

Theoretical Cosmology

Outline:

Observations:

- Trigonometry
- Parallax
- Optics
- Doppler
- Redshift
- Advanced methods

Theory:

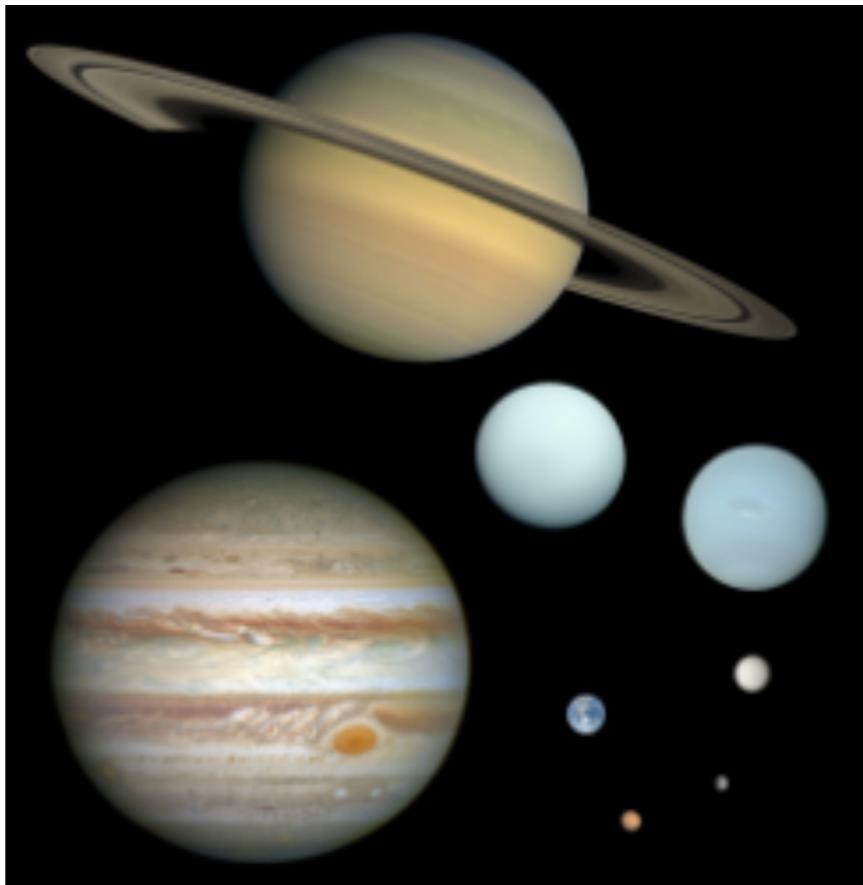
- Philosophy
- Mathematics
- Physics
- Current picture
- Components
- Baryon Acoustic Oscillations

Stellar objects:

- Planets
- Stars
- Galaxies
- Supernovae
- Quasars
- Black holes
- Hawking radiation
- Actionic field-particles

Hosted by Dr. Pierros Ntelis

Planet



10^6 m

A planet (*Πλανήτης, Wonderer*) is a celestial body which:

- (a) is in orbit around the Sun,
- (b) has sufficient mass for its self-gravity to overcome rigid body forces so that it assumes a hydrostatic equilibrium (nearly round) shape, and
- (c) has cleared the neighborhood around its orbit.

Star



10^9 m

A star (Αστέρι) is a fixed luminous point in the night sky which is a large, remote incandescent body like the sun

Star clusters



5-50 ly

It is a collection of stars.

An example is Pleades (Πλειάδες, Many)
visible by the naked eye

Galaxy



10 kly

Galaxy ($\Gamma\alpha\lambda-\alpha\xi\iota\alpha\varsigma=\text{Milky-axis}$)
is a system of
millions or billions of stars, gas and dust,
held together by gravitational attraction.



5-50 ly



3-300 kly

Galaxies are generally larger than star clusters.

"Galaxies are like the cities that star clusters live in," as Geller said.

If there's dark matter in the surroundings, then that group of stars is likely a galaxy.

Supernovae (Sn)

- a powerful and luminous explosion of a star.
- occurs during the last evolutionary stages of a massive star
- By measuring the brightness/radiation of Sn we can estimate the distance between us and the Sn

Let

Brightness = magnitude = m

then

$$(m-14)/5$$

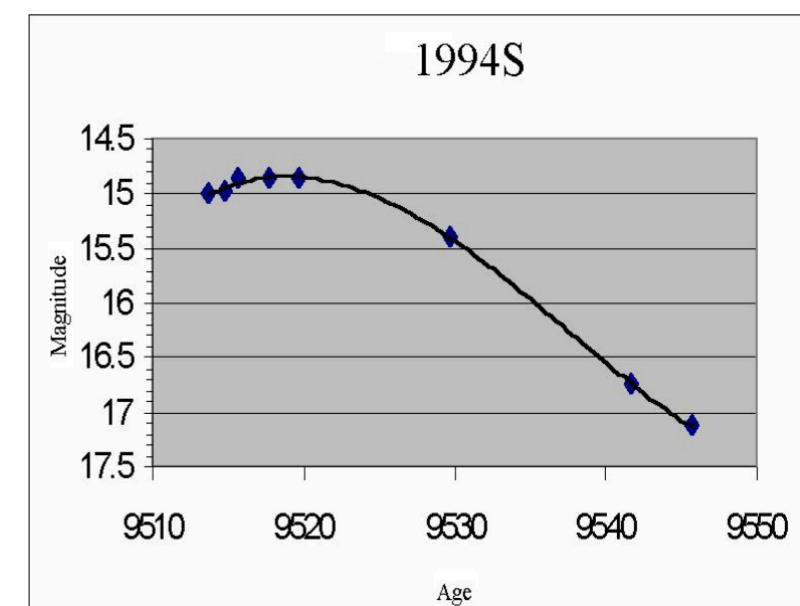
$$\text{distance} \sim 10 \times 10^{16} \text{ m}$$

$$(15-m)/5$$

$$\text{distance} \sim 10 \times 10^{16} \text{ m} = 1.5 \times 10^{16} \text{ m}$$



SN 1994D (bright spot on the lower left), a type Ia supernova within its host galaxy, NGC 4526



Quasar

A quasar is an extremely luminous active galactic nucleus (AGN). It is sometimes known as a quasi-stellar object, abbreviated QSO.

The emission from an AGN is powered by a supermassive black hole (SMBH)
 M_{SMBH} is $(10^6, 10^9)$ M_\odot

Surrounded by a gaseous accretion disc.
Gas in the disc falling towards the SMBH heats up and releases energy in form of EM radiation,
due to angular momentum conservation.

The radiant energy of quasars is enormous;
the most powerful quasars have luminosities:
 $L_{\text{QSO}} = 10^5 L_g$

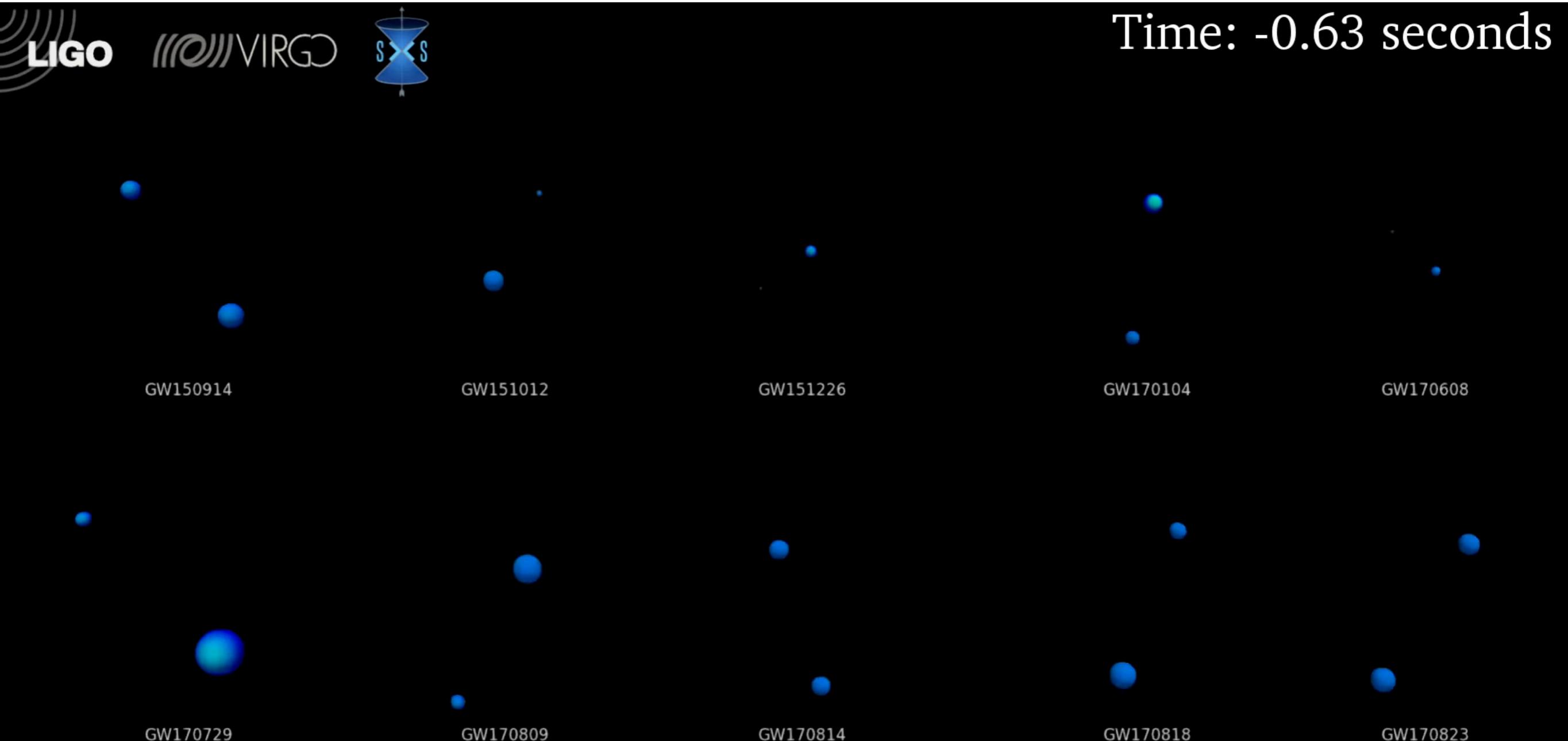


They appear in the early universe
exist since 7×10^8 y after B.B.
redshift, $z \sim 2-8$

Quasar from wiki

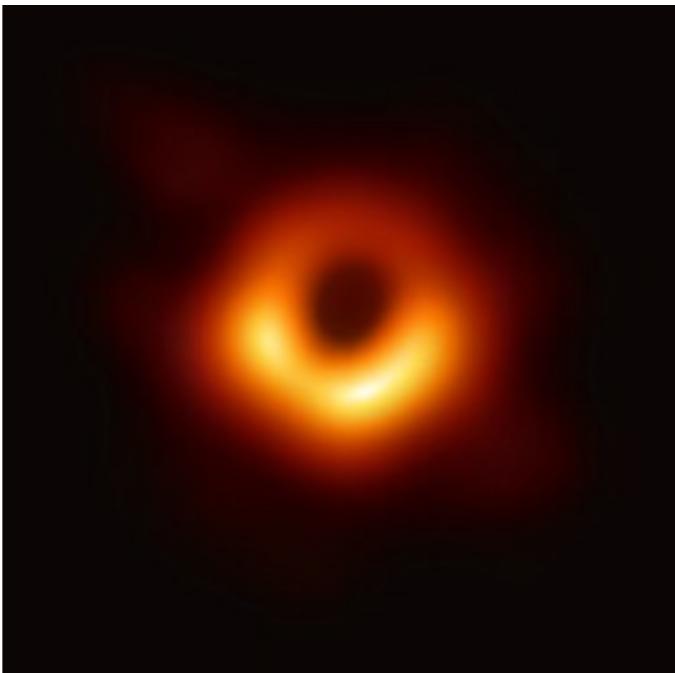
First one detected is GW170817, at 2017!

LIGO/VIRGOarXiv:gr-qc/1710.05832.



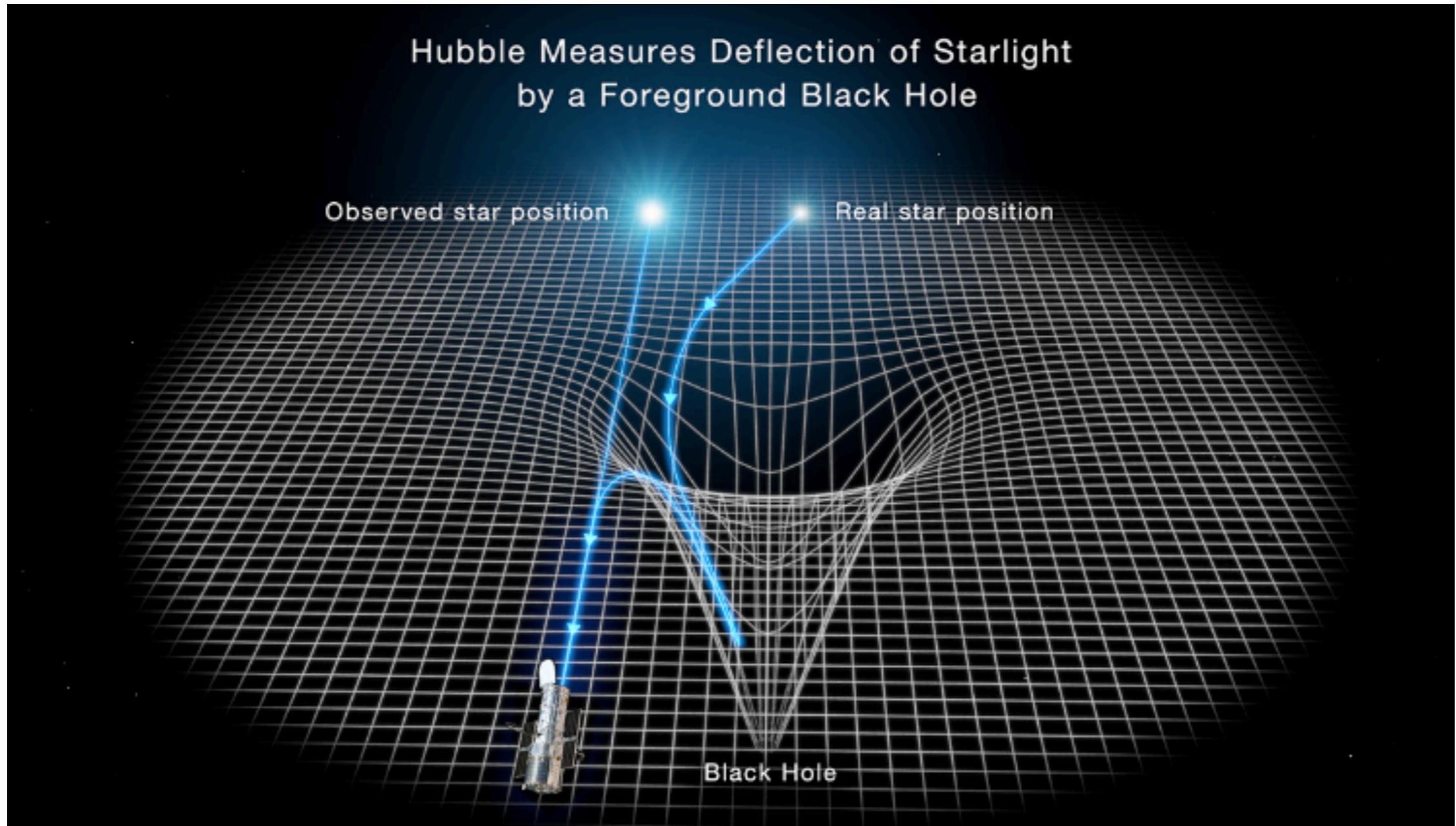
Black hole

Region of spacetime from which nothing, not even light can escape



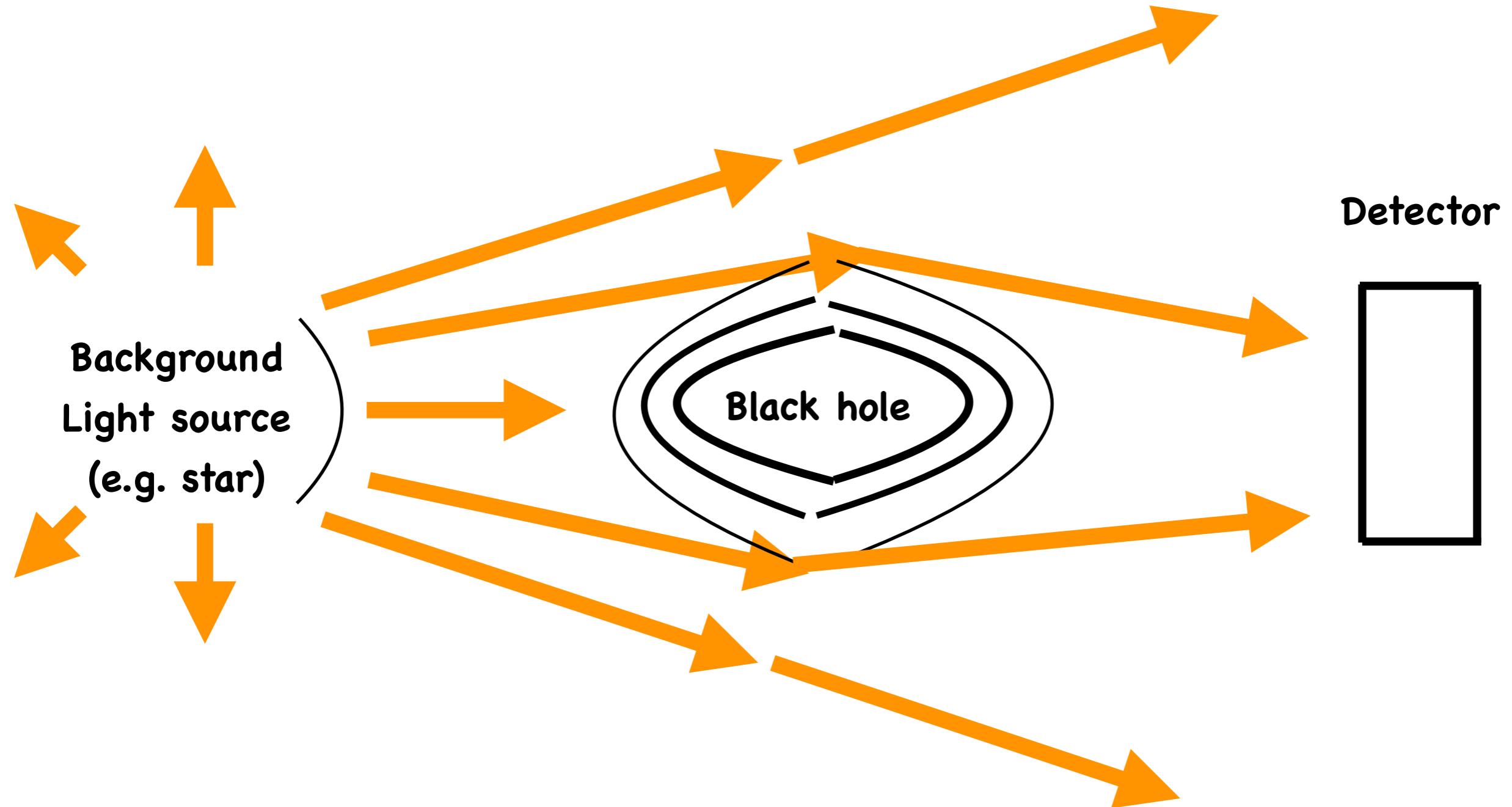
Lensing effect

Lensing effect



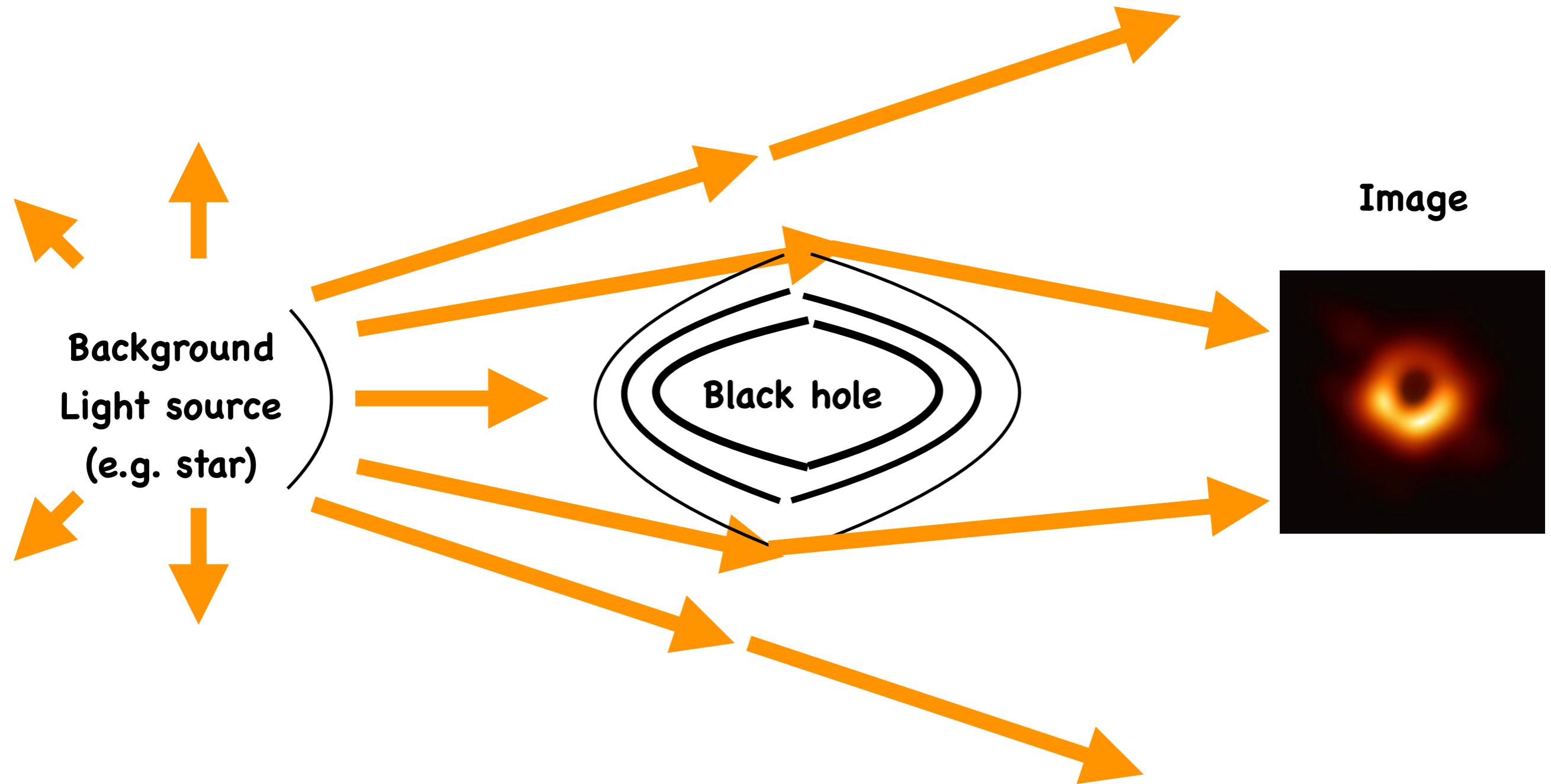
Black hole

Region of spacetime from which nothing, not even light can escape



Black hole

Region of spacetime from which nothing, not even light can escape



Black hole Radiation

Region of spacetime from which nothing, not even light can escape

However!

Black hole “Radiation”

We know that there is no such thing as empty spacetime

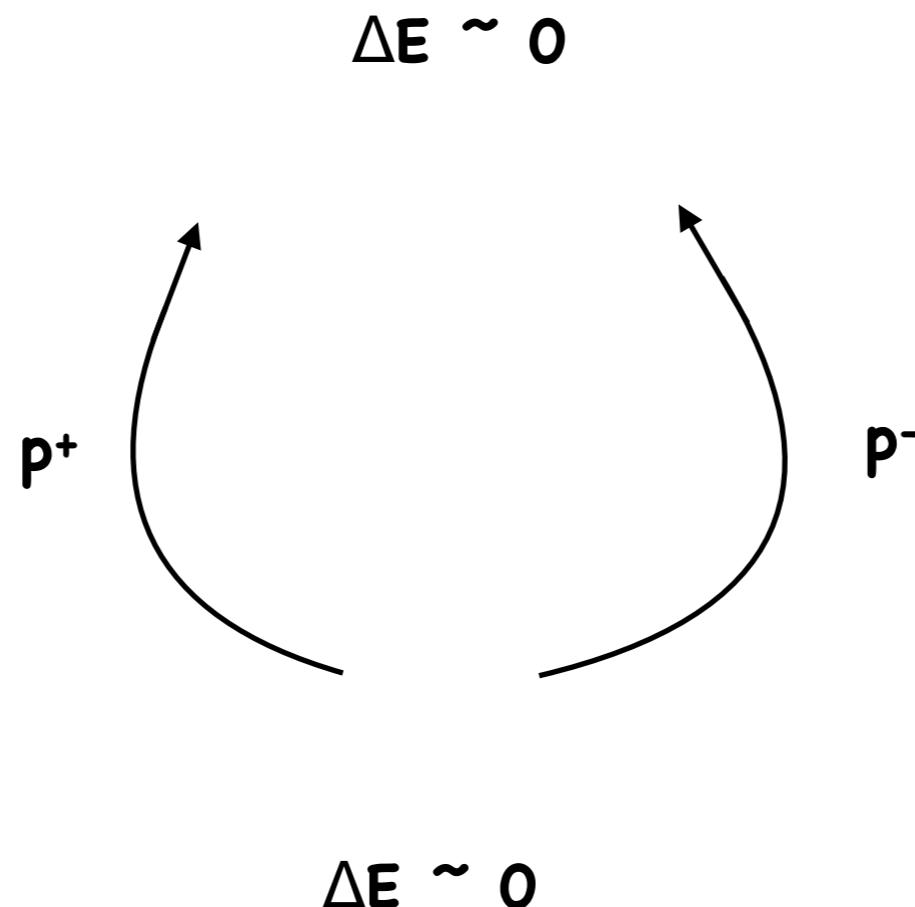
Empty spacetime means fluctuation of energy

Quantum Physics suggest that during fluctuations of energy

there is the possibility of particle- antiparticle production

Black hole “Radiation”

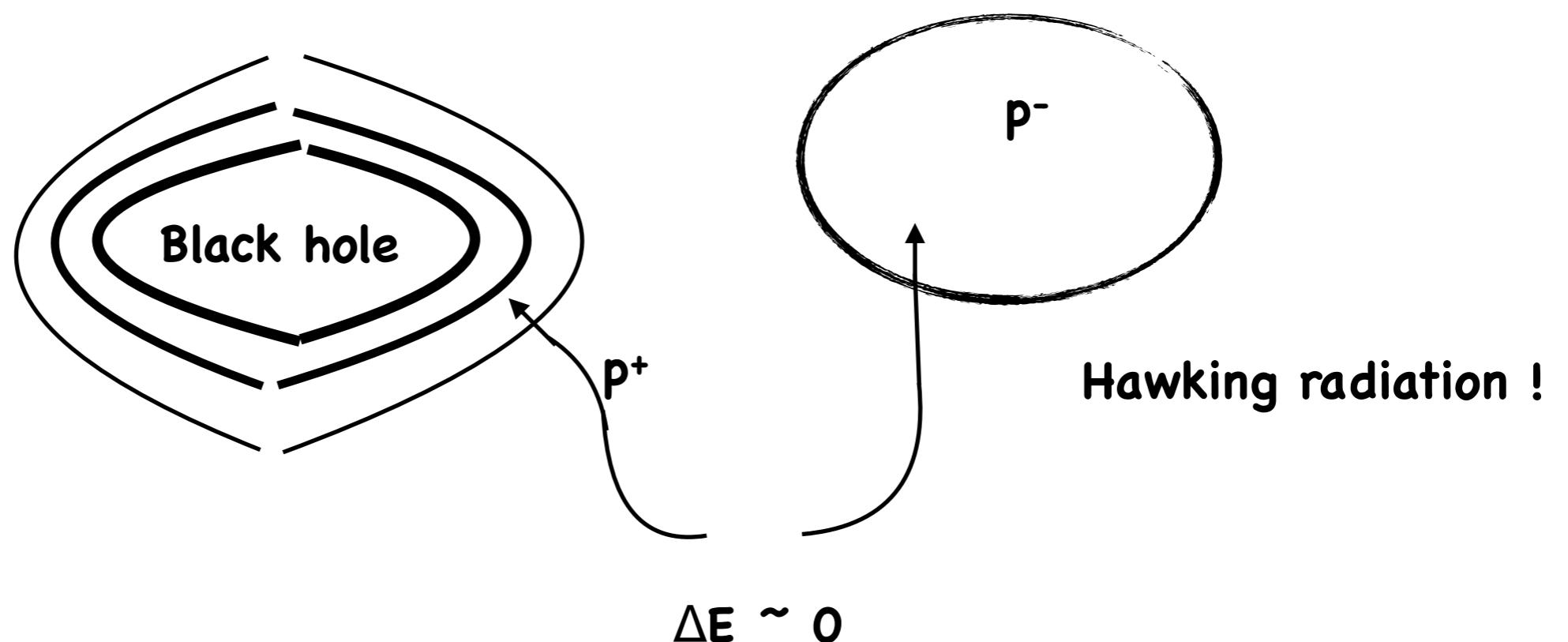
Quantum physics suggest that during quantum energetic fluctuations
there is the possibility of particle- antiparticle production



Black hole “Radiation”

particle- antiparticle production can happen near black.

If it happens close enough:



A phenomenon yet to be detected!

Actionic field-particles

Functor (F) is the generalisation concept of functionals

Functionals is the generalisation concept of functions

Action (A) in physics is a quantity which is the product of energy with time.

Action is a quantity which tell us the amount of possible ways a particle can travel from one point to another within a certain region

Functor of actions (FA) predict the possible existence of the **actionic fluctuations and field-particles** which are analogues of the **energetic fluctuations and field-particles**, in nature.

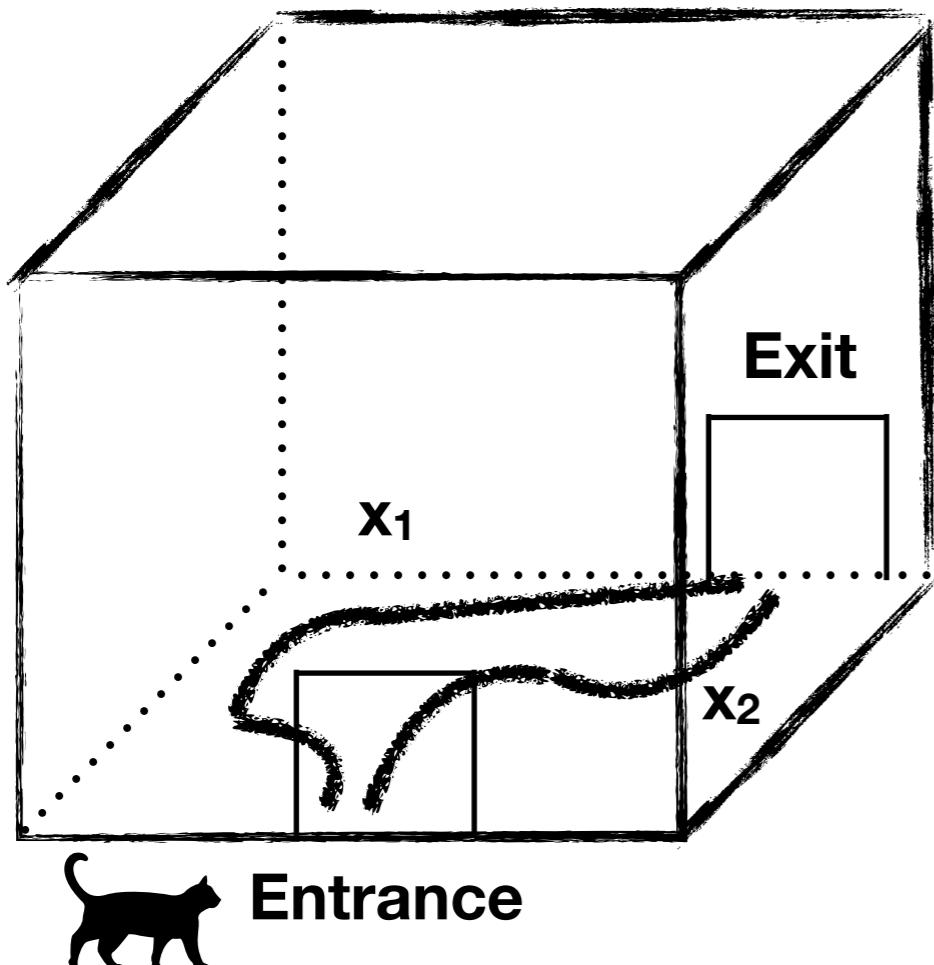
$$\text{Set of FA} = \mathcal{S}_{\text{FA}} \supset \int_{\Omega_A} dA' \supset A = \int_{\Omega} d^D x E$$

Actionic field interpretation

Action answers to the question :

What is the number of all possible routes
a cat can use to pass through each room ?

$$N = 2$$

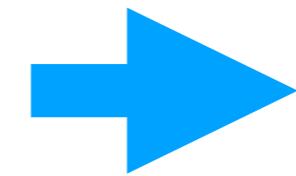


x_1 is possible for both rooms, x_2 is not possible for the 2nd room

space, x

Actionic field interpretation

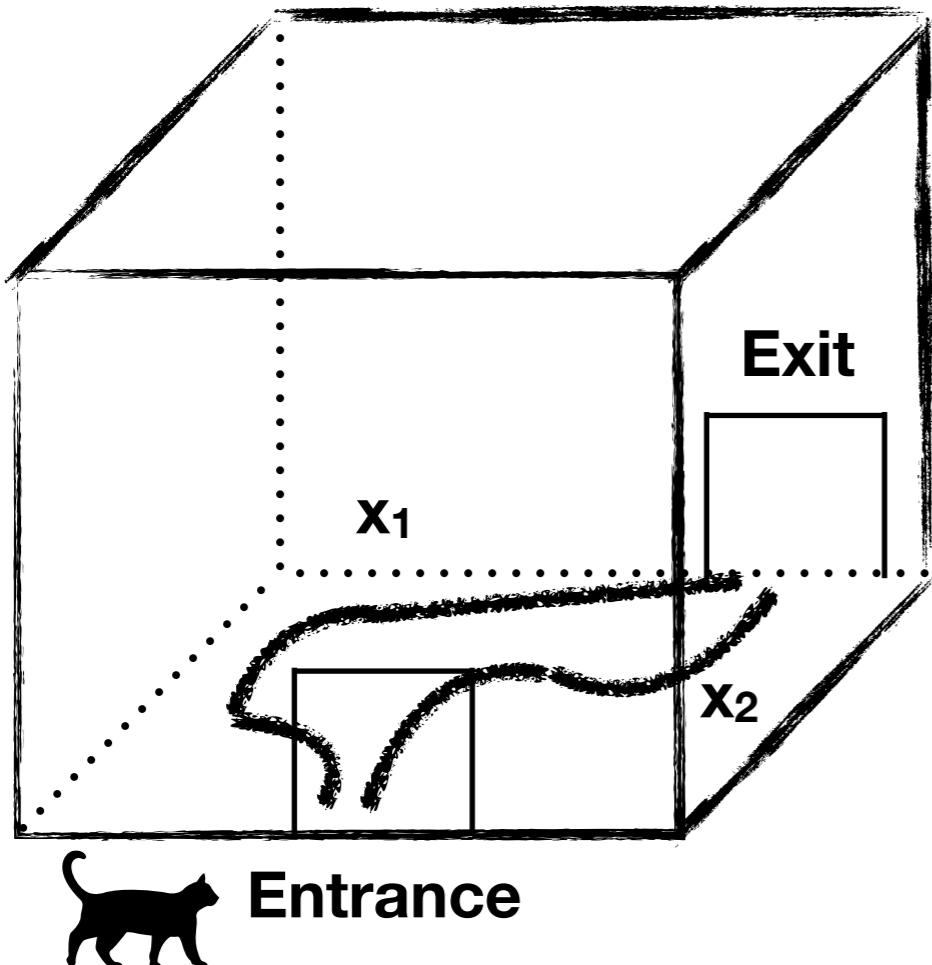
Action answers to the question :



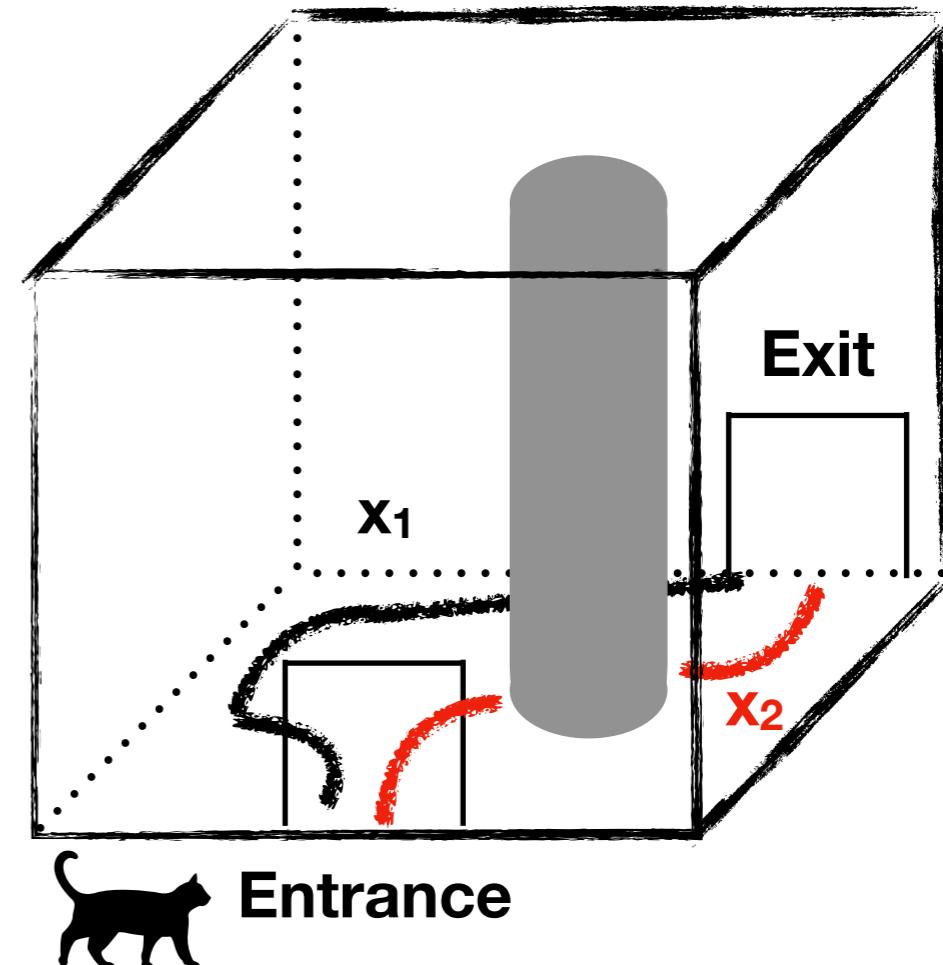
A actionic field everywhere
QM \Leftrightarrow actionion field-particle

What is the number of all possible routes
a cat can use to pass through each room ?

$$N = 2$$



$$\begin{matrix} N-n \\ 2-1 \end{matrix}$$



x_1 is possible for both rooms, x_2 is not possible for the 2nd room

space, x

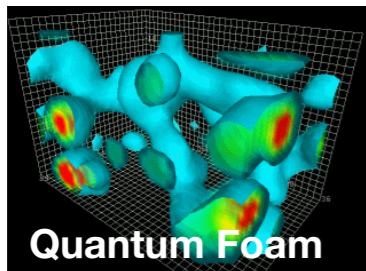


Current picture of structures

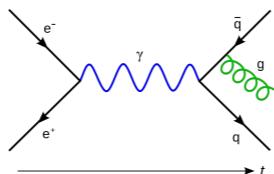
increasing scale

Actionions ? Strings ?

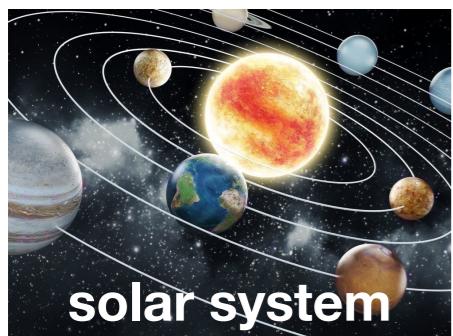
5



$q^\pm, H^0, l^\pm, \gamma, W^\pm, g^c, GW$



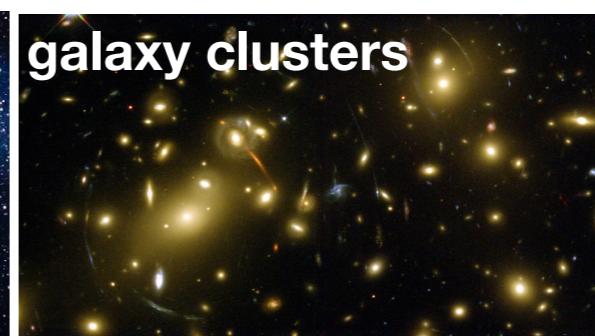
10⁻³⁵m - 10⁻¹⁰m



star cluster



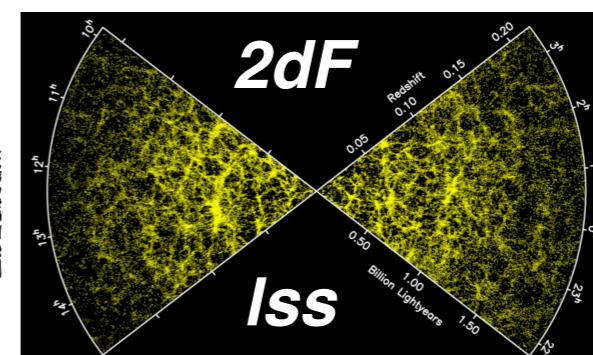
galaxy clusters



1 A.U. - kpc

10⁹ m - 10¹⁹ m

Cosmic Web: Voids, Nodes, Filaments & Sheets



Mpc - Gpc

point objects without structure

objects with structure

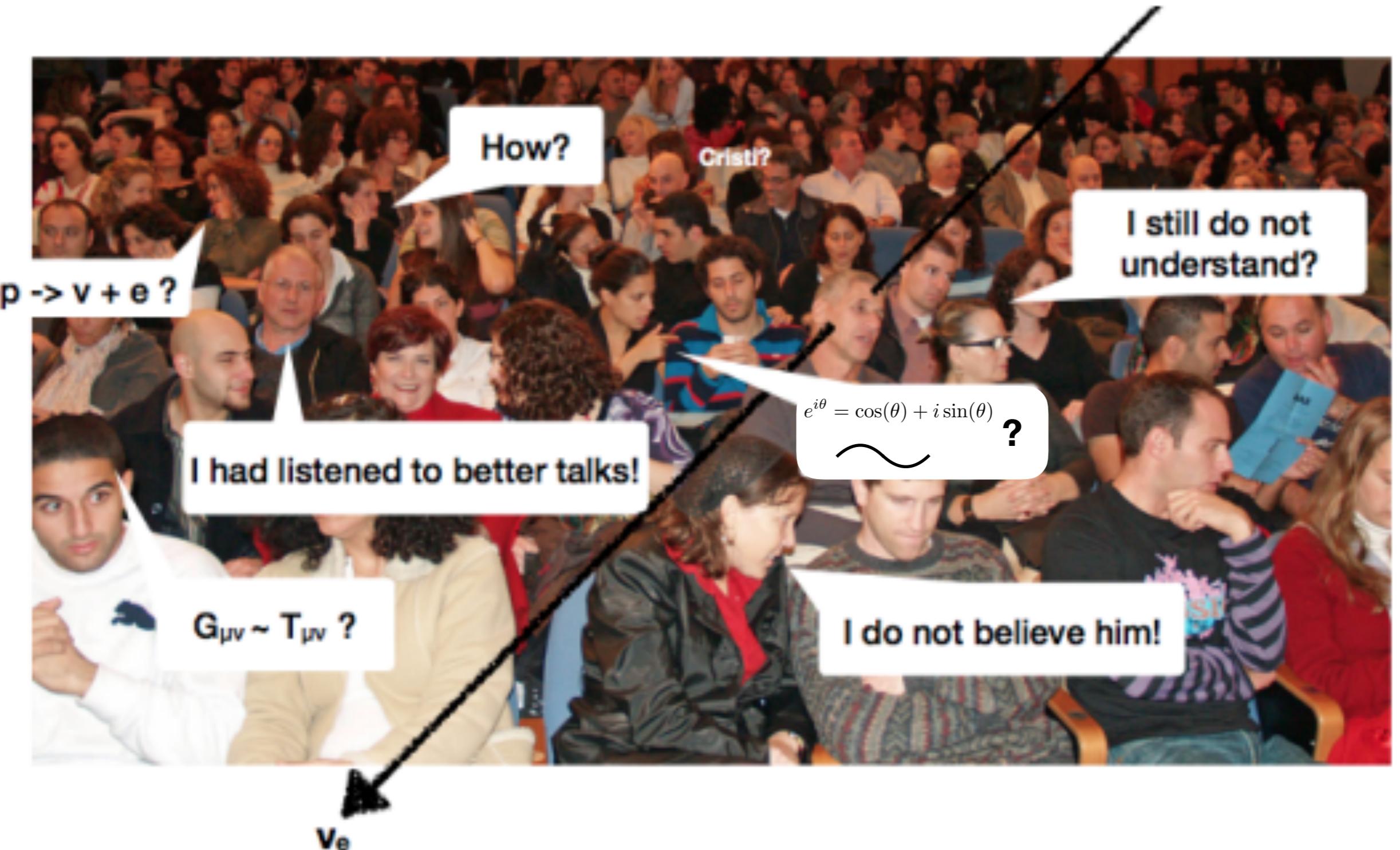
According to what?

density:

- # particles
- Temperature

Cosmic foam: at very small and very large scales

Thank you for your attention!



References

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S.Alam, ..., P.Ntelis, ... et al., Testing the theory of gravity with DESI, JCAP

Y.Mellier, ..., P.Ntelis et al., Overview of Euclid Mission, ArXiv

Thesis: Probing cosmology with the homogeneity scale of the universe through large scale structure surveys P.Ntelis 2017

P.Ntelis, 2018-2019, A note on large scale structure

Quasar from wiki

Hawking Radiation Wiki

Short related quizzes

Kahoot Advanced Cosmology