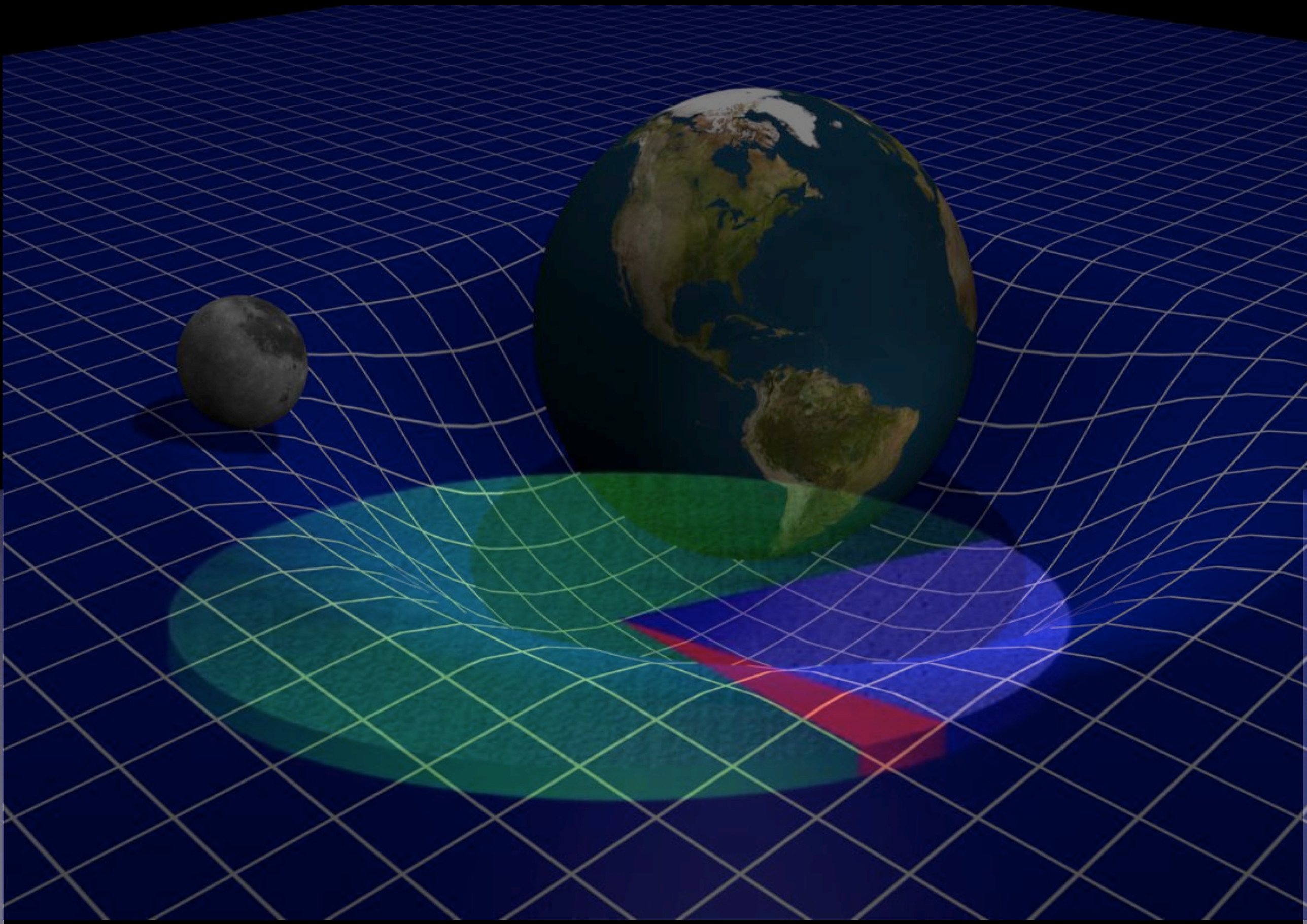


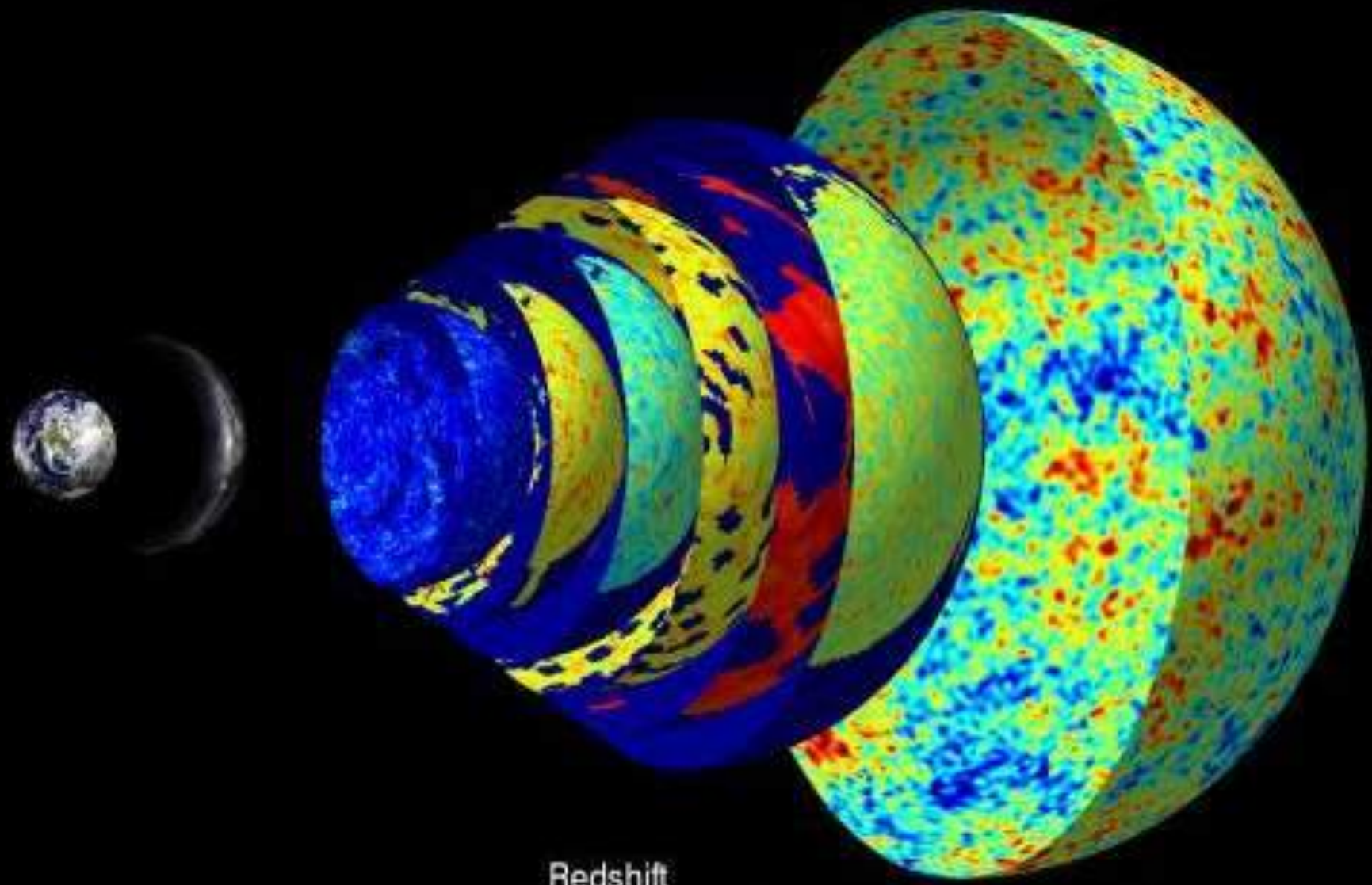
Sterk Lens-effect: beeld-verdubbeling



Zwak Lens-effect: beeld-vervorming






Redshift
0
0.1
0.5
1
2
1100
0
1.3
6
11
17
46
Distance (billions light-years)

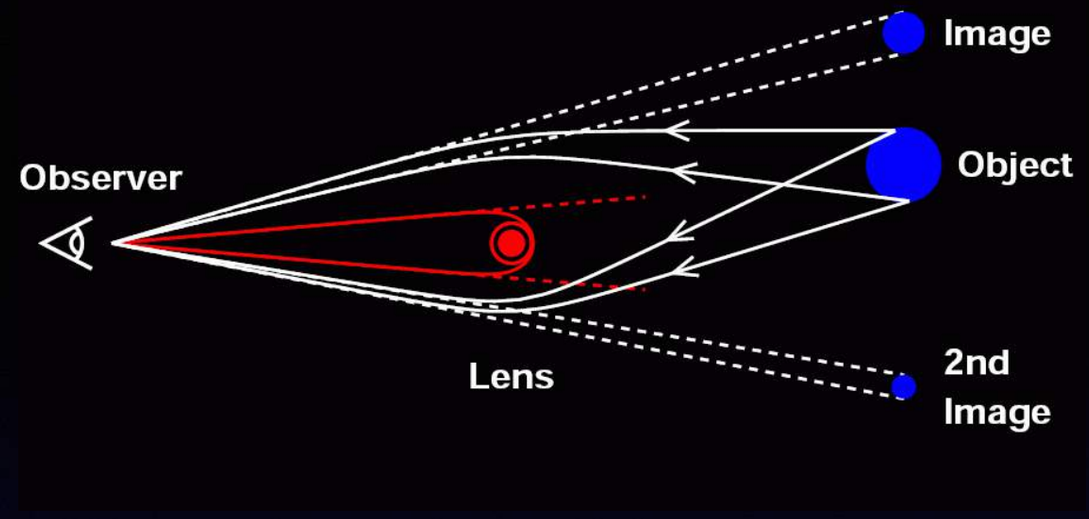
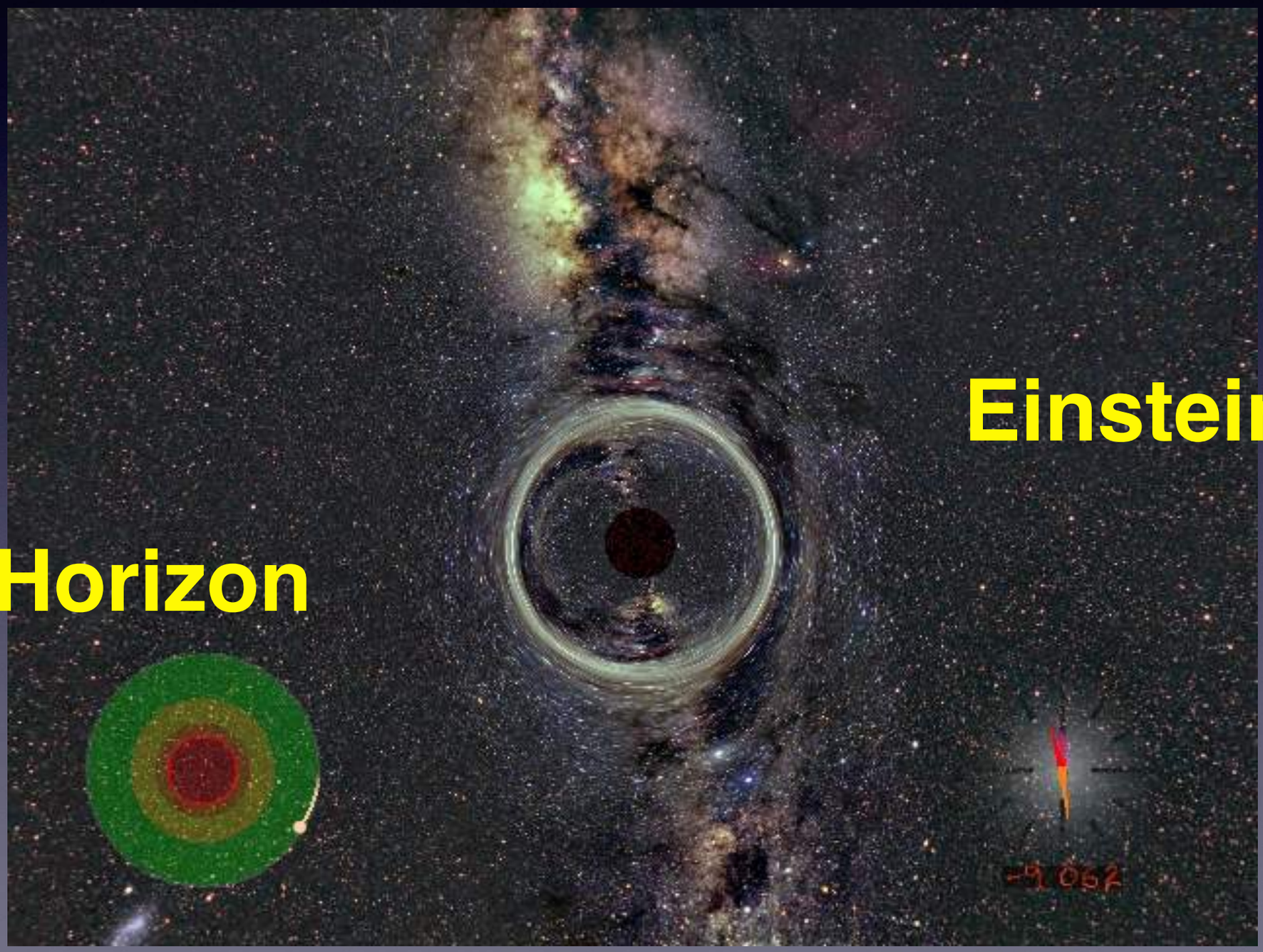


Image
Object
Observer
Lens
2nd
Image


Einstein-ring
Horizon