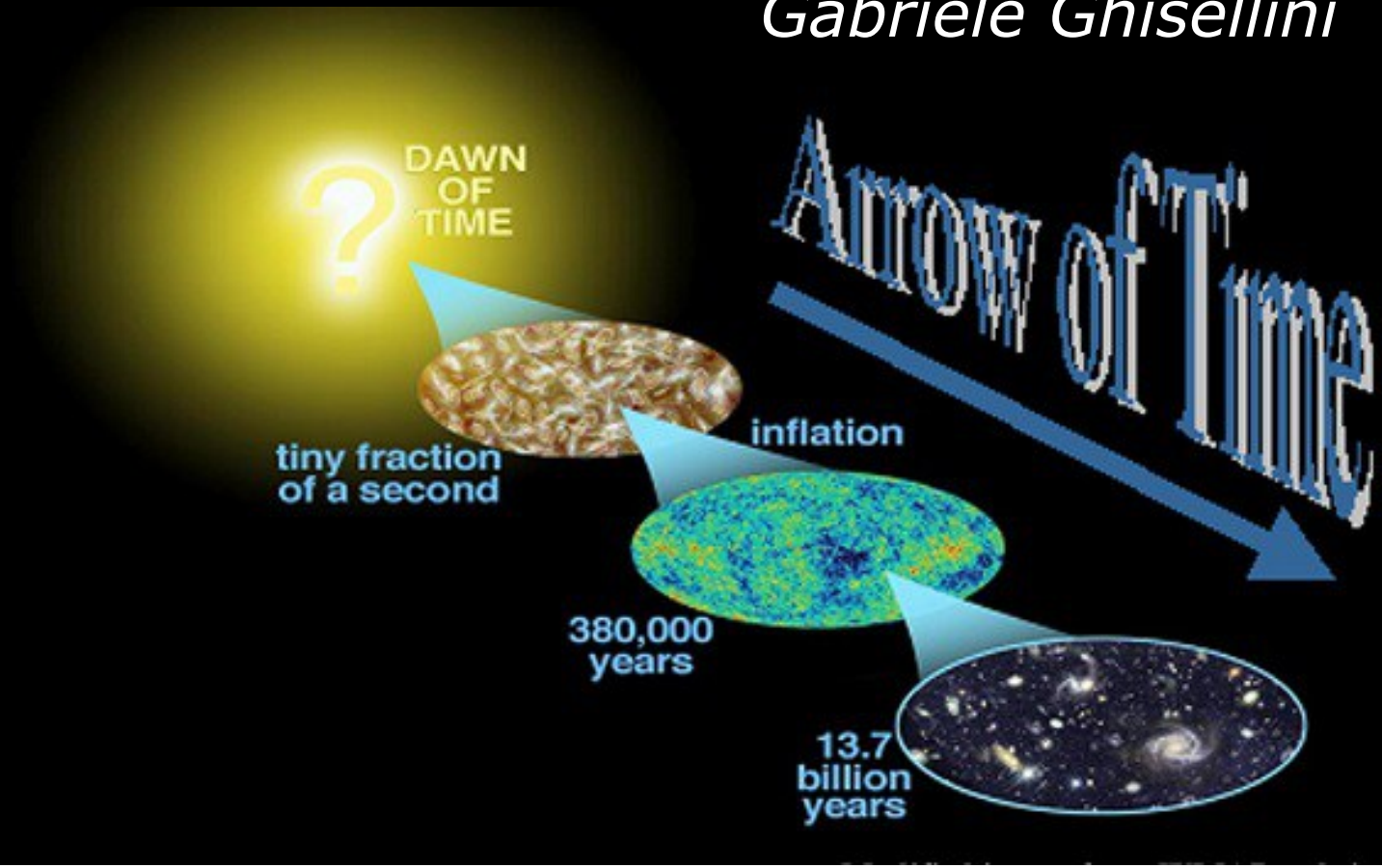
Istituto Nazionale di Astrofisica

Osservatorio astronomico di Brera

CHE COS'E' IL TEMPO?

Gabriele Ghisellini



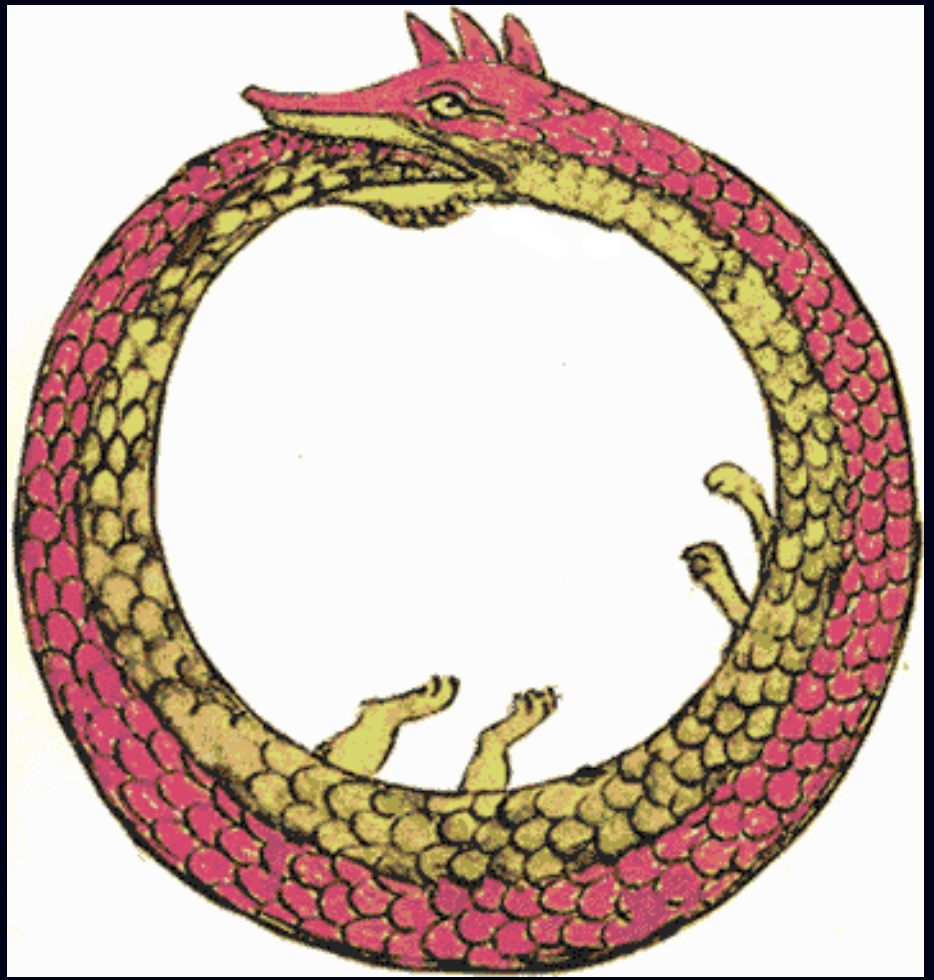
“Allora che cosa è il tempo? Se nessuno me lo domanda, lo so. Se voglio spiegarlo a chi me lo domanda, non lo so più".

Confessioni, Sant’Agostino (354-430 d.C.)

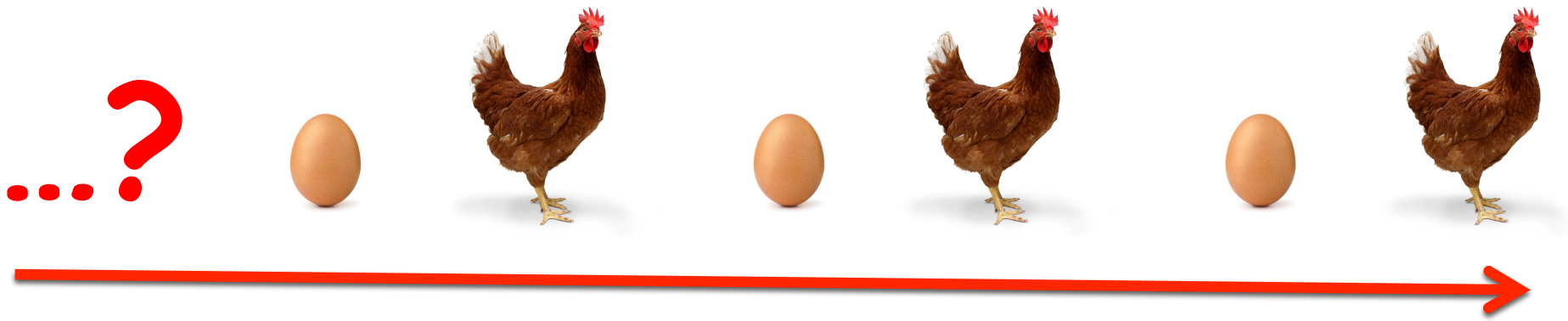
Il tempo e' il modo in cui Dio impedisce che le cose accadano tutte insieme.

Graffito anonimo texano

Tempo ciclico: Uroboro

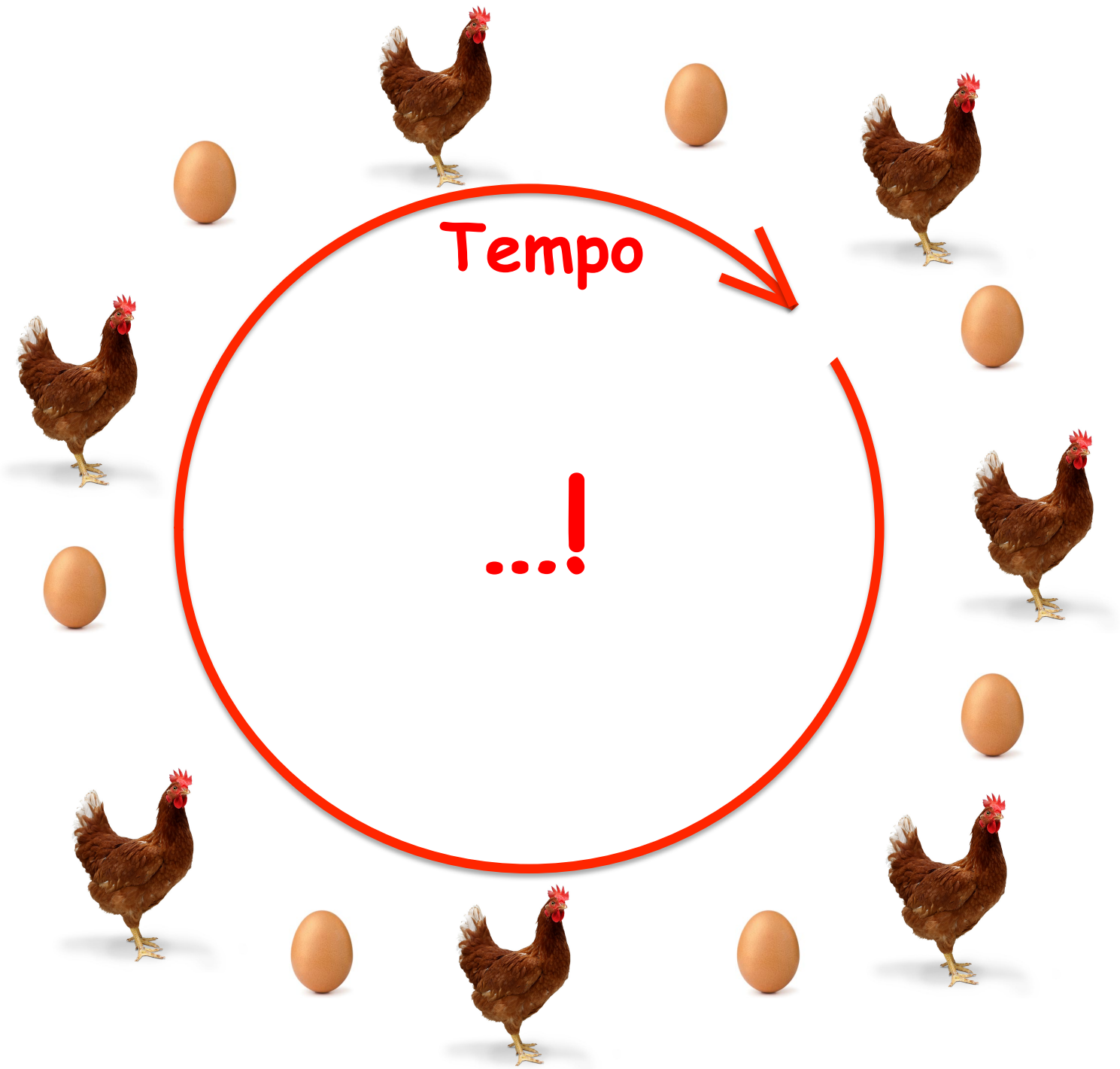


India - antico Egitto - antica Grecia - Maya - Atzechi

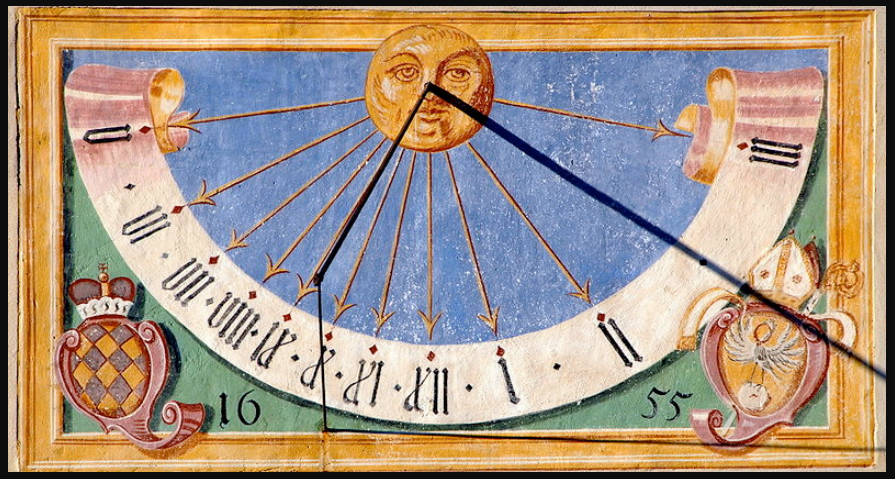


Tempo

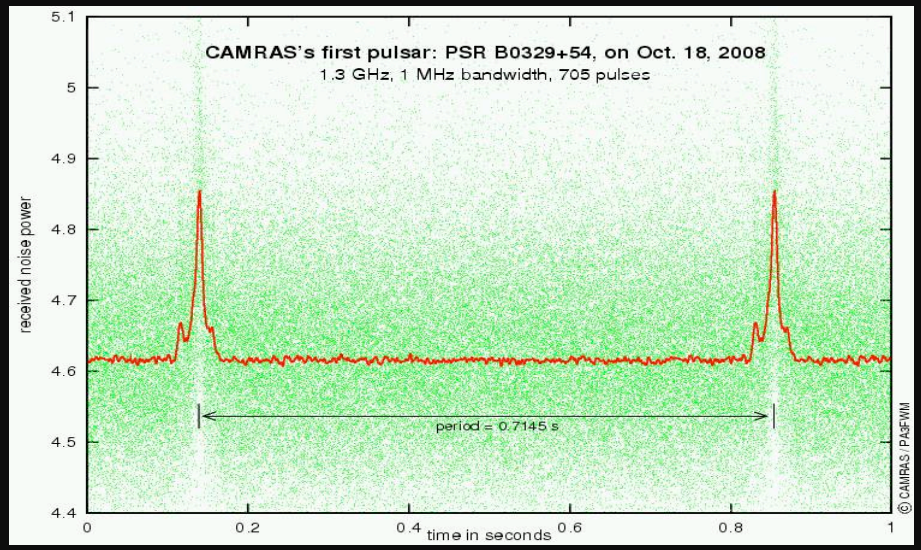
Religioni monoteiste → Creazione → inizio del tempo

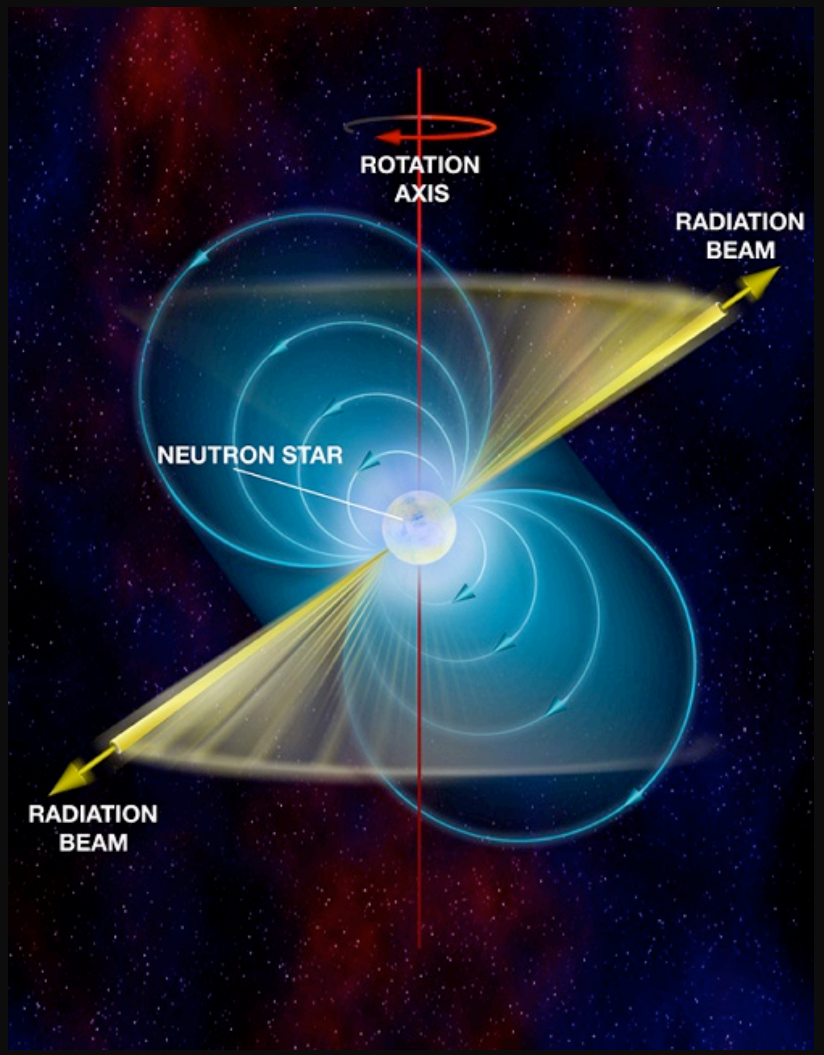

Tempo
...!

Misurare il tempo

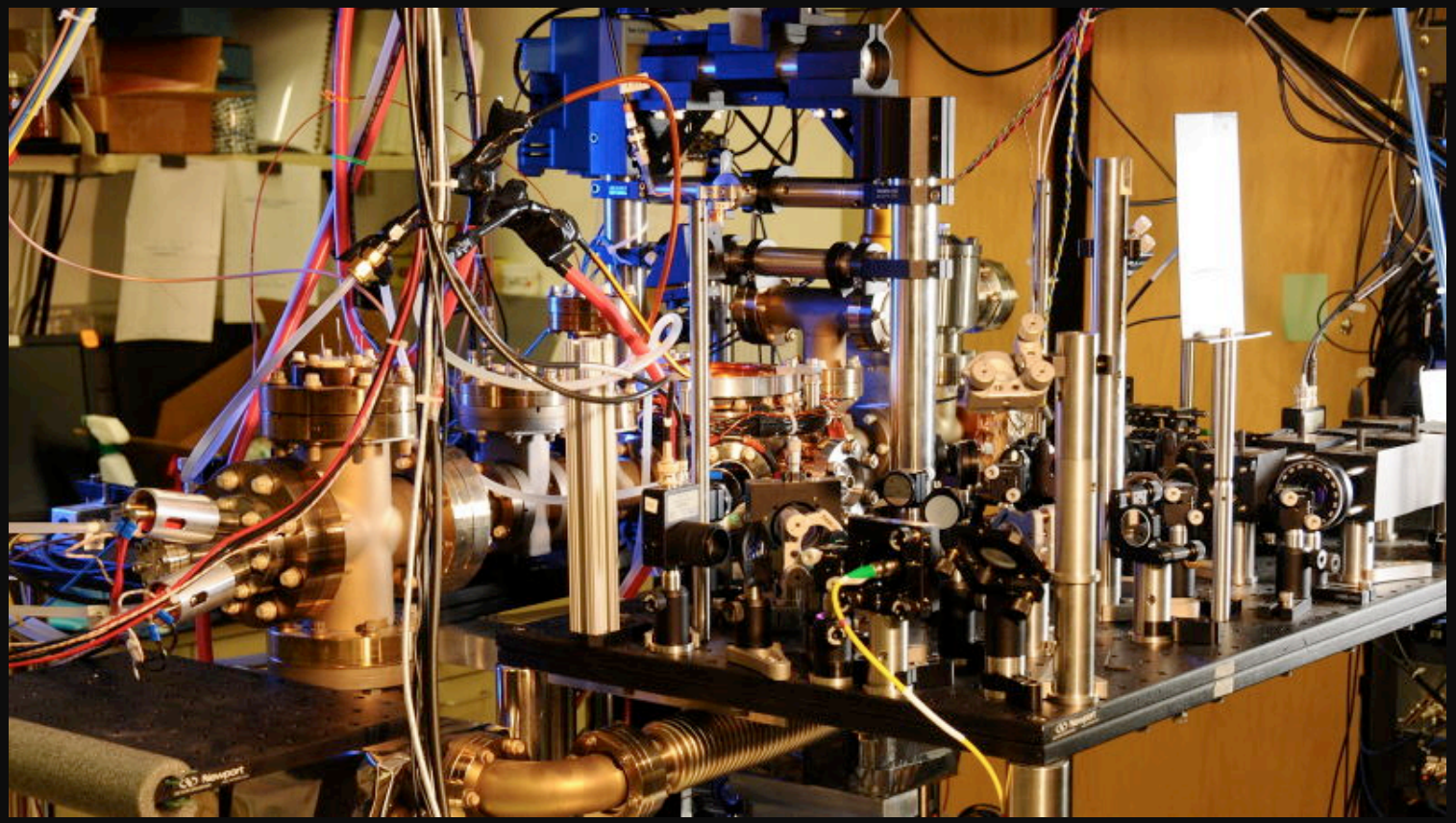


Stelle di neutroni: 1 secondo ogni 30 milioni di anni

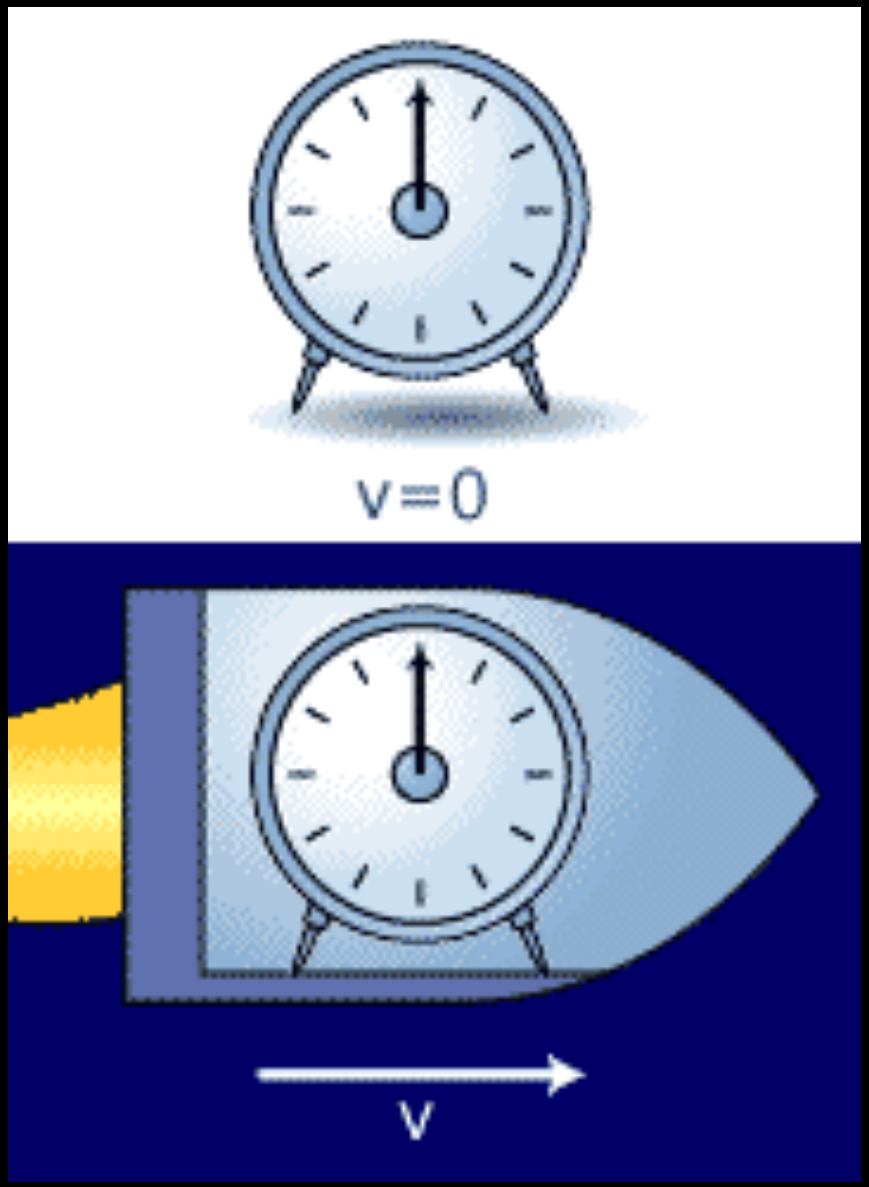


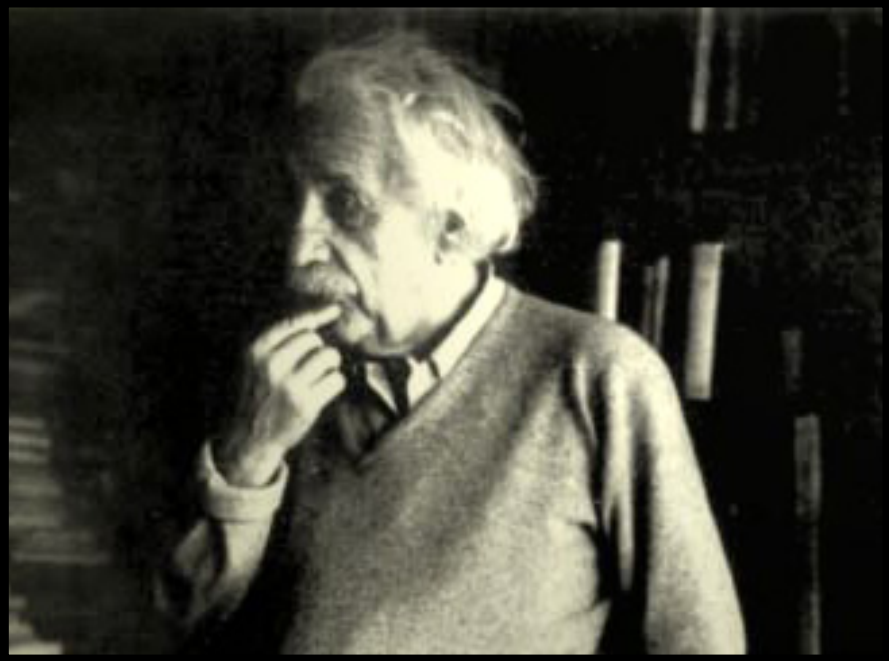


Orologi atomici: 1 secondo ogni 15 miliardi di anni

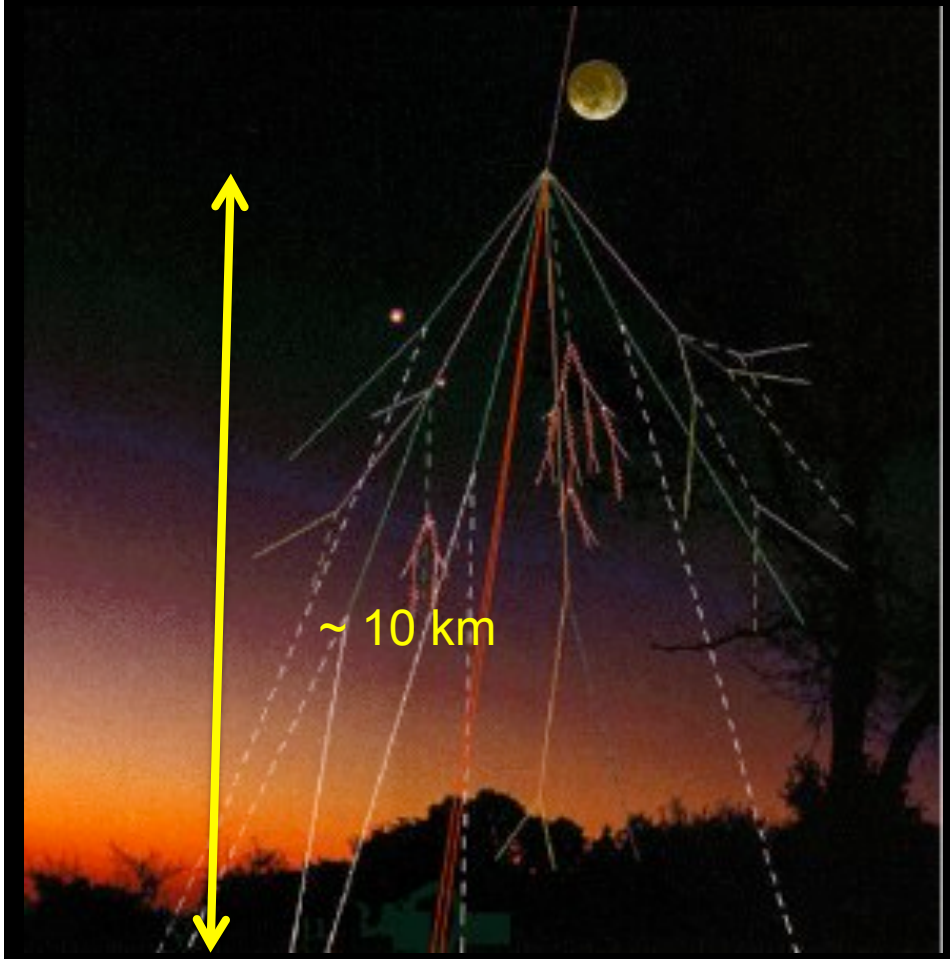


Einstein rivoluziona spazio e tempo





Mesoni longevi …



Tempo di vita del muone:
2.2 microsecondi.

c x 2.2 ms = 660 metri

Come fa a percorrere 10 km?

10 km / 0.66 km = 15

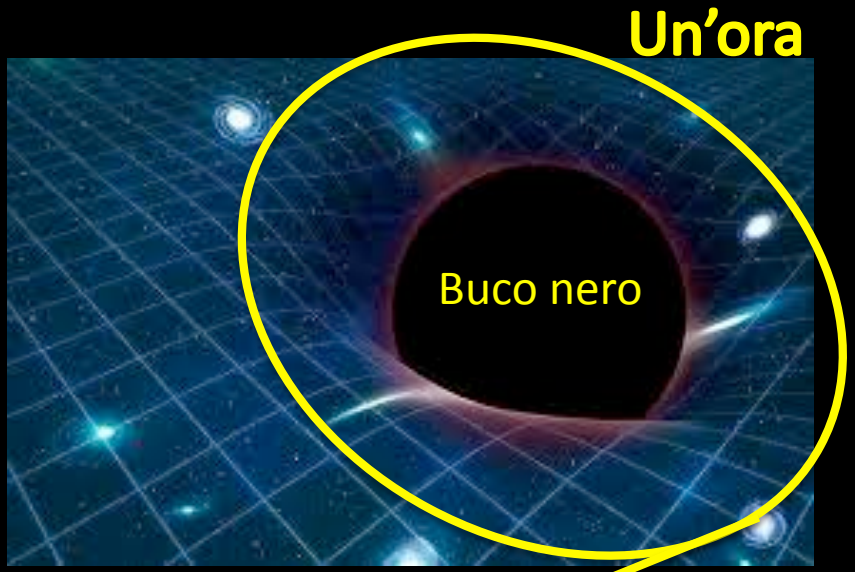
$t_{osservato} > 15\ t'_{proprio}$

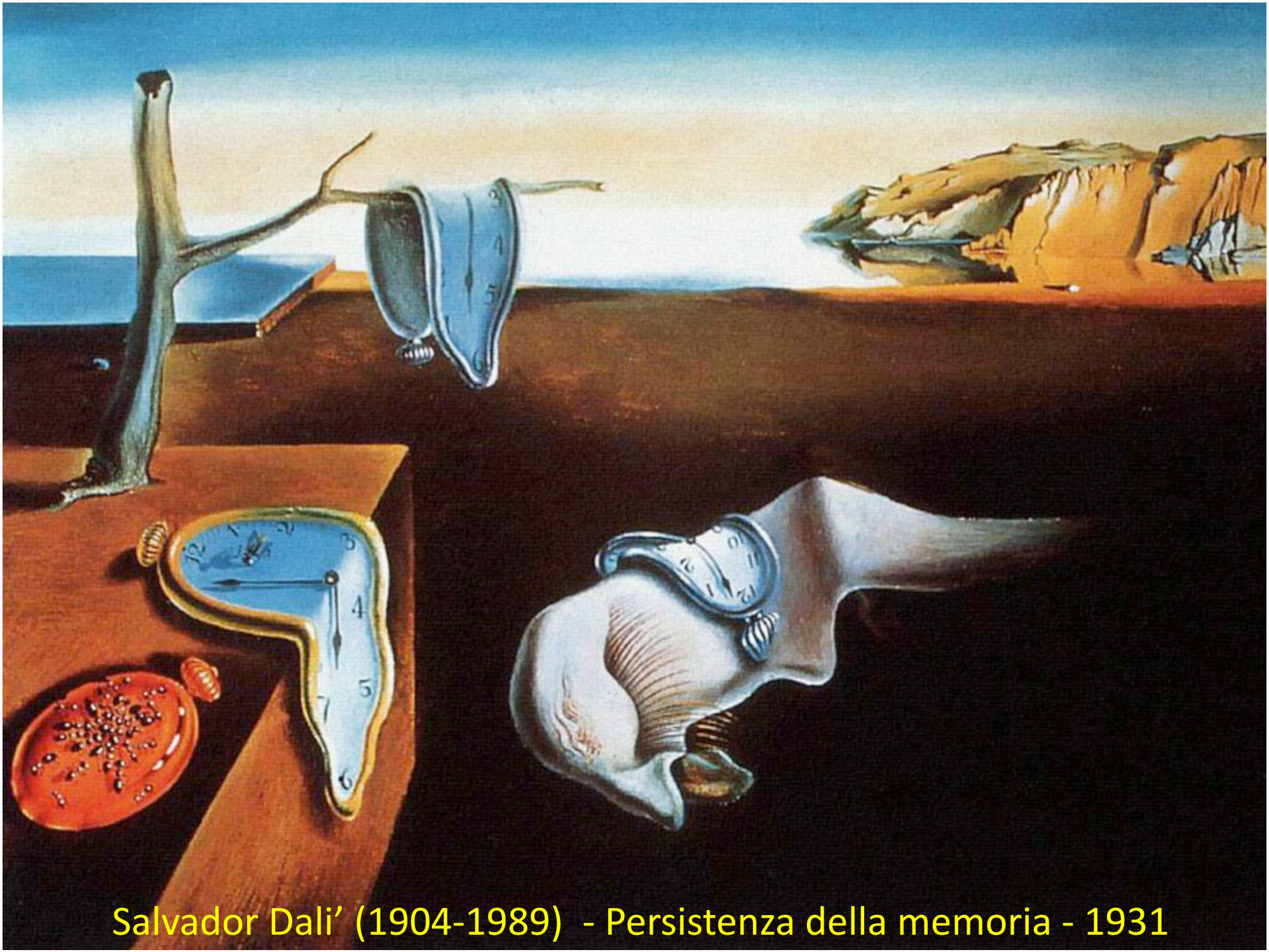
La gravita' rallenta il tempo….

Tempo scorre piu' velocemente

Tempo scorre piu' lentamente

Interstellar…





Salvador Dali’ (1904-1989) - Persistenza della memoria - 1931

Il tempo meccanico, misurabile con gli orologi, è messo in crisi dalla memoria umana, che del tempo ha una percezione ben diversa. **L'opera sembra dunque richiamare una visione del mondo parallela a quella introdotta dalla teoria della relativita' speciale di Einstein**.

In risposta ad una lettera di Ilya Prigogine, Dalì spiegò che il concepimento della sua opera fosse in realtà legato ad una sua personale riflessione surrealistica riguardo all' "ipermollezza" e allo scioglimento del formaggio al sole (probabilmente il celebre Camembert)

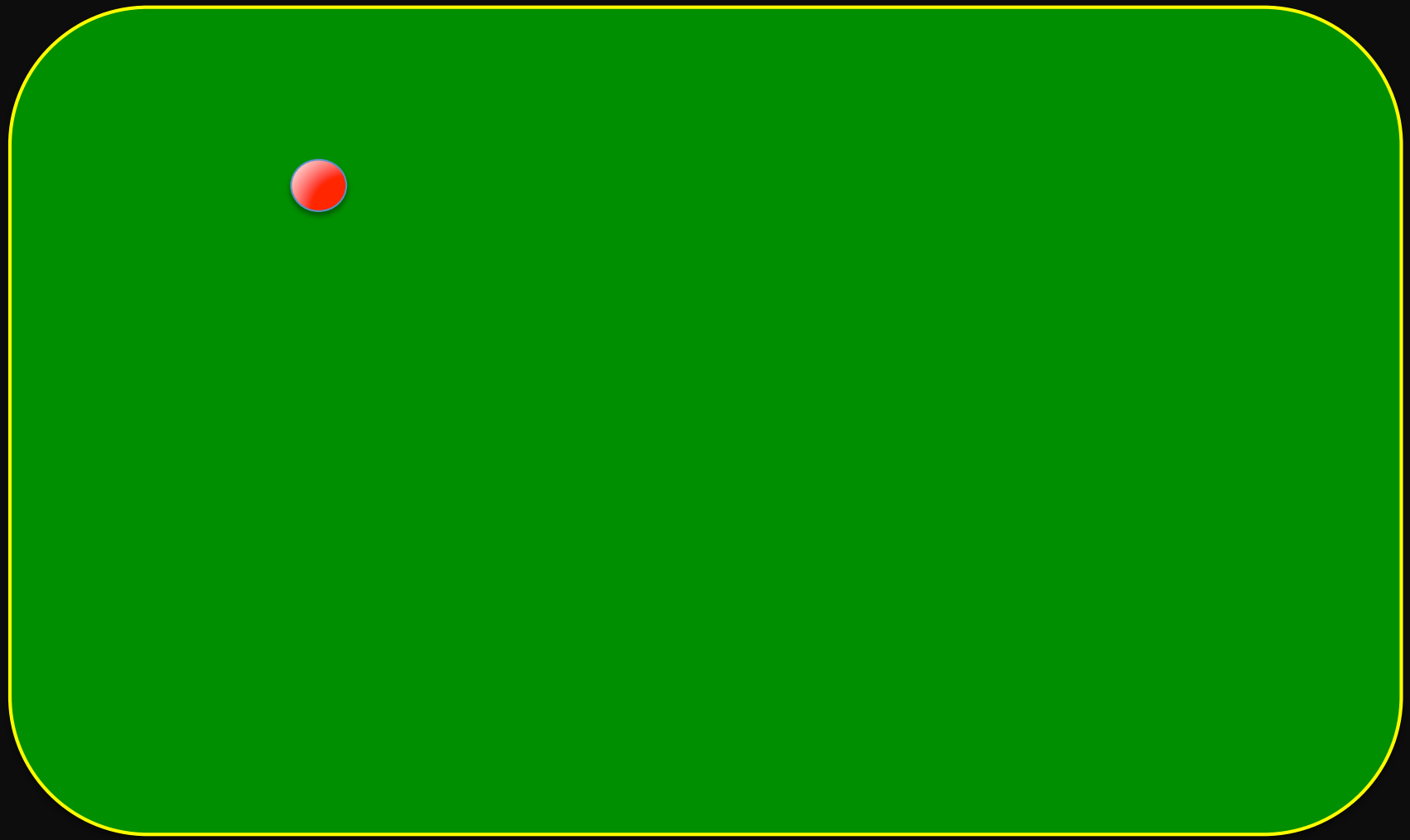
(*La Dimensione di Dalì: Decifrando la Mente di un Genio*).

Problema

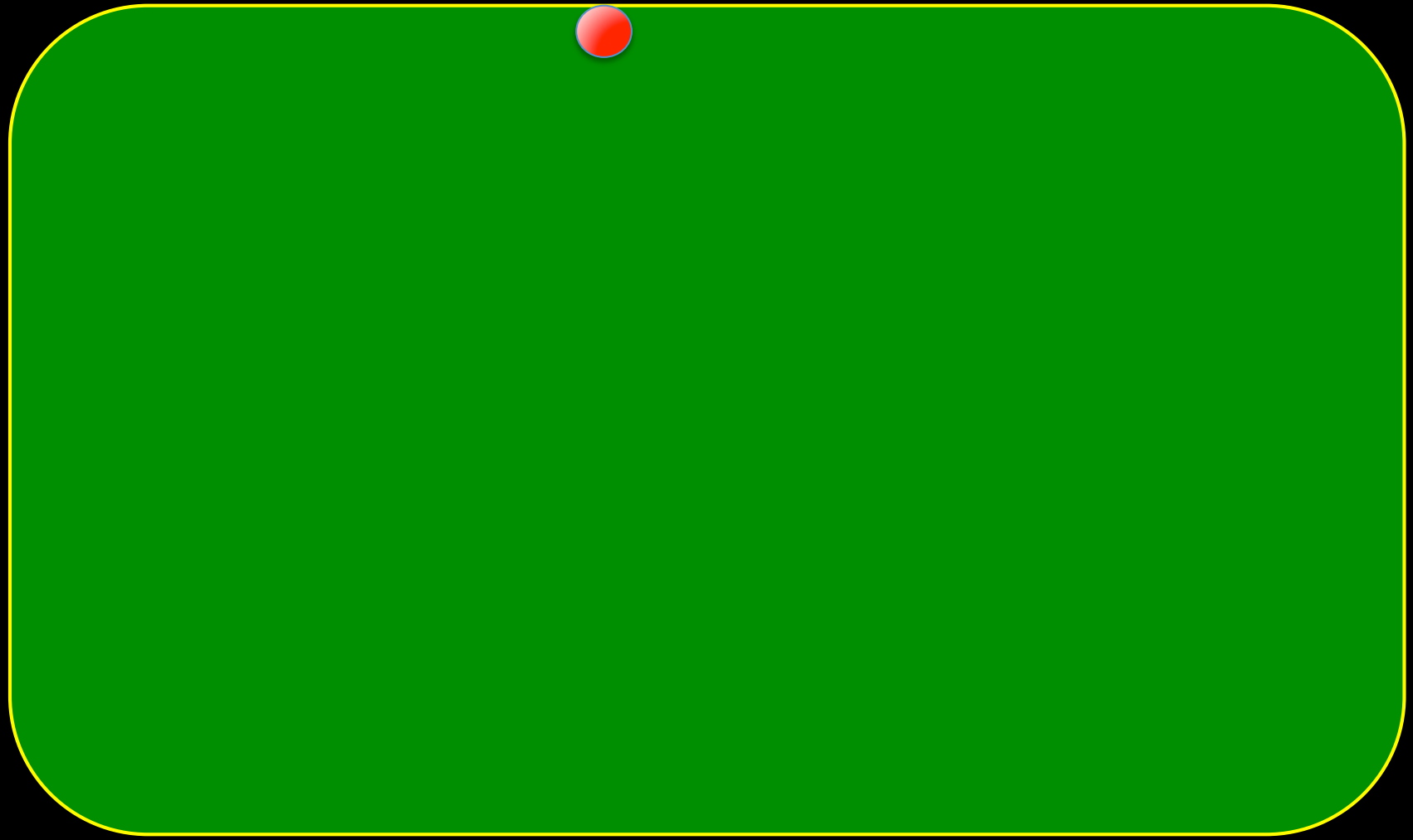
Noi percepiamo chiaramente che il tempo "va sempre in avanti" (purtroppo!!!)

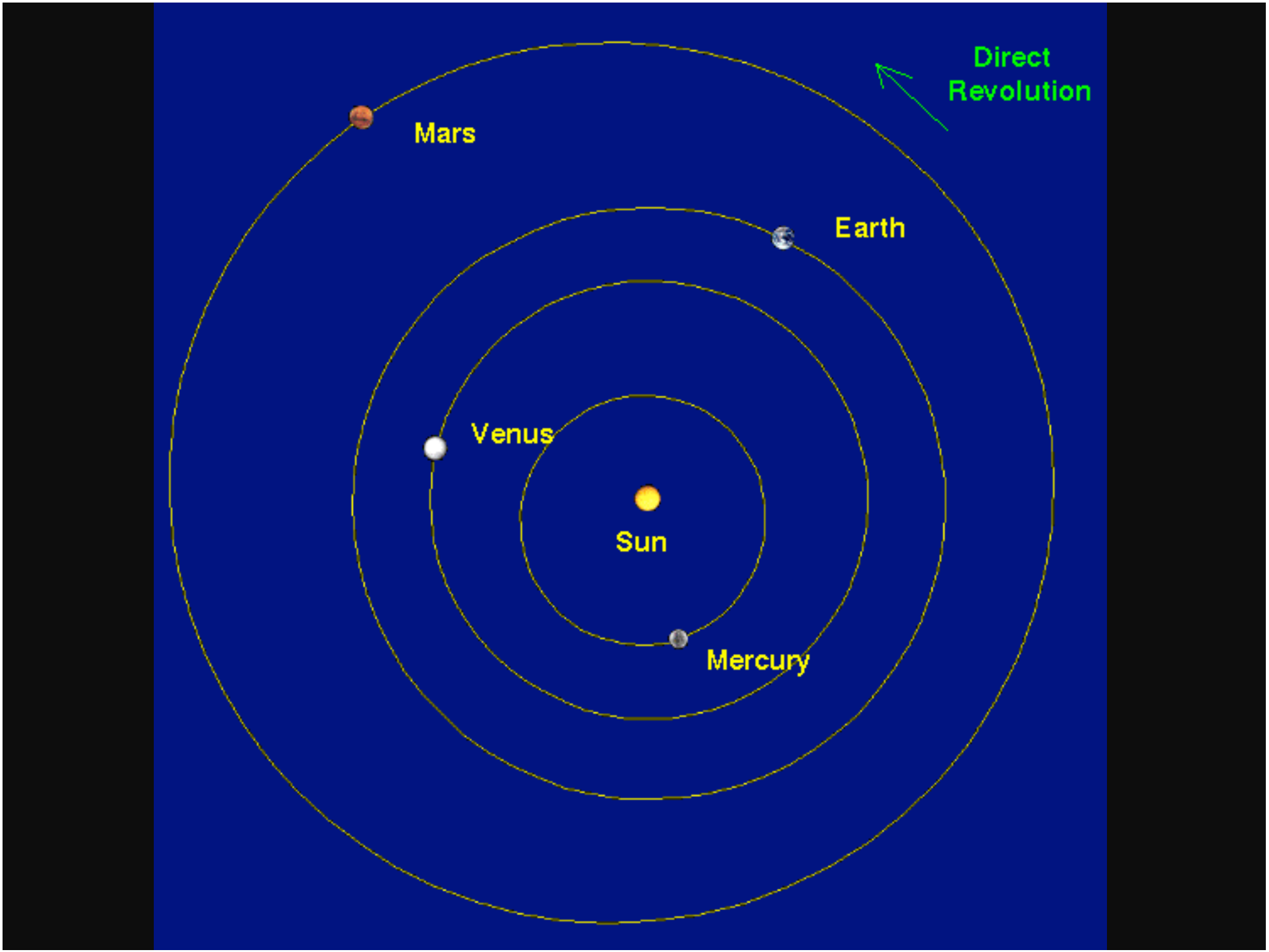
Le leggi fisiche non distinguono lo scorrere in avanti o indietro del tempo

Le leggi fisiche non distinguono lo scorrere in avanti o indietro del tempo



Le leggi fisiche non distinguono lo scorrere in avanti o indietro del tempo




Direct
Revolution
Mars
Earth
Venus
Sun
Mercury

SPL

dreamstime.com

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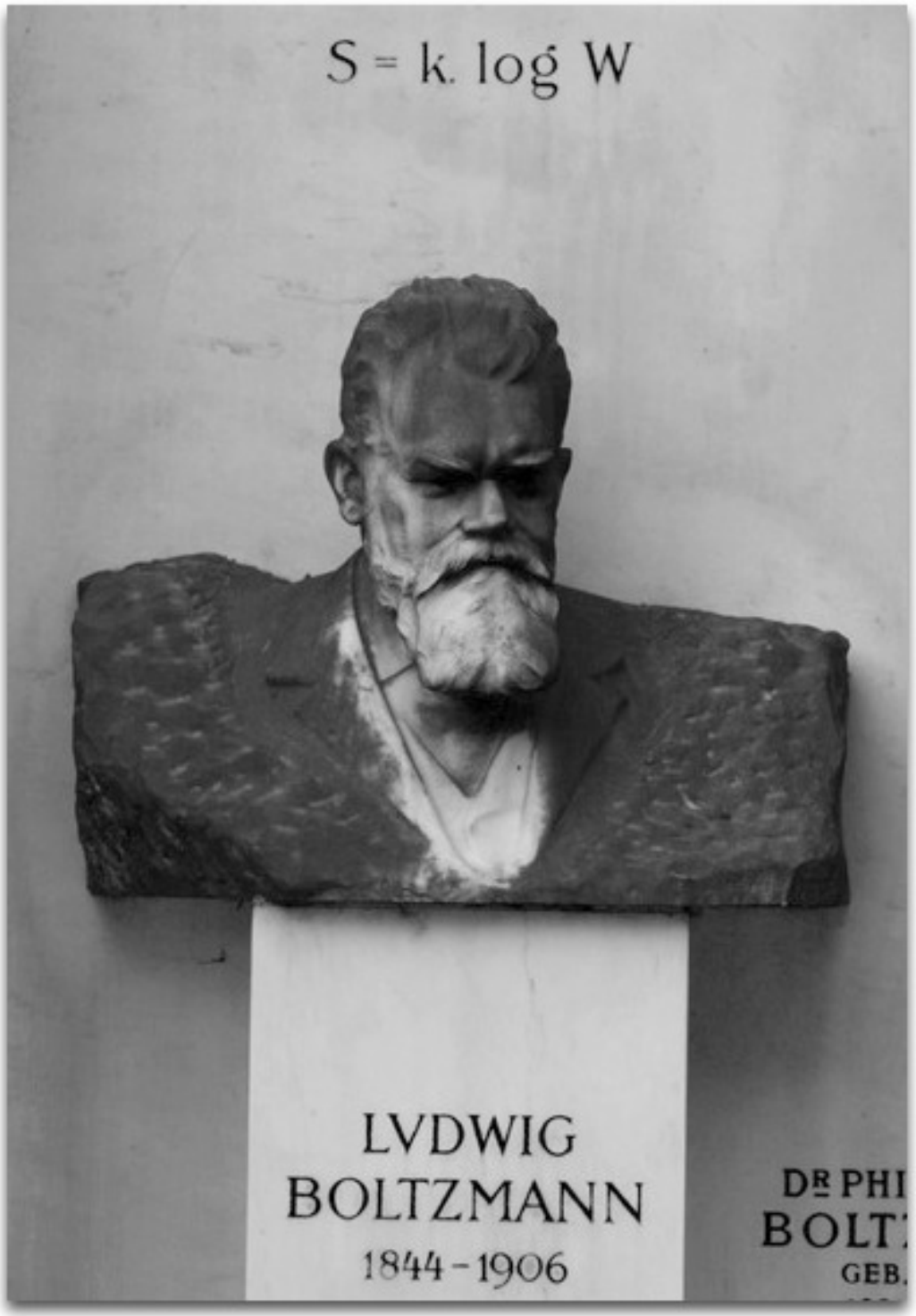
Secondo principio della termodinamica

Mattone caldo

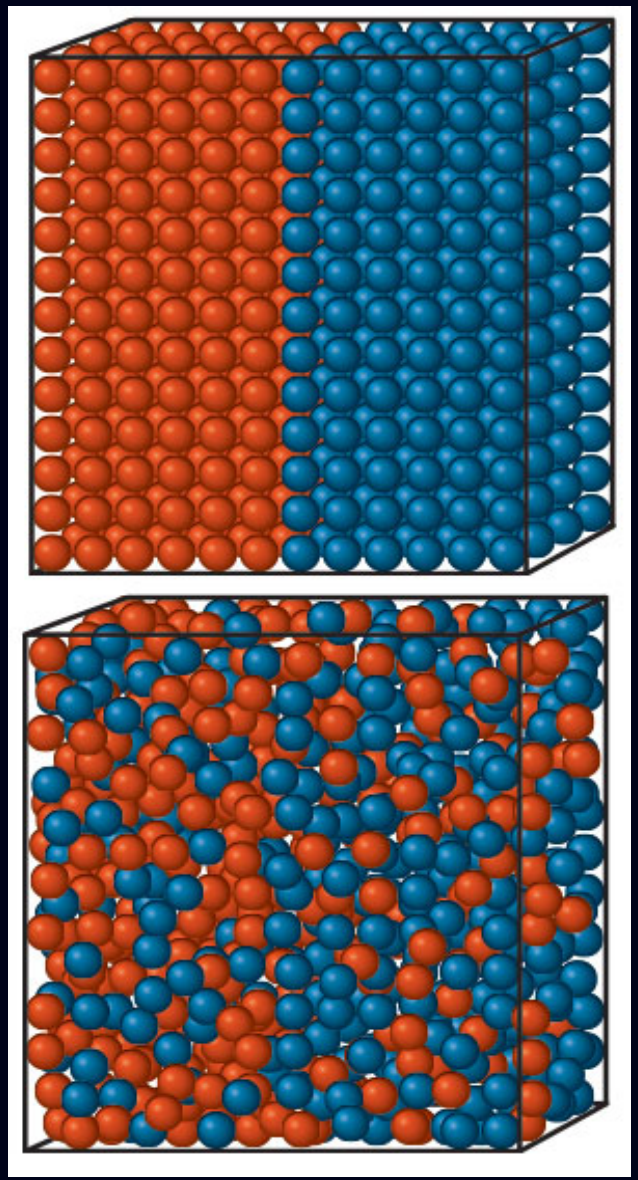
Mattone freddo

Calore


S = k. log W
LVDWIG
BOLTZMANN
1844 - 1906
DR PHI
BOLT
GEB.

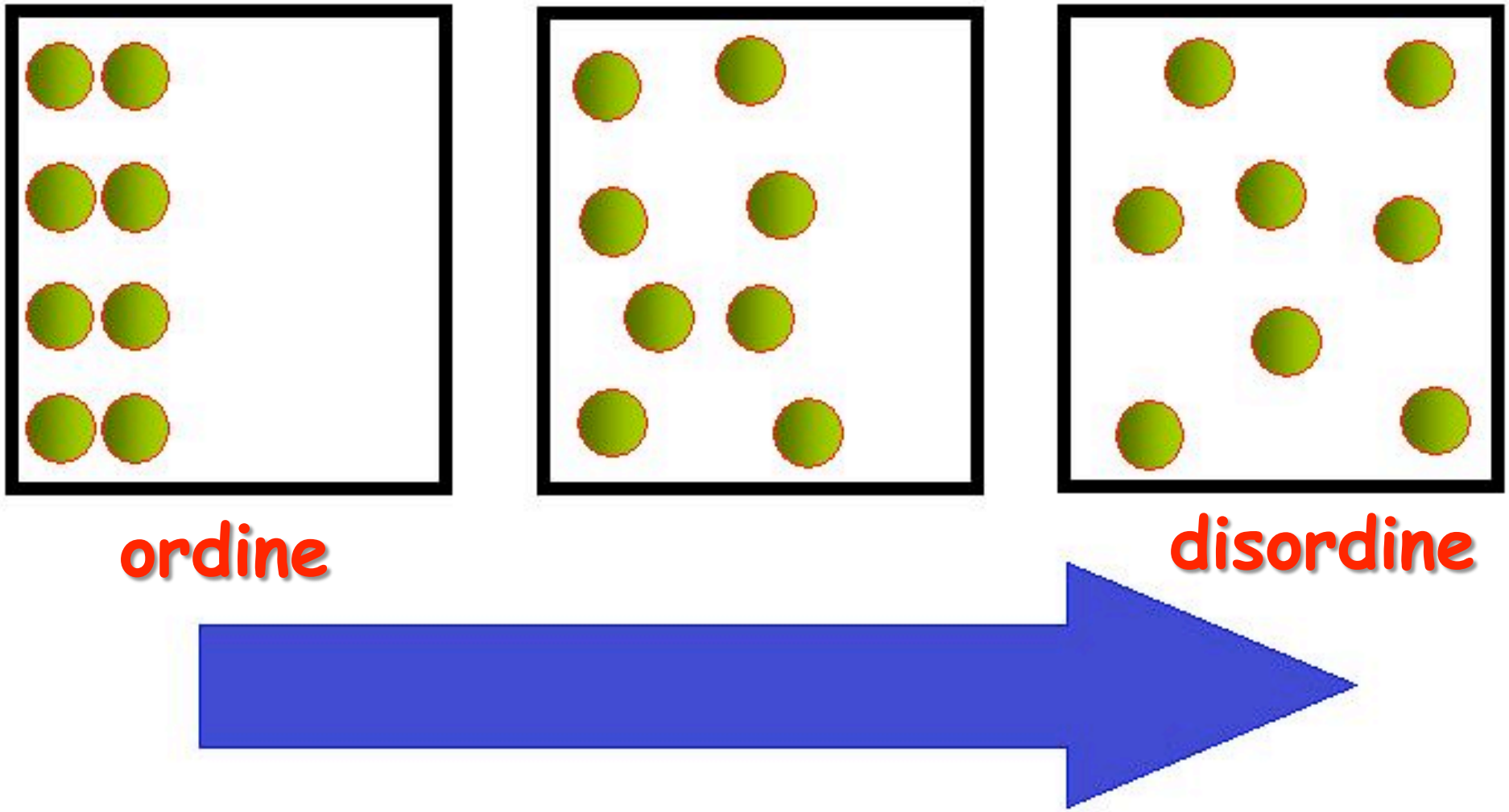
Entropia

Ordine



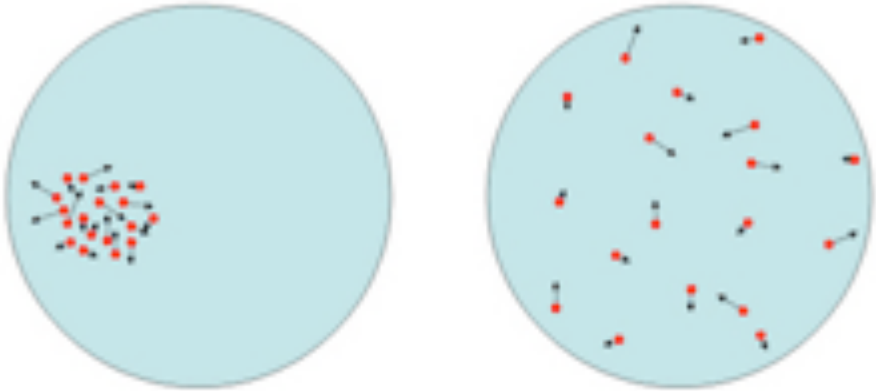
Disordine

Entropia aumenta



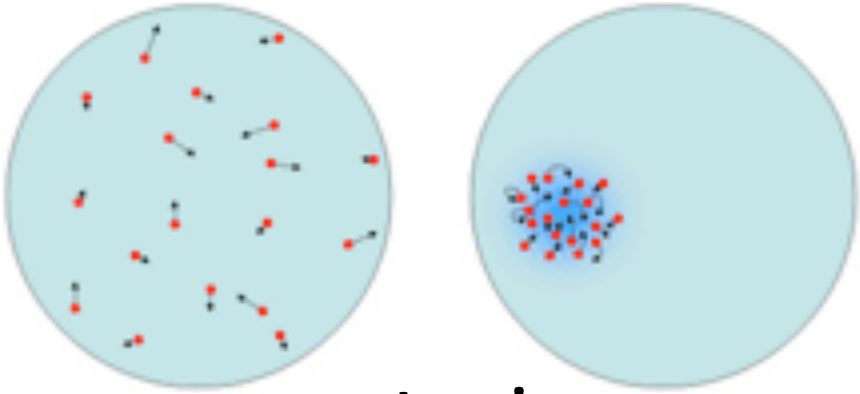
Entropia aumenta

Senza gravita’



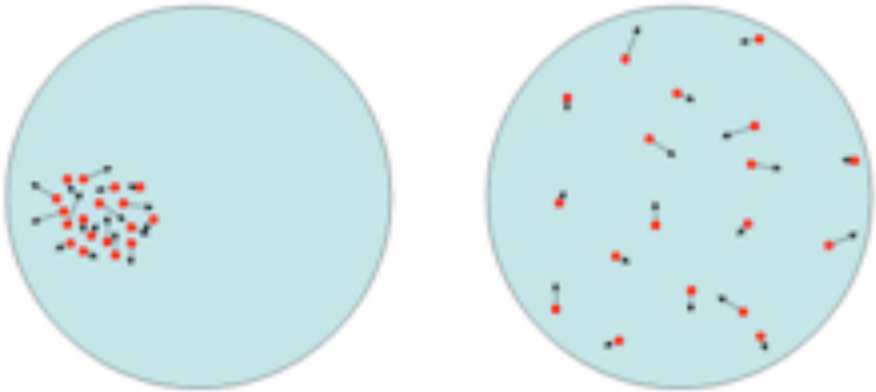
entropia

Con gravita’



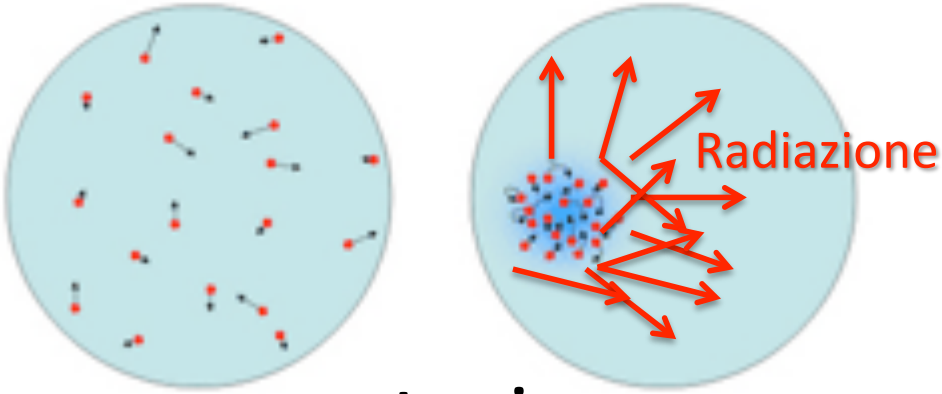
entropia

Senza gravita’



entropia

Con gravita’



entropia

Vita: diminuzione di entropia!! (maggiori informazioni → maggiore ordine)… Ma per farlo dissipiamo calore… → l'entropia dell'ambiente aumenta.

Aumento entropia →Freccia del tempo

Artur Eddington 1888-1944

Nonostante le leggi fisiche non distinguano la direzione del tempo, l'aumento di entropia indica il futuro

Quindi nel passato l'Universo intero aveva meno entropia: era piu' ordinato….

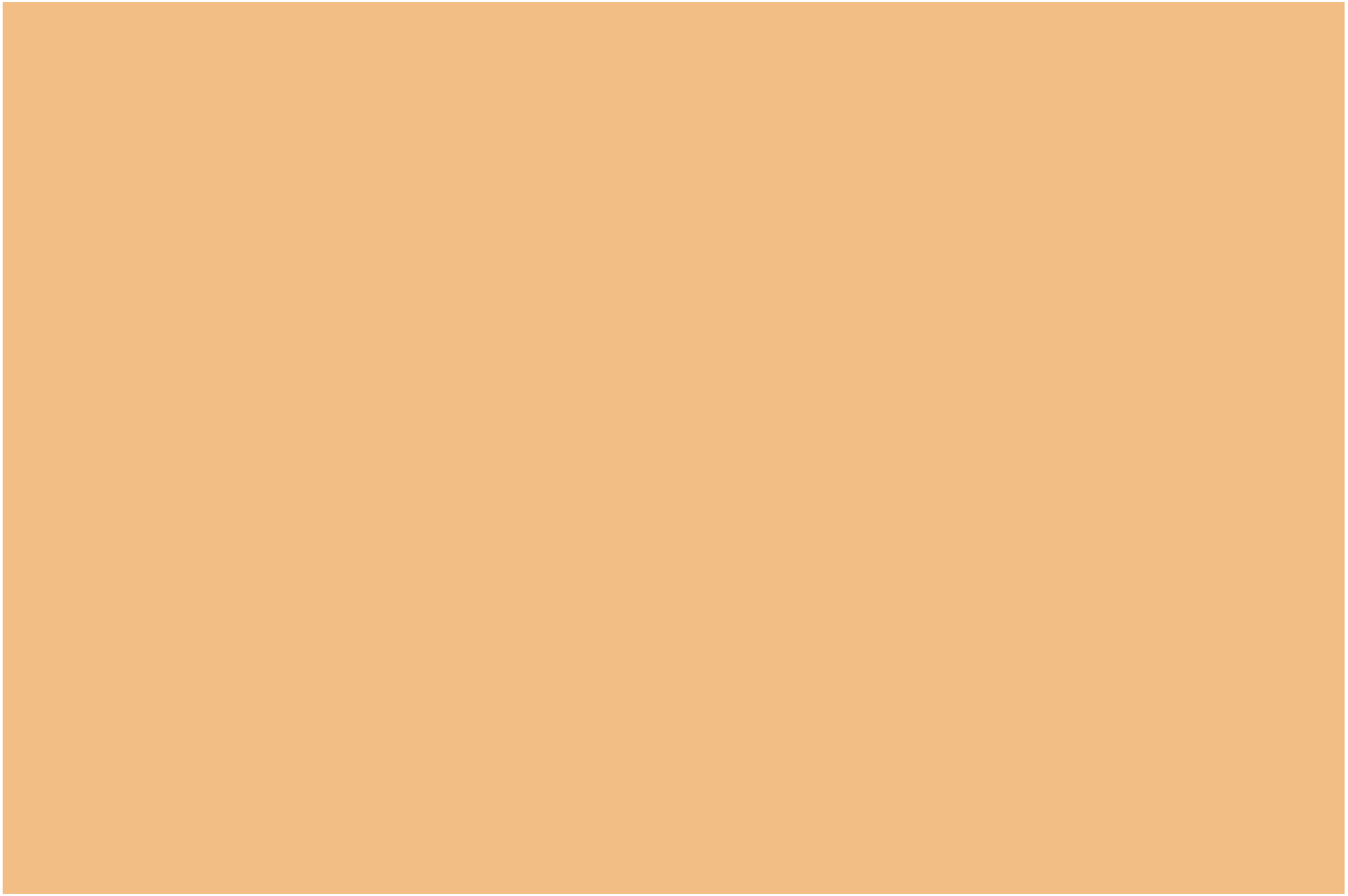
Ma come e' possibile??

COBE DMR Microwave Sky at 53 GHz

T=2.726 K = -270.424 C

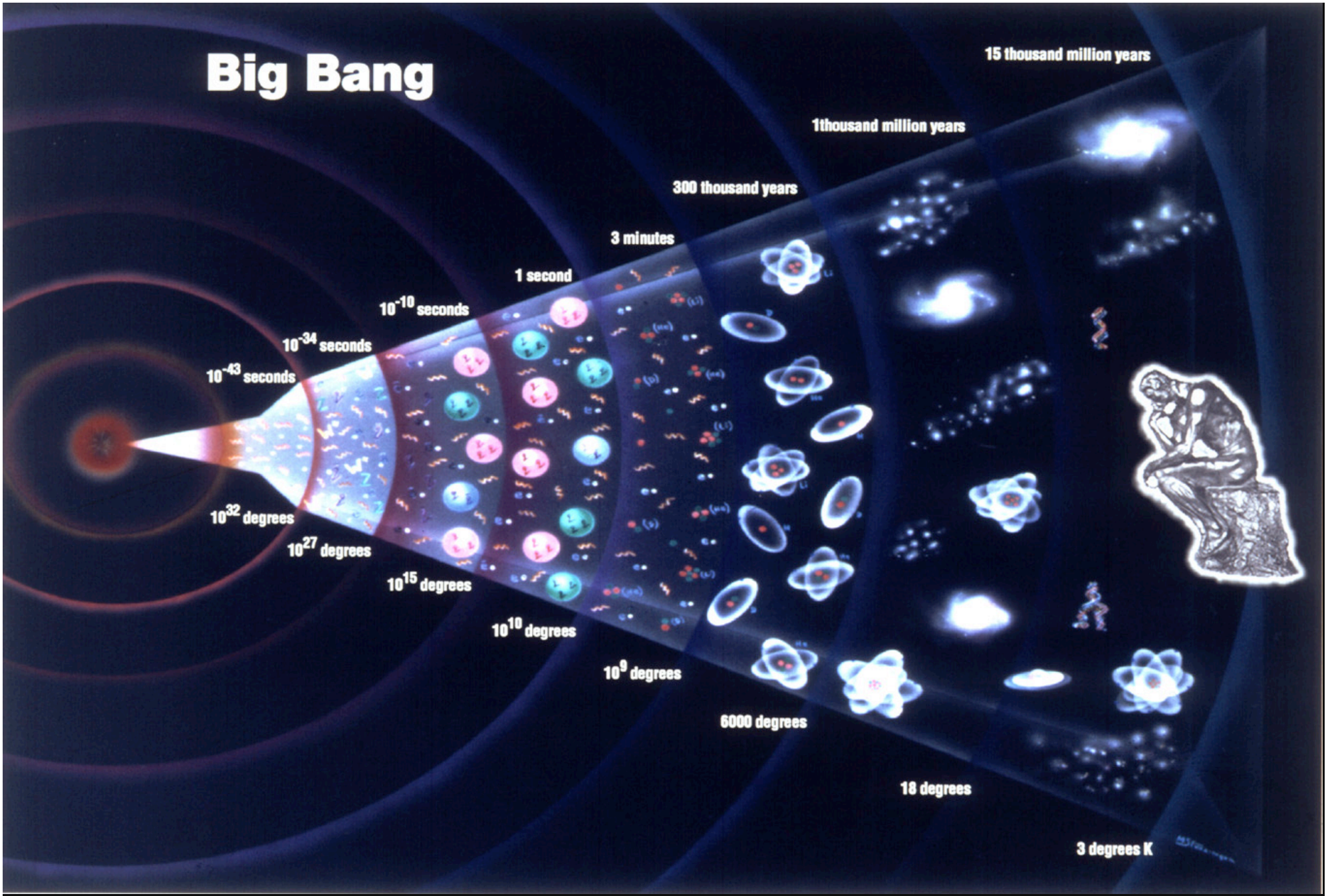
La stessa dappertutto, tranne deviazioni di
1 parte su centomila

All'inizio: molto calda, molto uniforme → grande entropia…

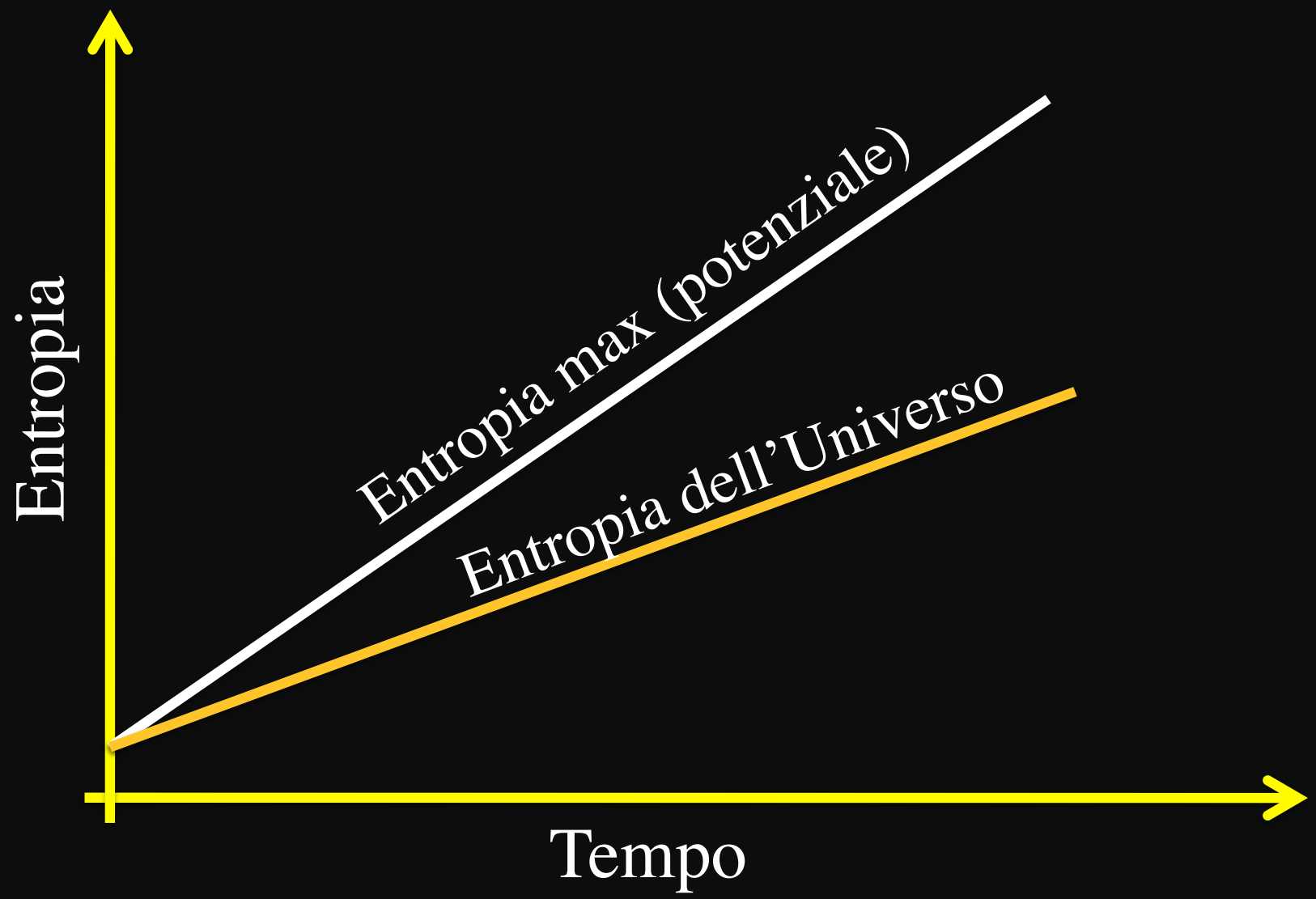


Radiazione termica (corpo nero) senza differenze
→grande miscuglio
→grande disordine
→grande entropia

→????


Big Bang
15 thousand million years
1thousand million years
300 thousand years
3 minutes
1 second
10^{-10} seconds
10^{-34} seconds
10^{-43} seconds
10^{32} degrees
10^{27} degrees
10^{15} degrees
10^{10} degrees
10^{9} degrees
6000 degrees
18 degrees
3 degrees K

L’Universo si espande! Lo spazio in piu’ permette piu’ “configurazioni”: piu’ modi in cui le particelle e la radiazione possono disporsi…



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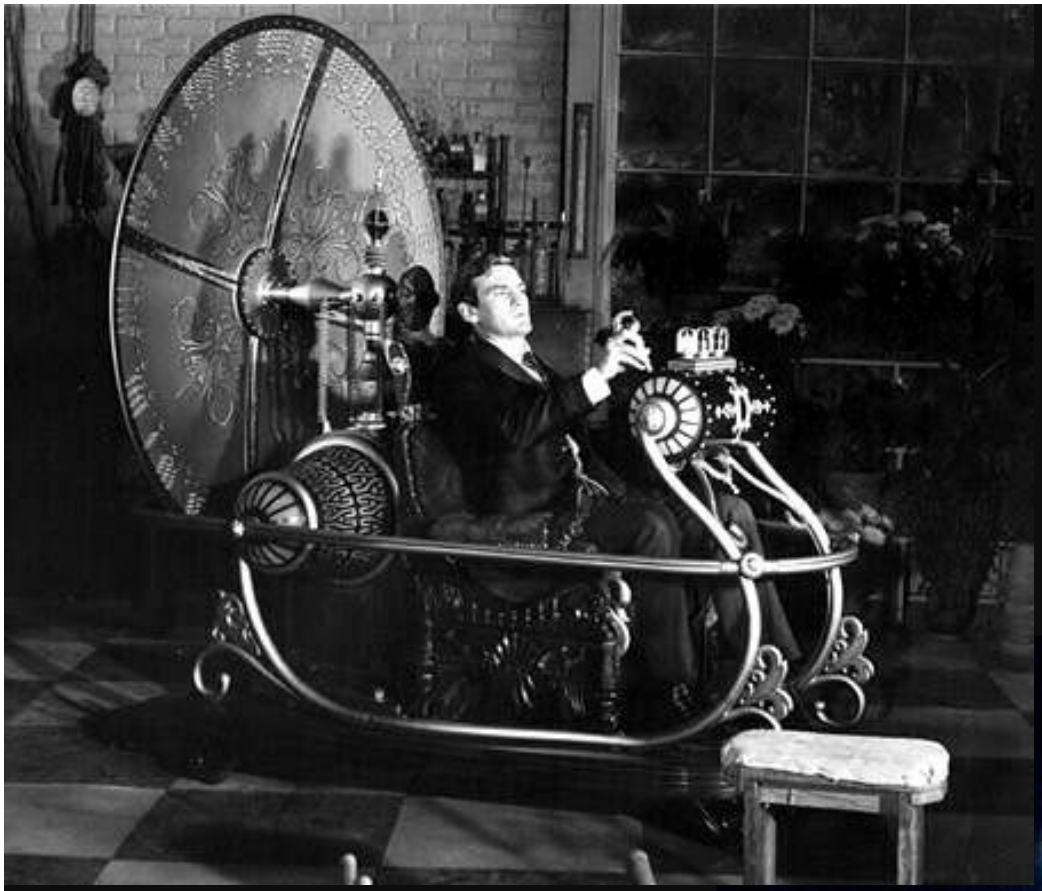
gettyimages

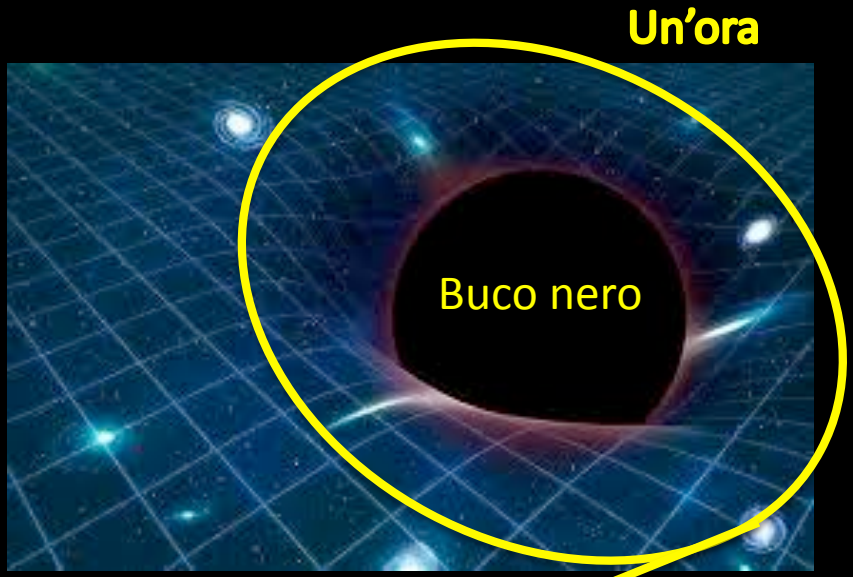
Viaggi nel tempo

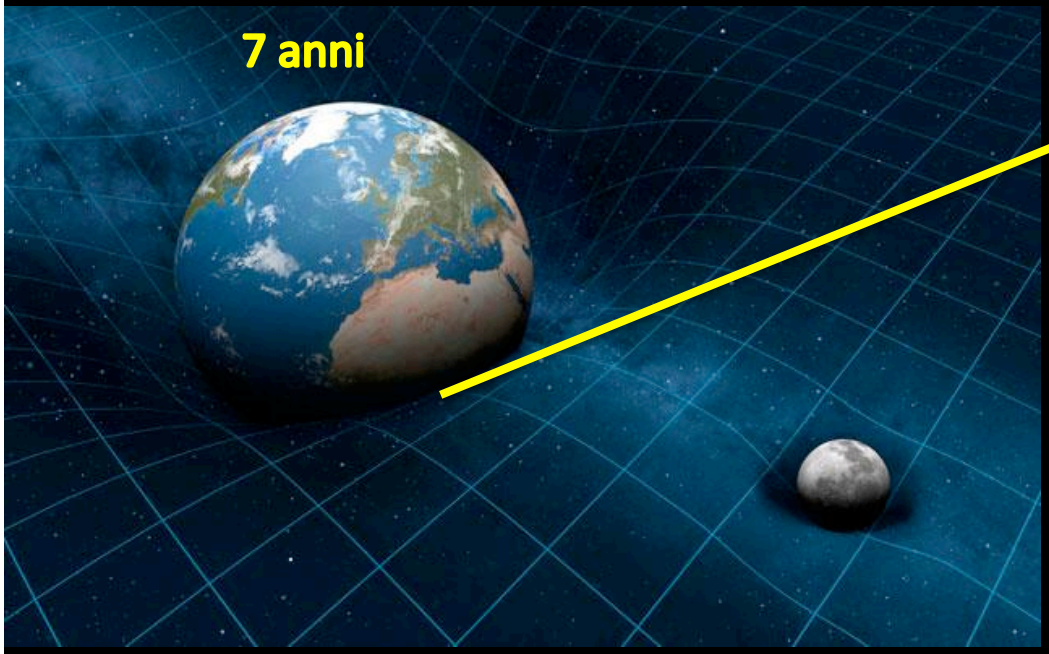


Viaggiare nel futuro…

- Non c’e` problema.
- Molti modi per farlo
- Non ci sono paradossi logici

Interstellar…





Sirio, 9 anni luce da noi

~18 anni per Leila e Luke

Sirio, 9 anni luce da noi

99.5% c

~2 anni per Han Solo

Viaggiare nel passato…

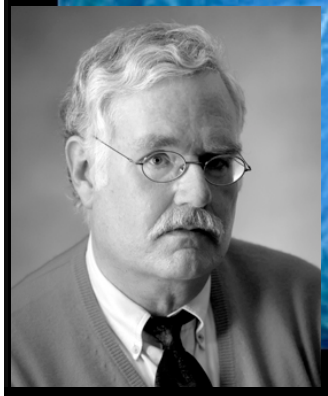
Assumiamo che:

- La realta` e` una e non modificabile
- Esiste un solo Universo

L’Universo rotante di Godel

Il Cilindro rotante di Tipler

Tipler Cylinder

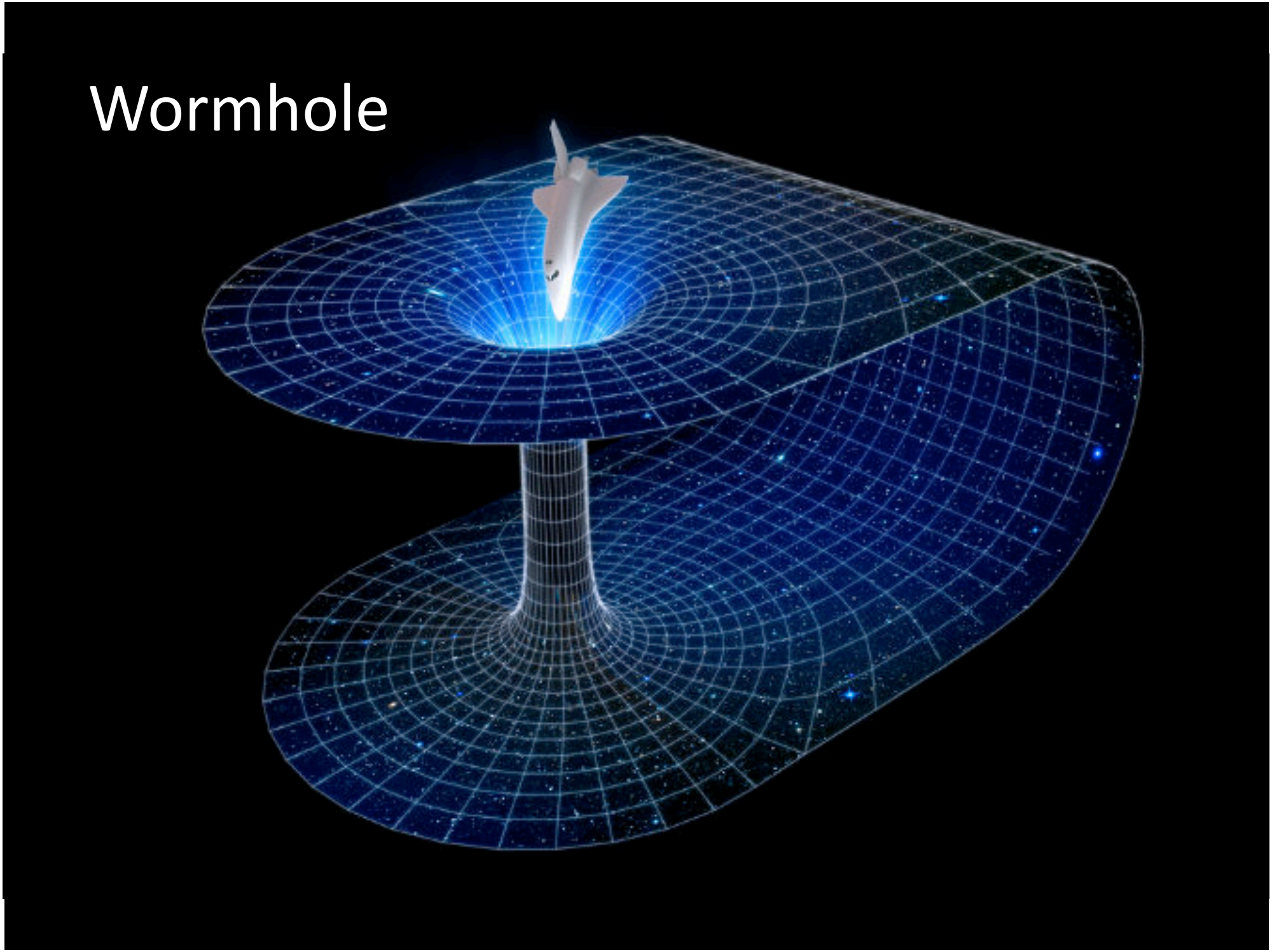


Frank Tipler

Tipler Cylinder: uses a massive and long cylinder spinning around its longitudinal axis.

The rotation creates a frame-dragging effect and fields of closed timelike curves traversable in a way to achieve subluminal time travel to the past.

Wormhole



1916 Ludwig Flamm

1935 Ponte di Einstein Rosen

1957 John Archibald Wheeler lo battezza “wormhole”

1916 Ludwig Flamm
1935 Ponte di Einstein Rosen
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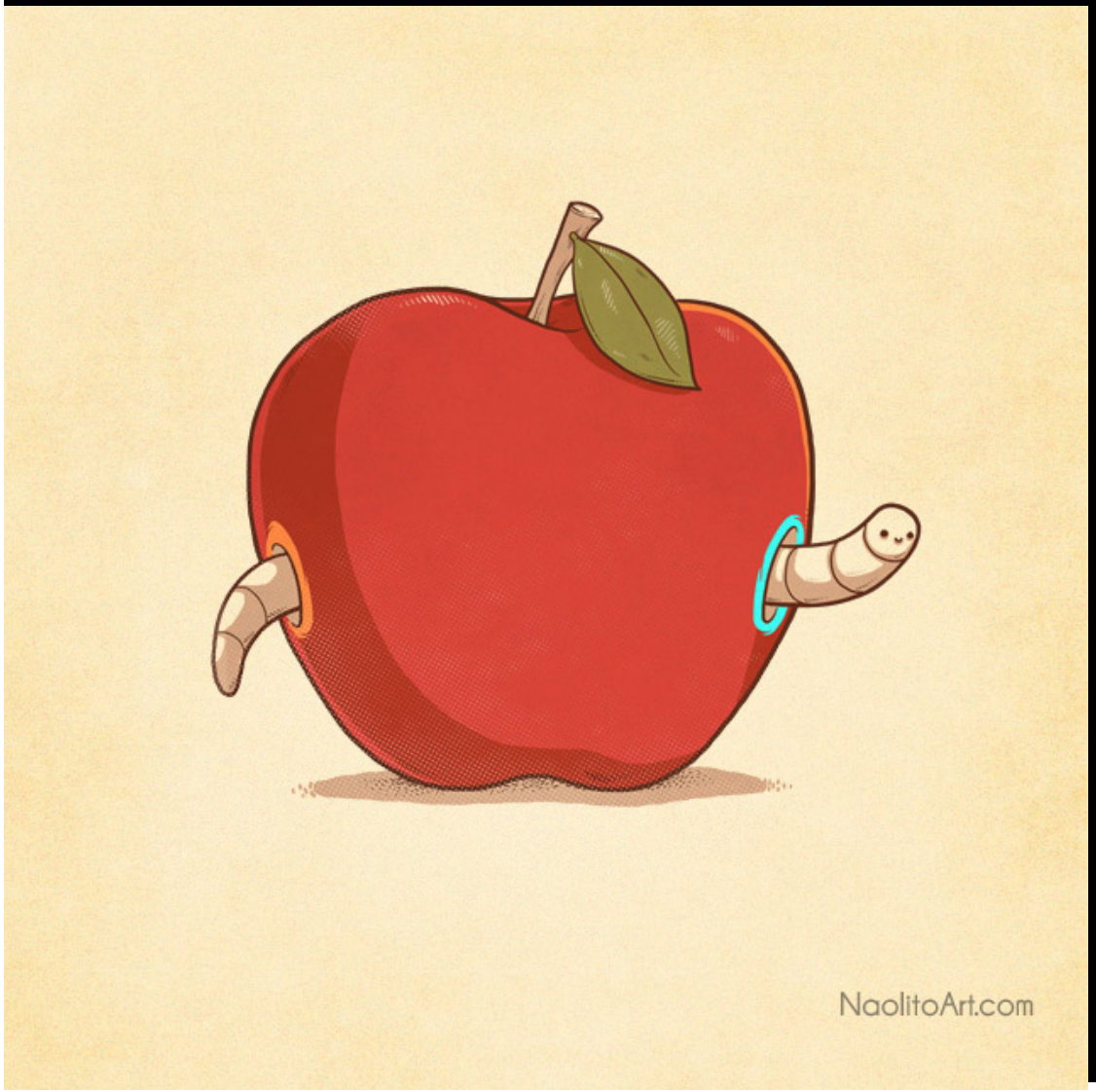

1916 Ludwig Flamm
1935 Ponte di Einstein Rosen
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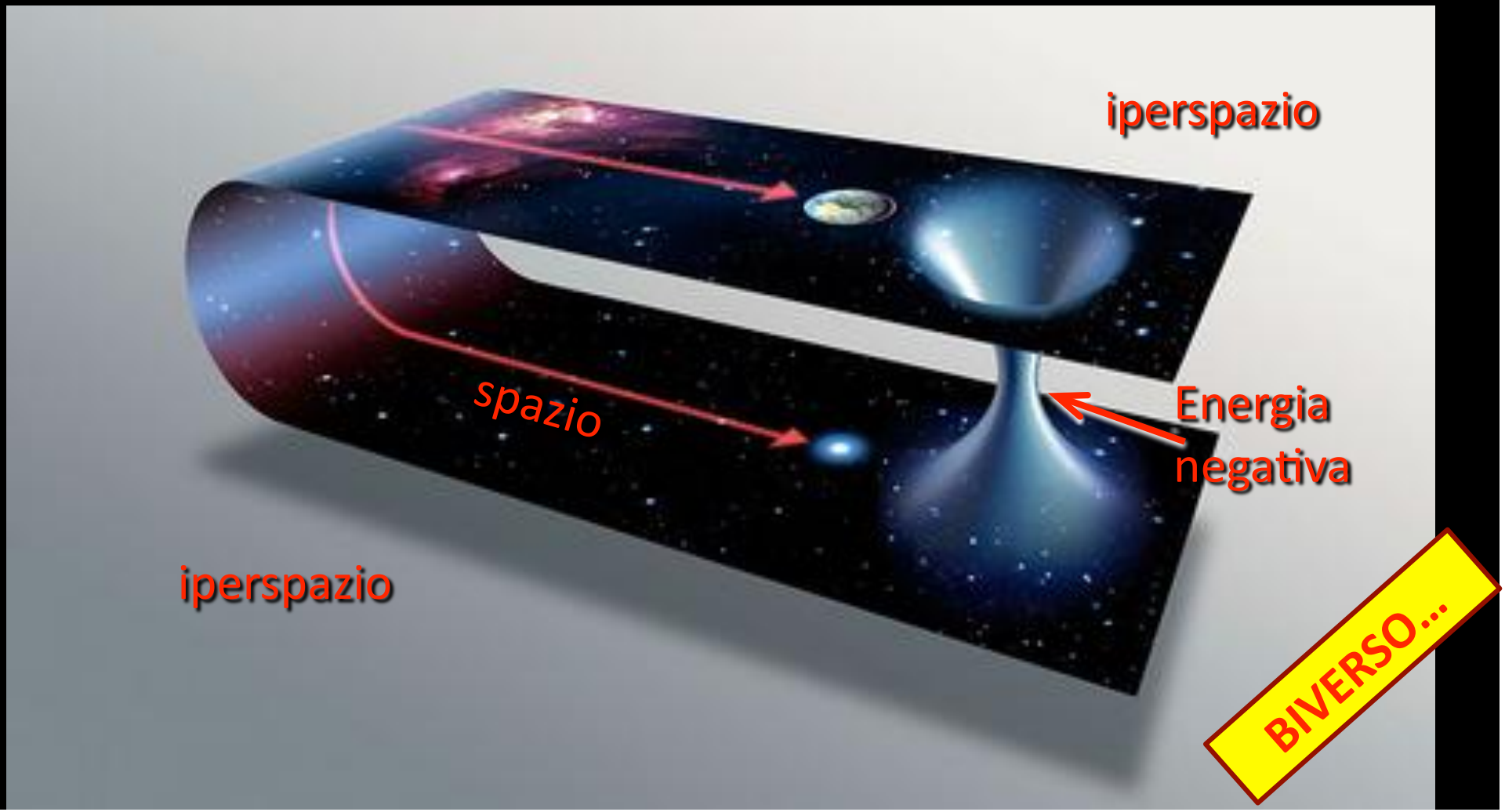
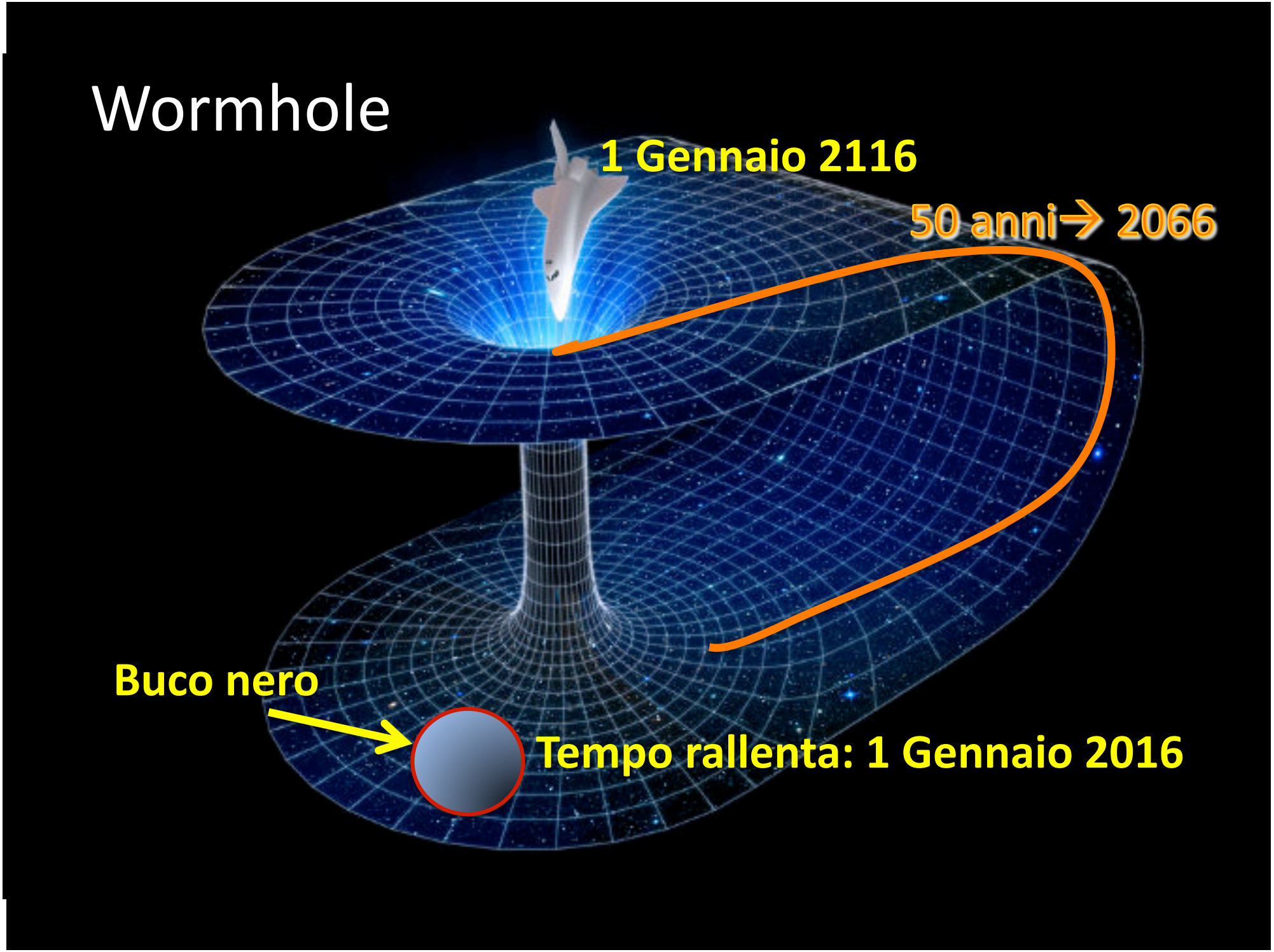
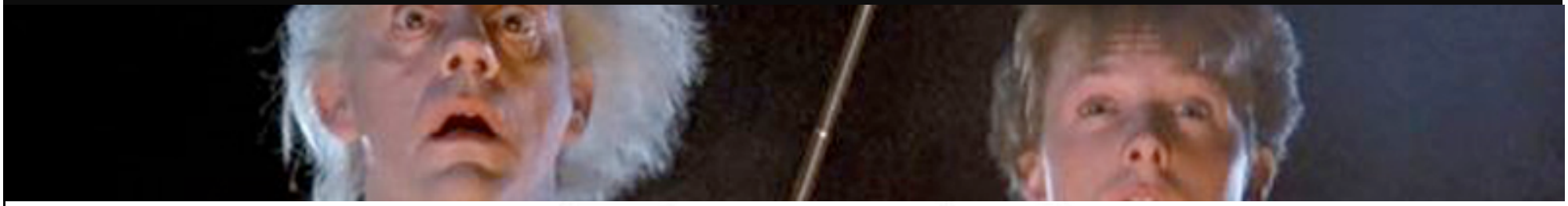
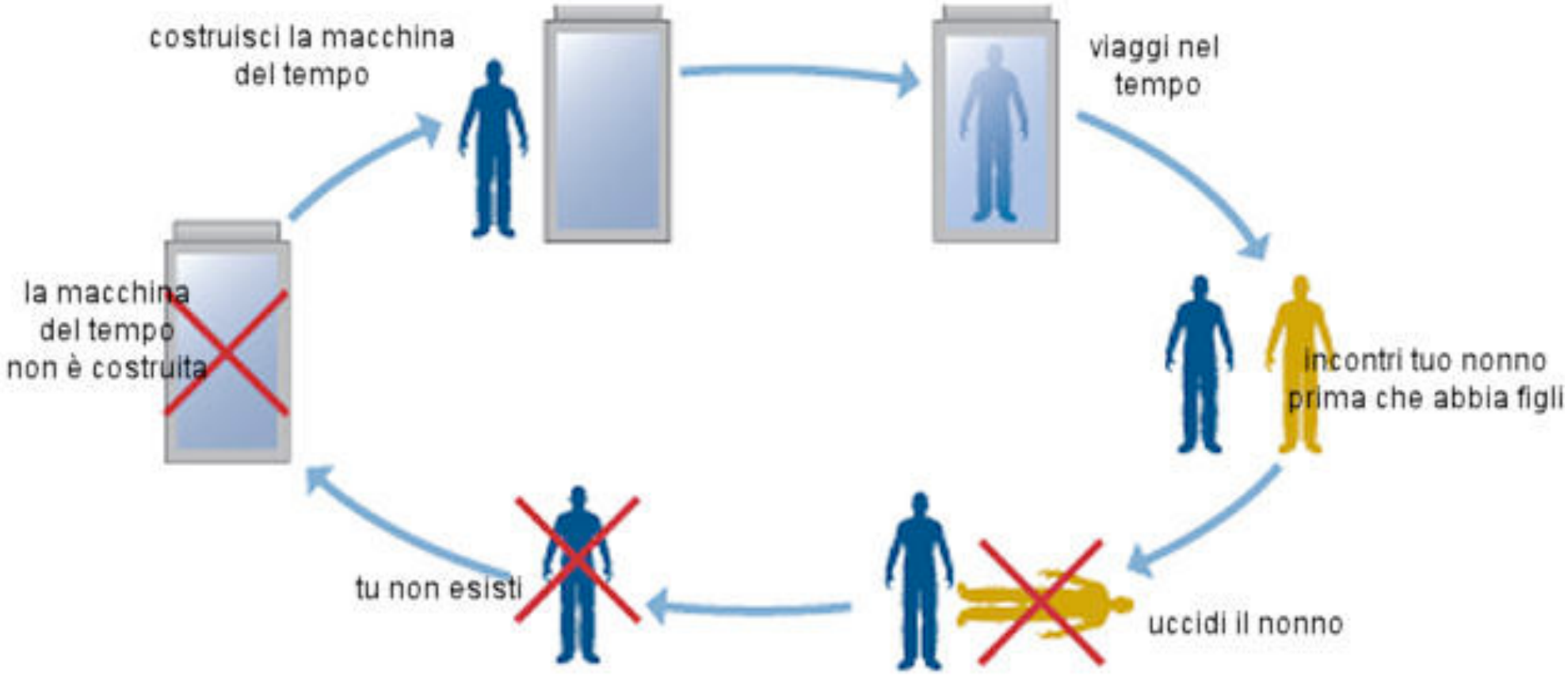


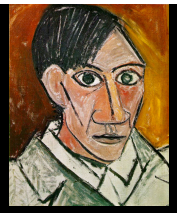
Wormhole


1 Gennaio 2116
50 anni→ 2066
Buco nero
Tempo rallenta: 1 Gennaio 2016

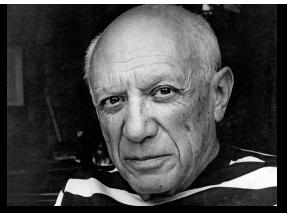
Paradosso del nonno



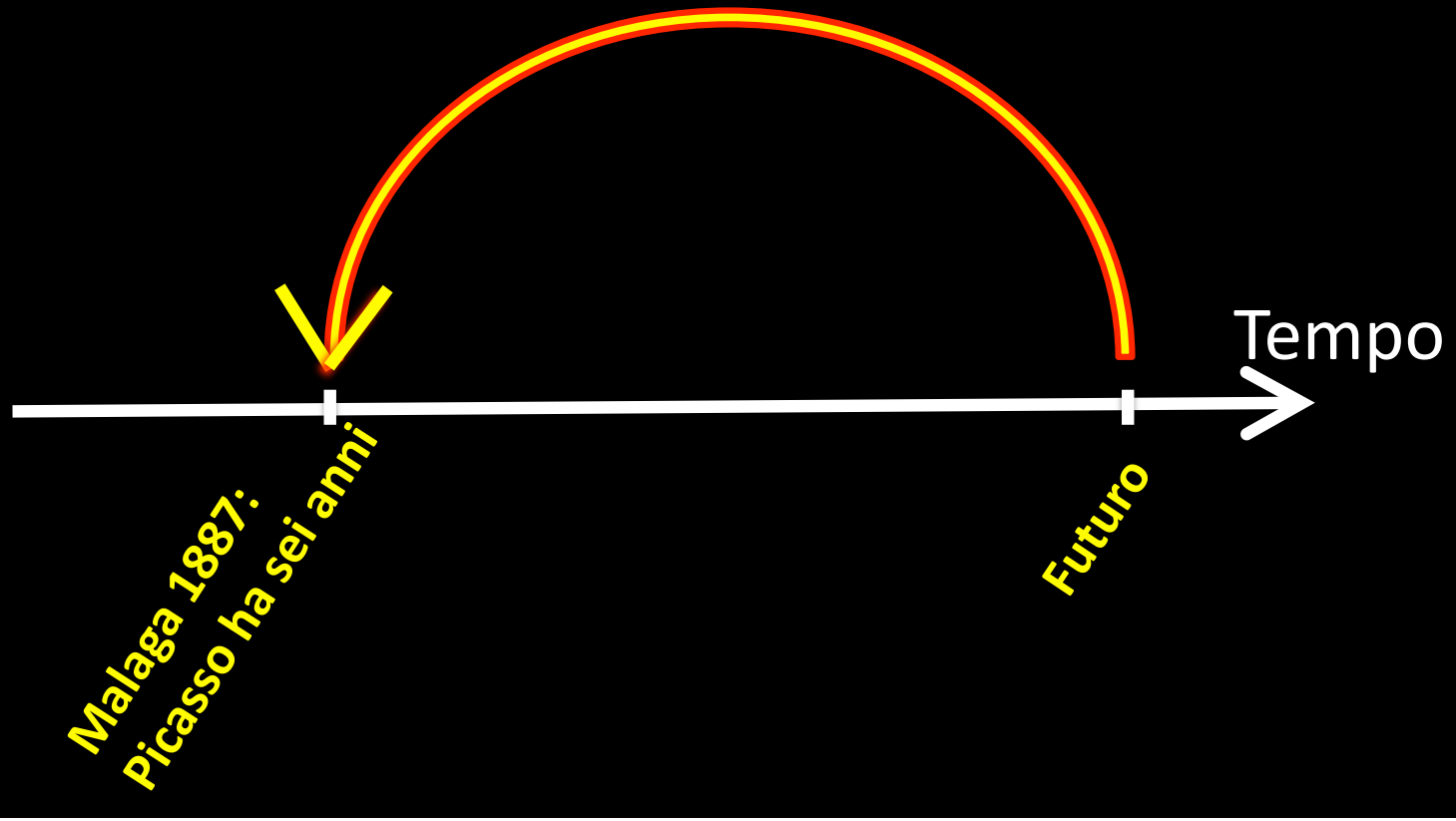




Paradosso di Picasso



Catalogo opere di Picasso



Conclusioni

- Siamo ancora lontani dal capire cos'e' il tempo
- Perche' tante dimensioni spaziali, ma solo una temporale?
- Il tempo e' quantizzato?
- E' una illusione?

- Forse pero' nei prossimi 20 anni ci sara' una svolta dalla gravita' quantistica....

Grazie per l'attenzione

Science of Interstellar	Kip Thorne 2014 Northon
Il fiume del tempo	Igor Novikov 2000 Longanesi
Buchi neri e salti temporali	Kip Thorne (1994) 2013 Castelvecchi
Costruire la macchina del tempo	John Gribbin 1992 Aporie
Tempo. Guida per viaggiatori	Clifford Pickover 1998 Cortina
I misteri del tempo	Paul Davies 1996 Mondadori
La nascita del tempo	Ilja Prigogine 1988 Bompiani
The arrow of time	Peter Coveney & Roger Highfield 1990 Fawcett
La freccia del tempo	Autori Vari 1997 Cuen-SISSA
L'universo elegante	Brian Green 2000 Einaudi
La trama del Cosmo	Brian Green 2004 Einaudi
La realta' nascosta	Brian Green 2012 Einaudi
Sette brevi lezioni di fisica	Carlo Rovelli 2015 Adelfi
Che cos'e` la vita?	Erwin Schrodinger 1944 (1955) Adelfi