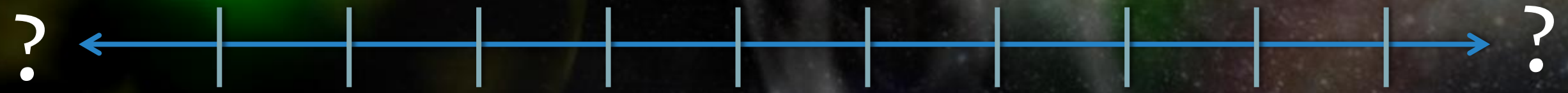
Les deux infinis

Les différentes échelles de l'univers

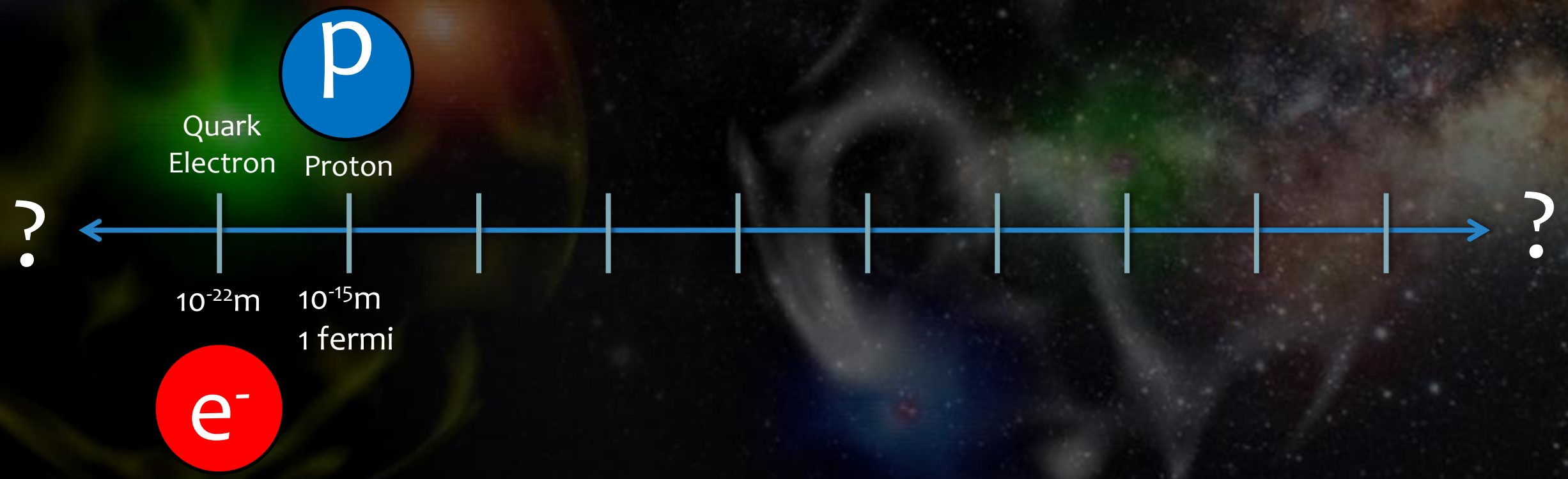


Les différentes échelles de l'univers

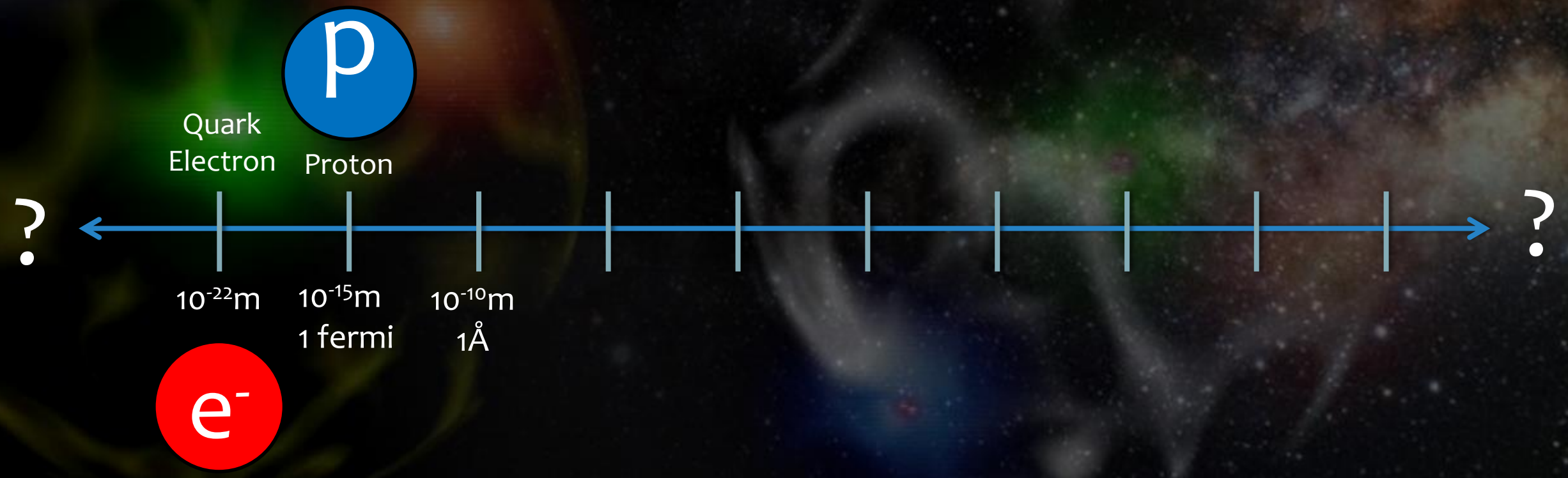
Les différentes échelles de l'univers

Les différentes échelles de l'univers

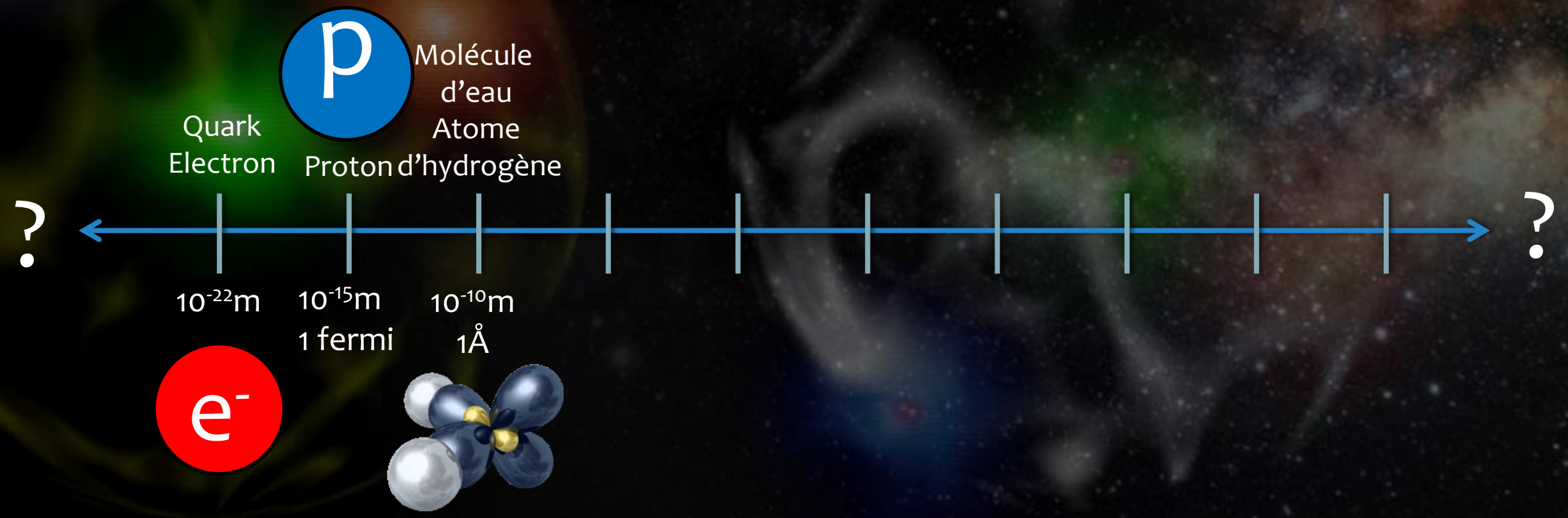
Les différentes échelles de l'univers



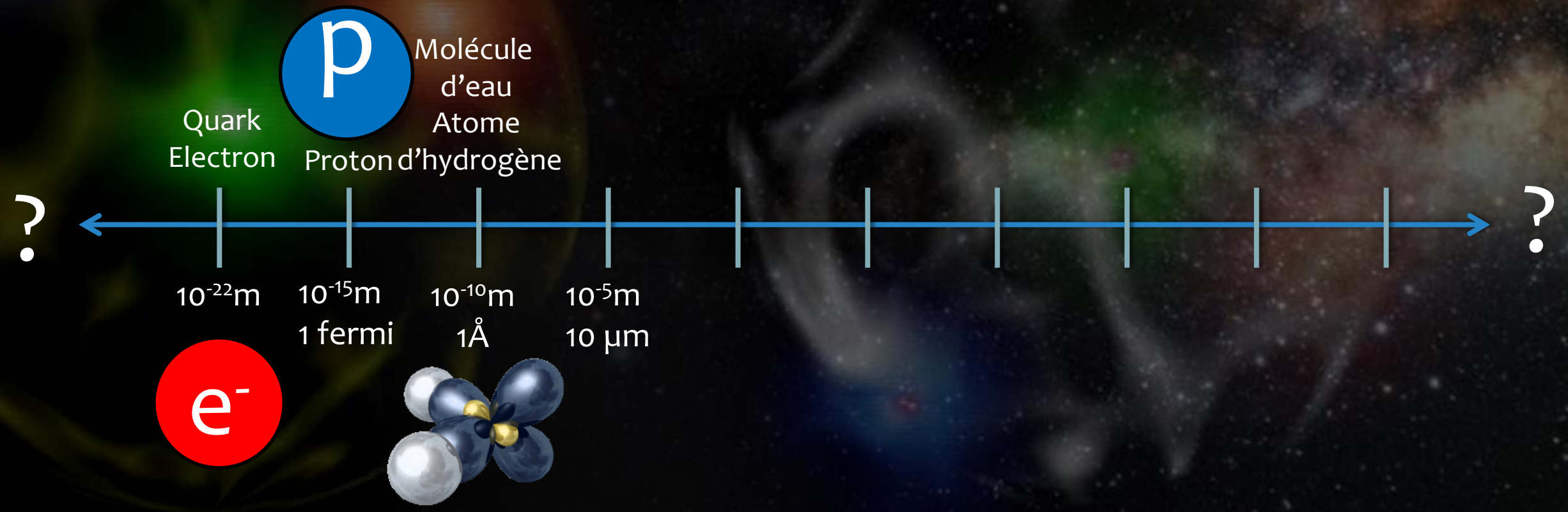
Les différentes échelles de l'univers



Les différentes échelles de l'univers



Les différentes échelles de l'univers



Les différentes échelles de l'univers

Molécule d'eau

Chromosome

Quark

Atome

Globule rouge

Electron

Proton

d'hydrogène

?

?

10^{-22}m

10^{-15}m
1 fermi

10^{-10}m
1Å

10^{-5}m
10 µm

Les différentes échelles de l'univers

Molécule d'eau

Chromosome

Quark

Atome

Globule rouge

Electron

Proton

d'hydrogène

?

?

10^{-22}m

10^{-15}m

1 fermi

10^{-10}m

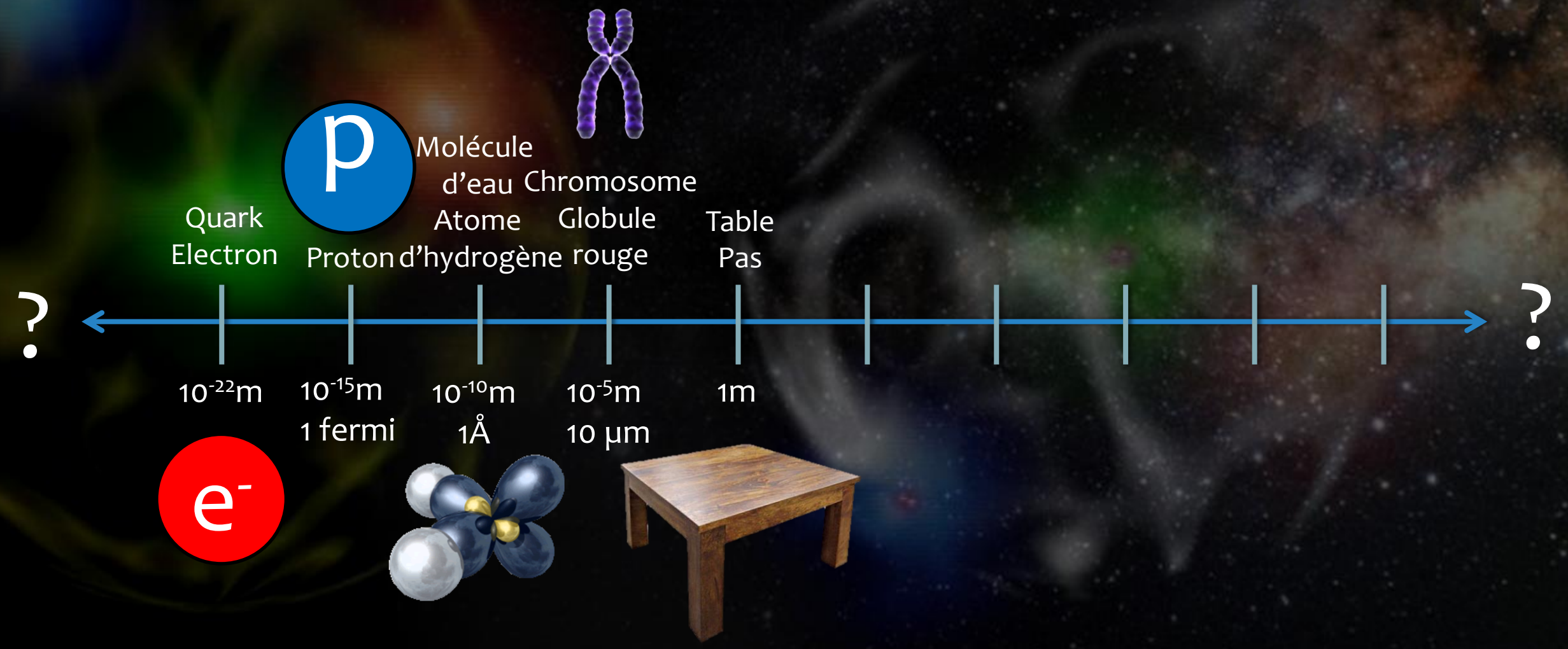
1Å

10^{-5}m

10 µm

1m

Les différentes échelles de l'univers



Les différentes échelles de l'univers

Molécule d'eau

Chromosome

Quark

Atome

Globule rouge

Table

Electron

Proton

d'hydrogène

Pas

?

?

10^{-22}m

10^{-15}m
1 fermi

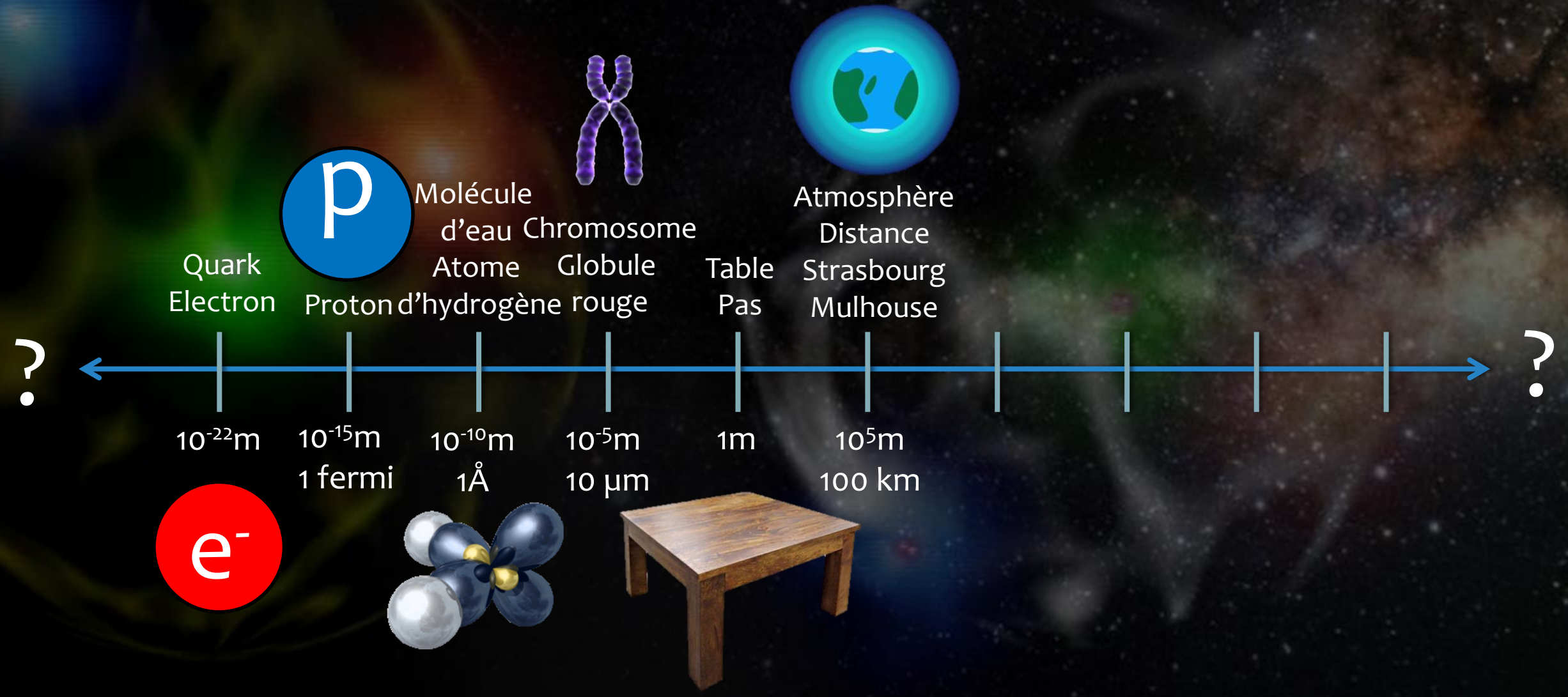
10^{-10}m
1Å

10^{-5}m
10 µm

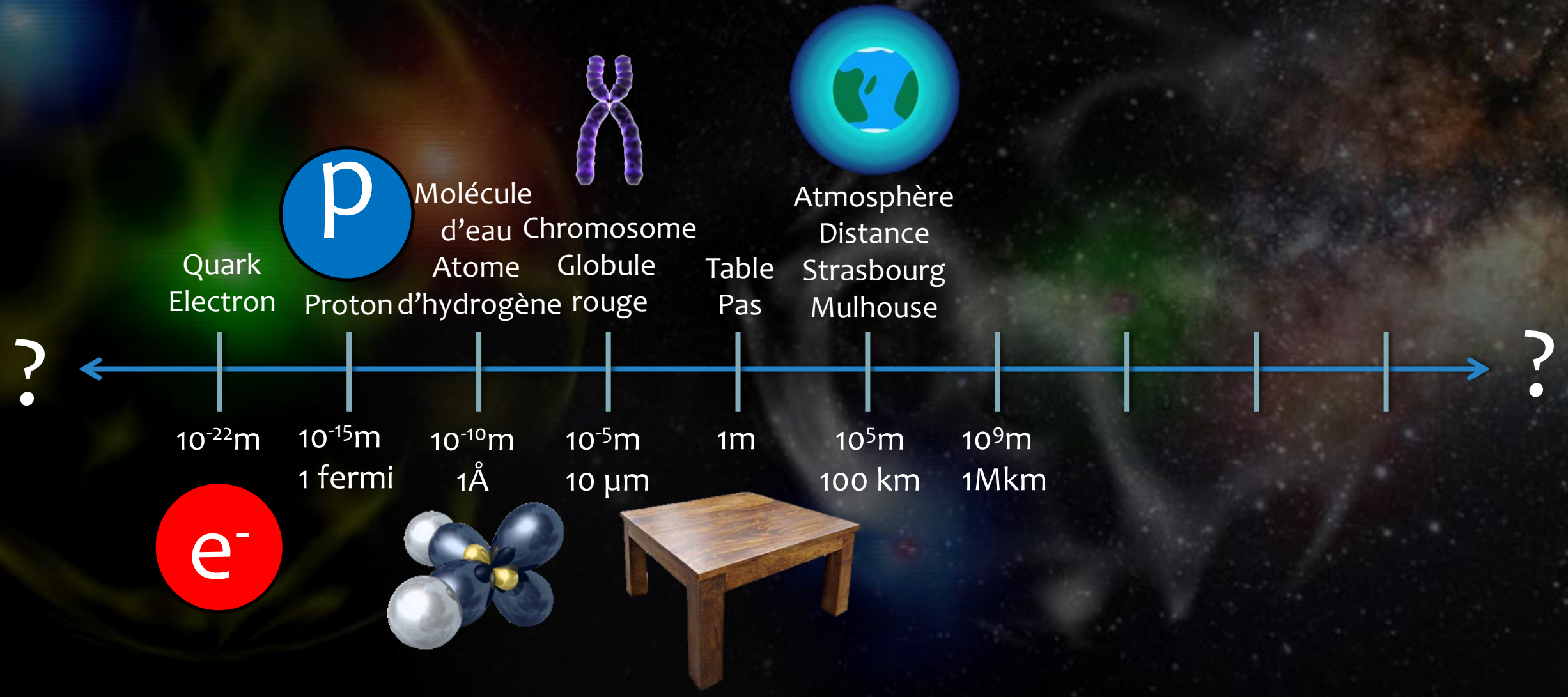
1m

10^{5}m
100 km

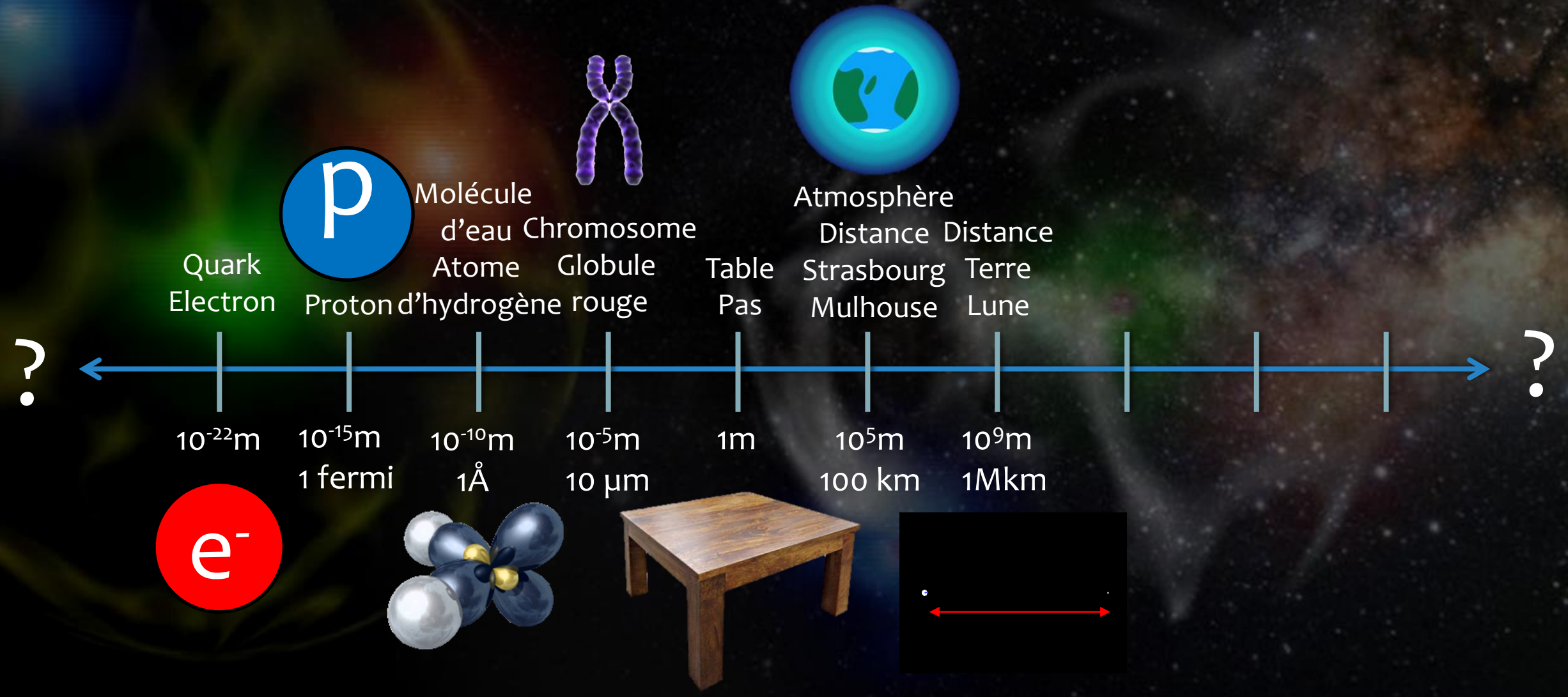
Les différentes échelles de l'univers



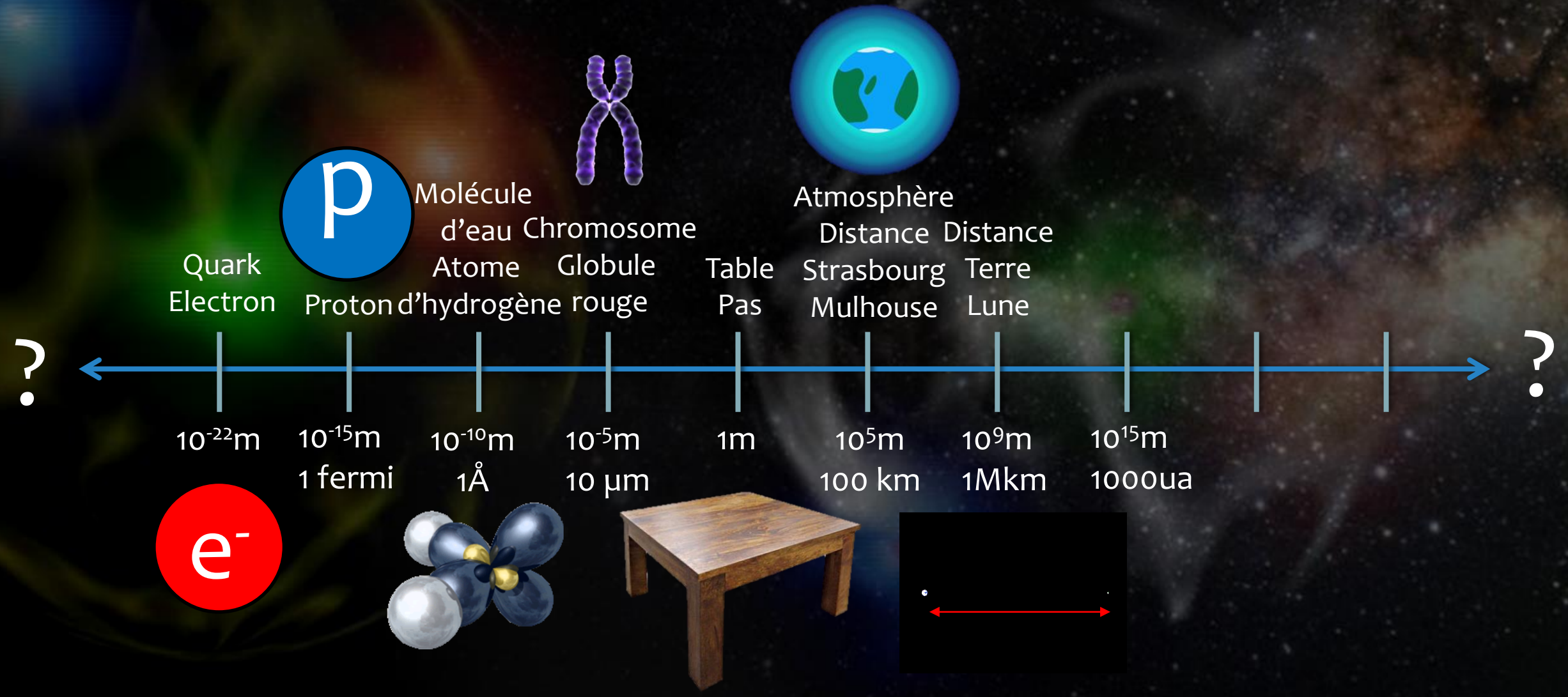
Les différentes échelles de l'univers



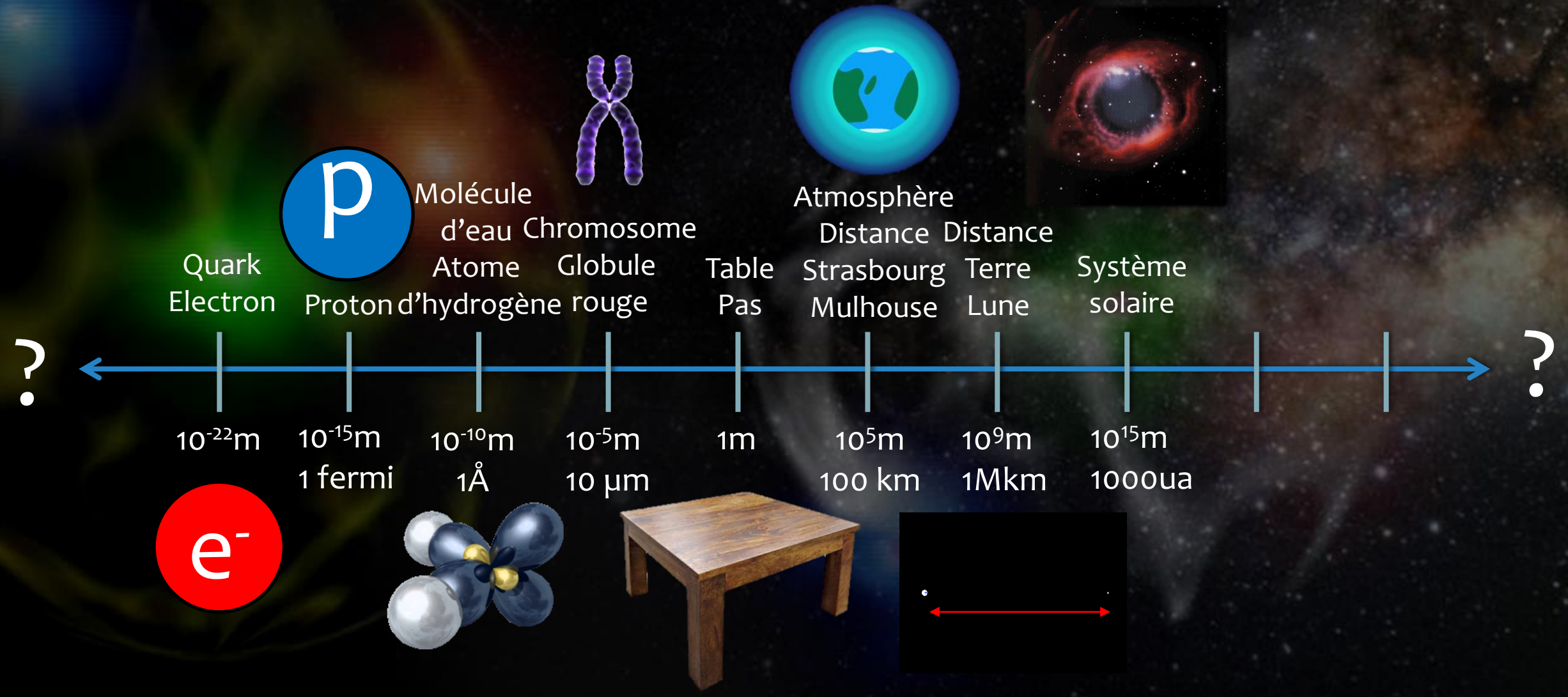
Les différentes échelles de l'univers



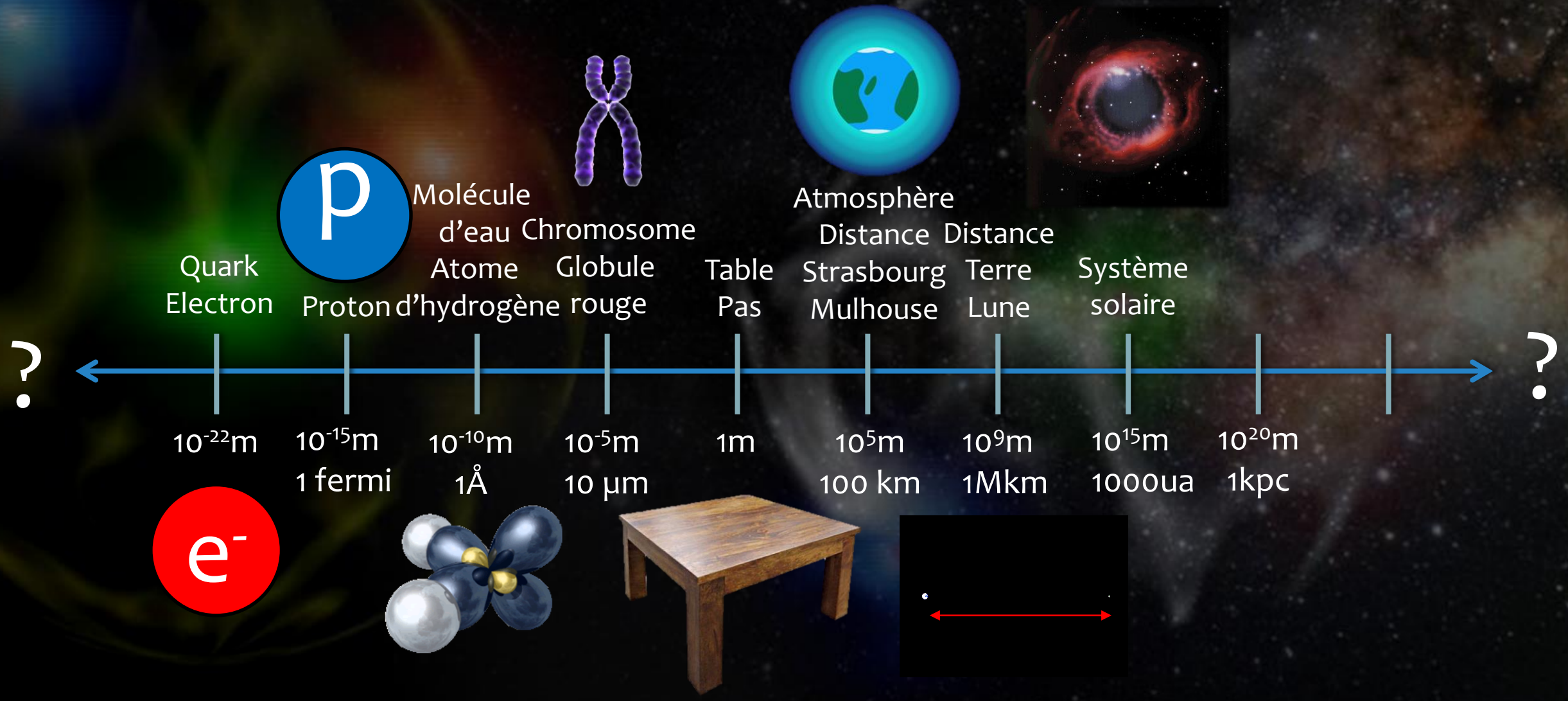
Les différentes échelles de l'univers



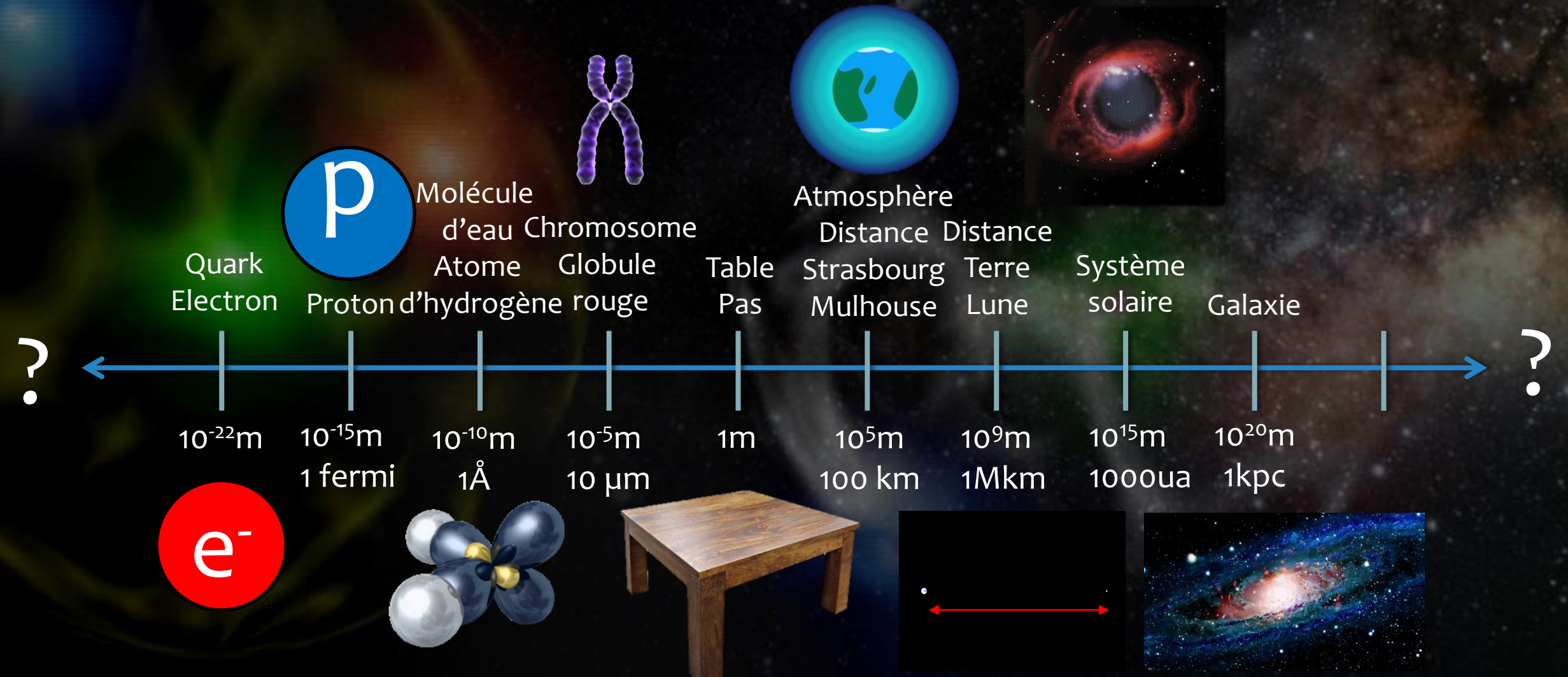
Les différentes échelles de l'univers



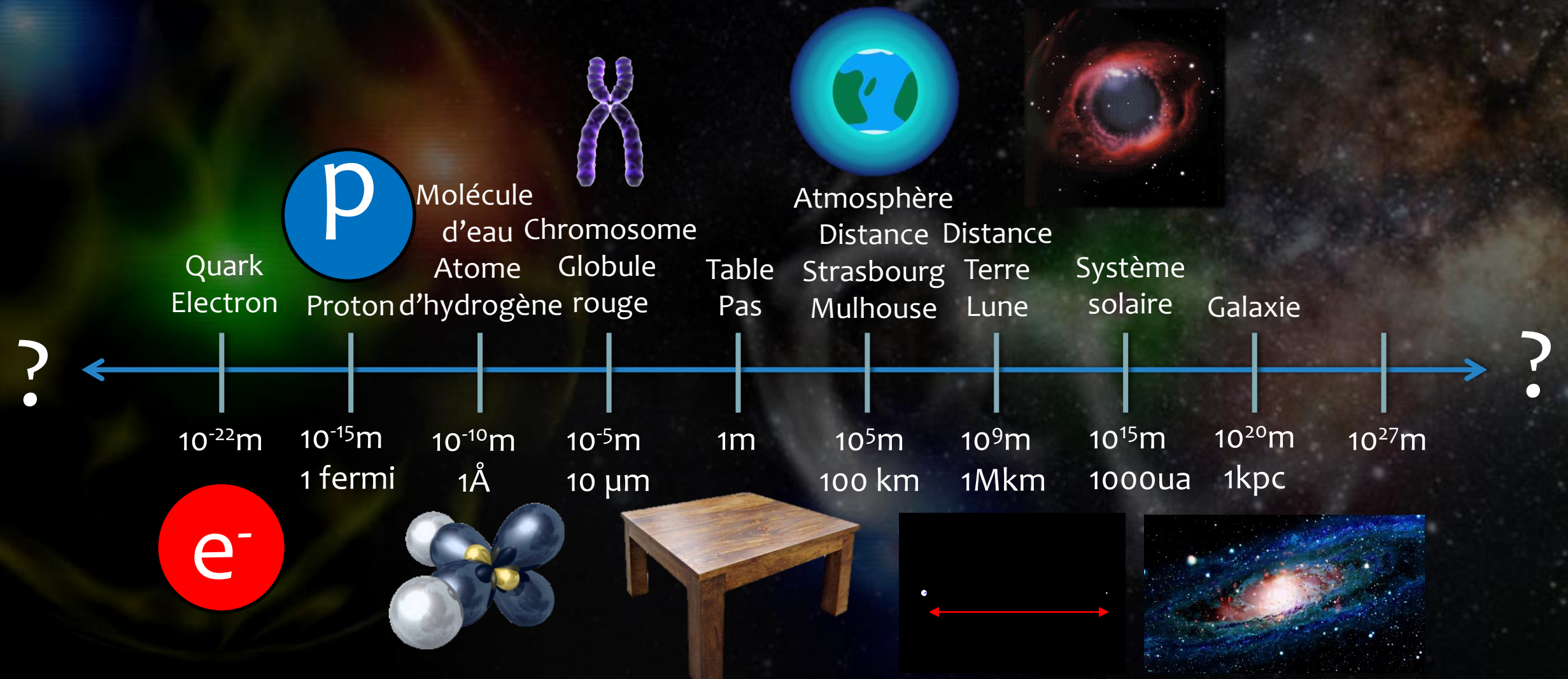
Les différentes échelles de l'univers



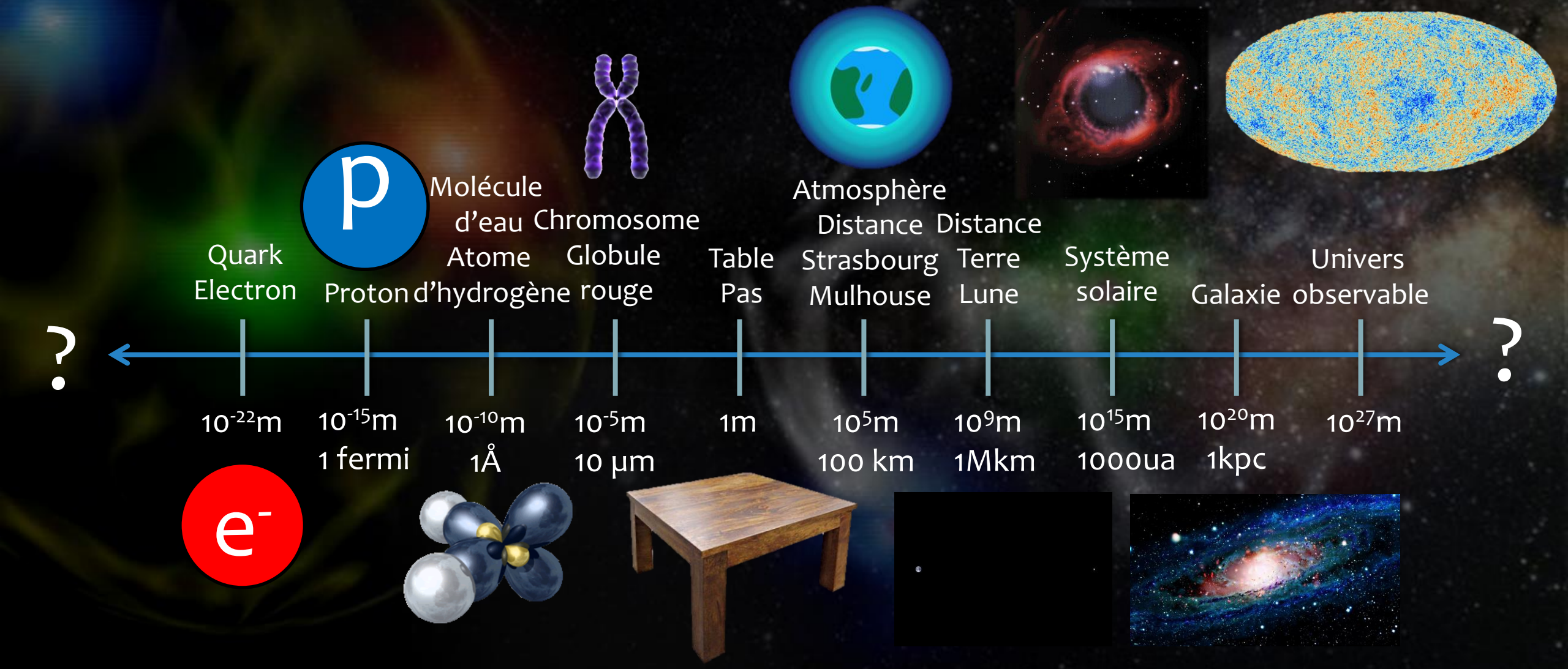
Les différentes échelles de l'univers



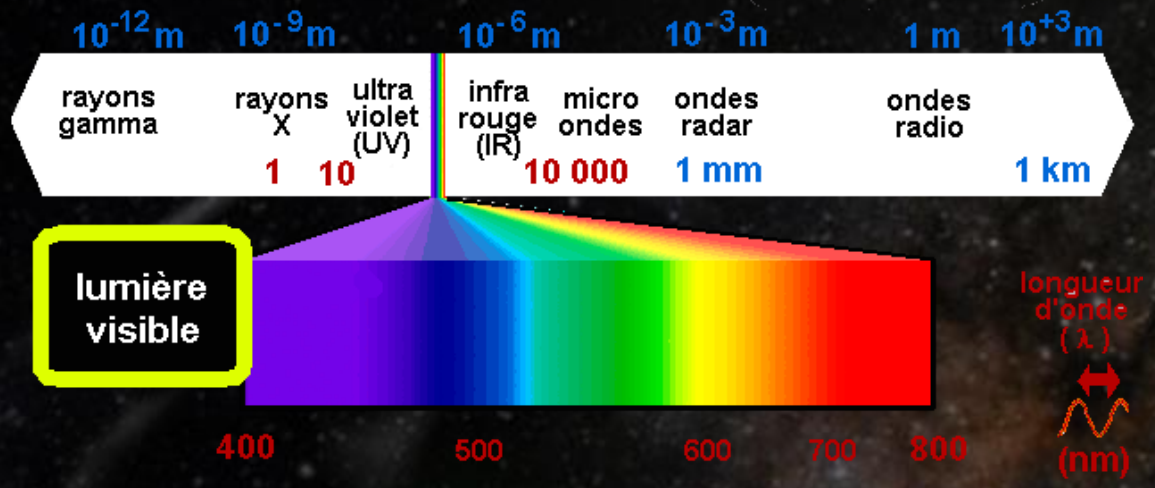
Les différentes échelles de l'univers



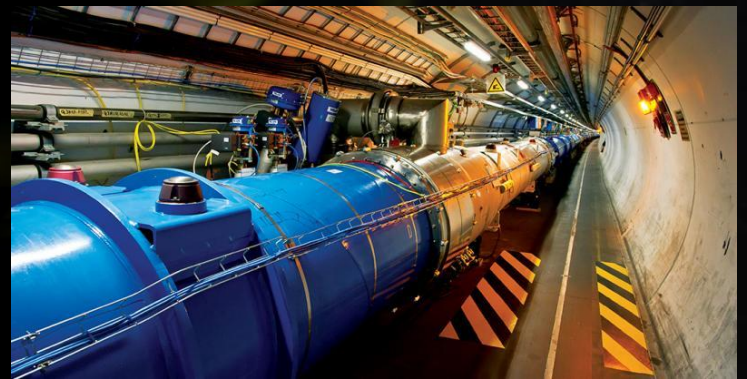
Les différentes échelles de l'univers



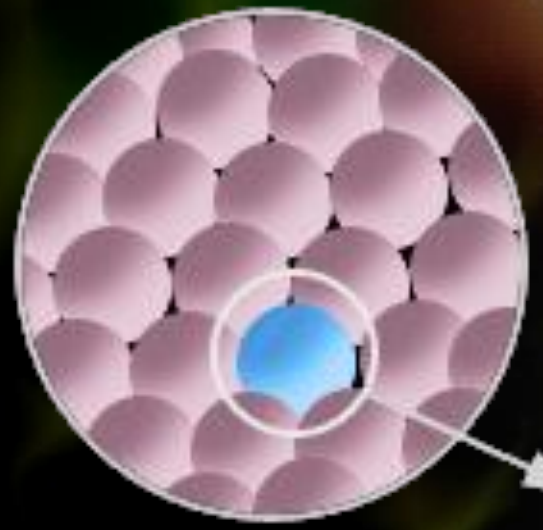
Voir l'infiniment petit

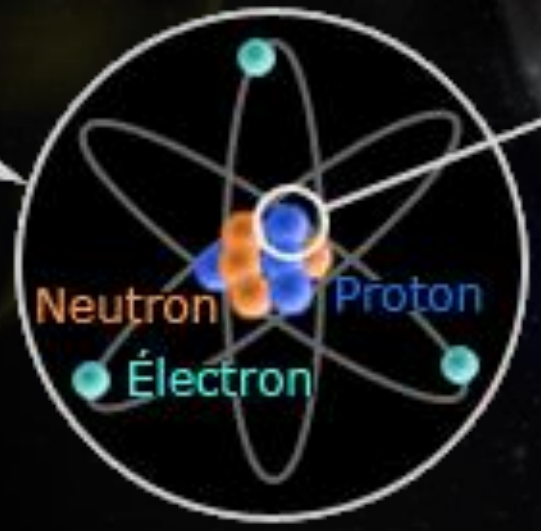


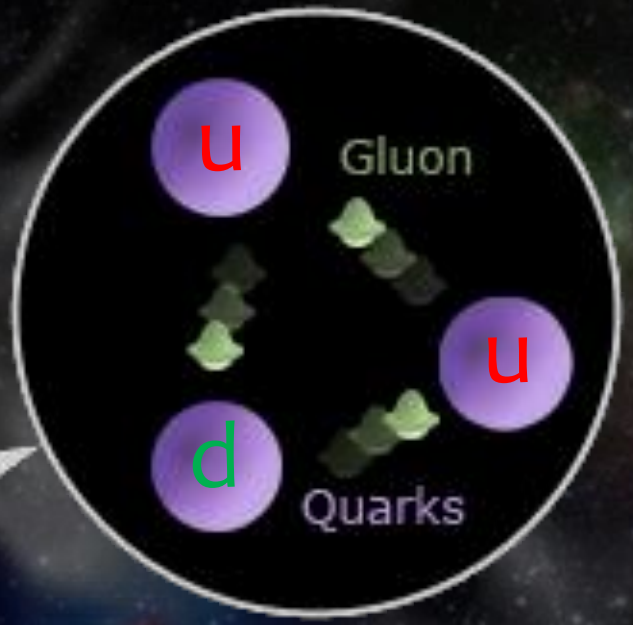
- Taille de l'objet visible > longueur d'onde λ du rayonnement
- Objets plus petits → rayonnement de plus haute énergie : $E = h\nu = hc/\lambda$
- Lumière visible ≈ 1 eV
- Microscope Electronique à Balayage = 15 keV
- Large Hadron Collider (LHC) = 13 TeV



Composition de la matière







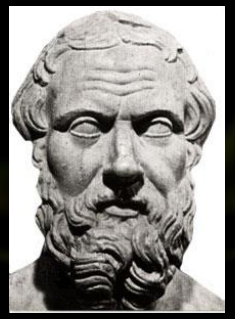
Nucléon
(proton et neutron)

- Trois particules pour la matière ordinaire :
  - Quark down
  - Quark up
  - Electron
- Proton : uud
- Neutron : udd

Histoire de la matière

Démocrite
Atome =
particule
indivisible
de matière

-400



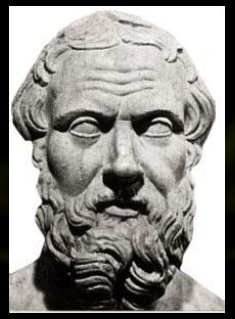
Histoire de la matière

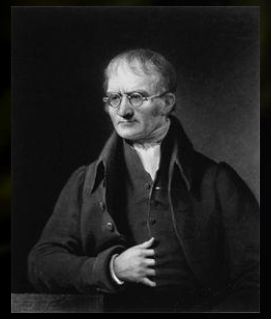
Démocrite
Atome =
particule
indivisible
de matière

Dalton
matière
composée
d'atomes
de masses
≠

-400

1811





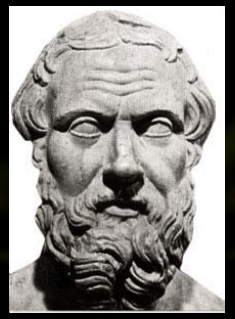
Histoire de la matière

Démocrite
Atome =
particule
indivisible
de matière

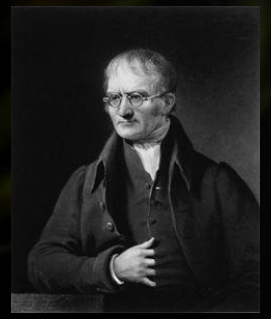
Dalton
matière
composée
d'atomes
de masses
≠

Thomson
électron

-400



1811



1896

Histoire de la matière

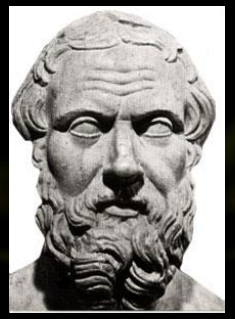
Démocrite
Atome =
particule
indivisible
de matière

Dalton
matière
composée
d'atomes
de masses
≠

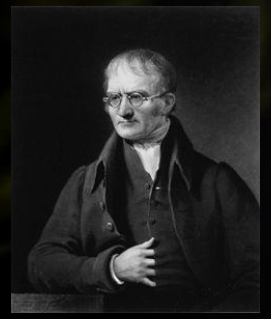
Thomson
électron

Rutherford
noyau
Perrin
atomes et
molécules

-400

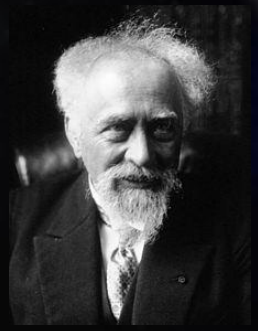


1811



1896

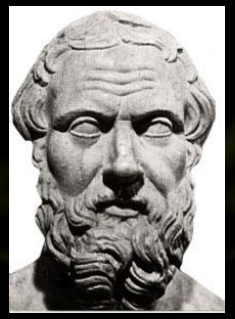
1911



Histoire de la matière

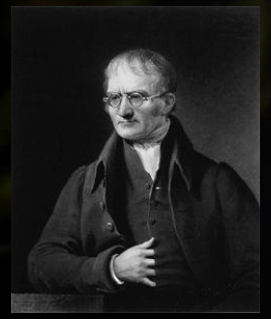
Démocrite
Atome =
particule
indivisible
de matière

-400



Dalton
matière
composée
d'atomes
de masses
≠

1811

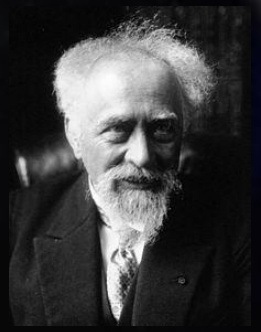


Thomson
électron

1896

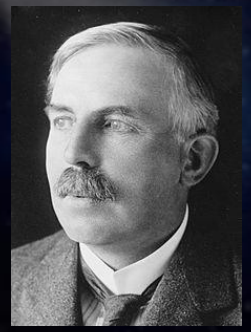
Rutherford
noyau
Perrin
atomes et
molécules

1911



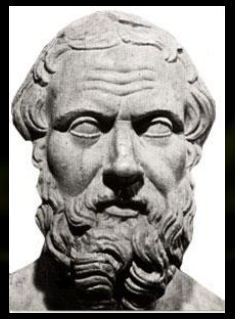
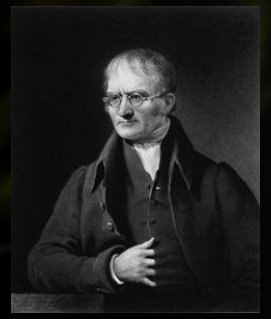
Rutherford
proton

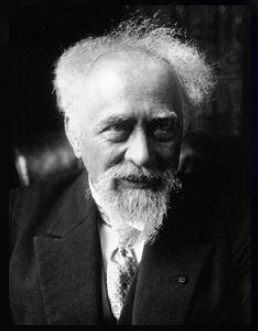
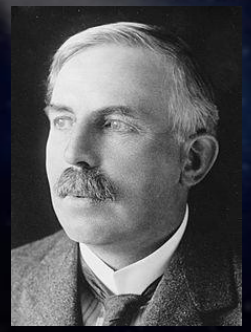
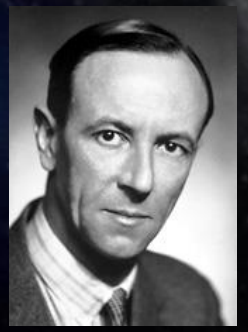
1919



Histoire de la matière

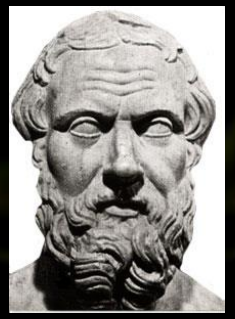
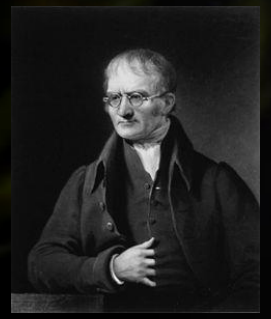
-400	1811	1896	1911	1919	1932
Démocrite Atome = particule indivisible de matière	Dalton matière composée d'atomes de masses ≠	Thomson électron	Rutherford noyau Perrin atomes et molécules	Rutherford proton	Chadwick neutron

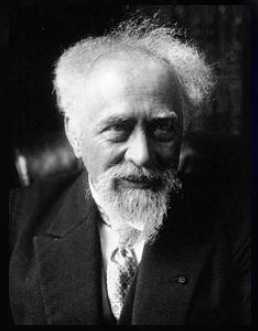
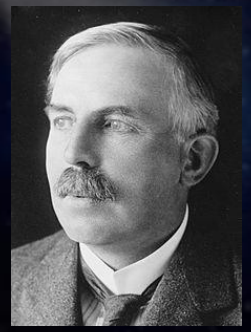
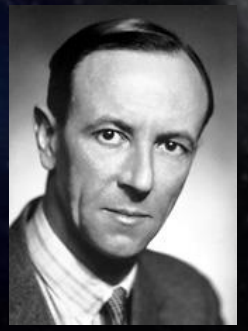



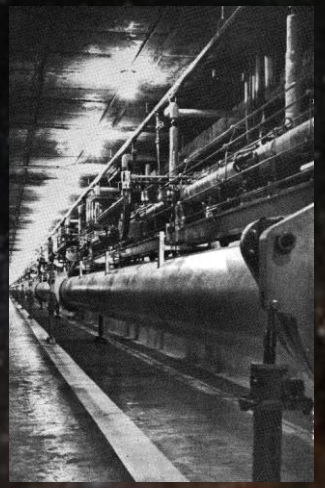
Histoire de la matière

-400	1811	1896	1911	1919	1932	1963
Démocrite Atome = particule indivisible de matière	Dalton matière composée d'atomes de masses ≠	Thomson électron	Rutherford noyau Perrin atomes et molécules	Rutherford proton	Chadwick neutron	Gell-Mann et Zweig modèle des quarks

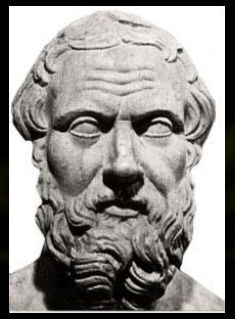
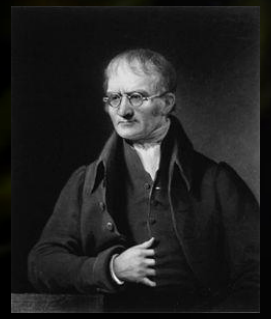



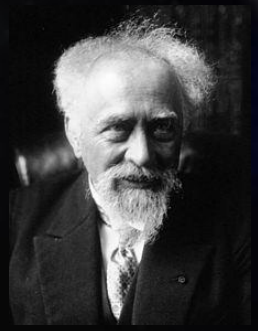
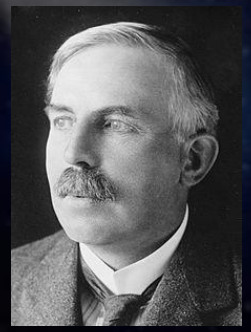
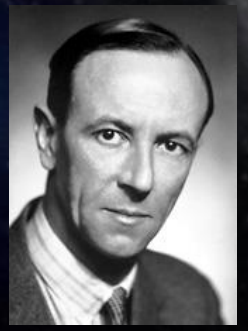




Histoire de la matière



-400	1811	1896	1911	1919	1932	1963	1967
Démocrite Atome = particule indivisible de matière	Dalton matière composée d'atomes de masses ≠	Thomson électron	Rutherford noyau Perrin atomes et molécules	Rutherford proton	Chadwick neutron	Gell-Mann et Zweig modèle des quarks	Découverte des quarks up et down SLAC Californie

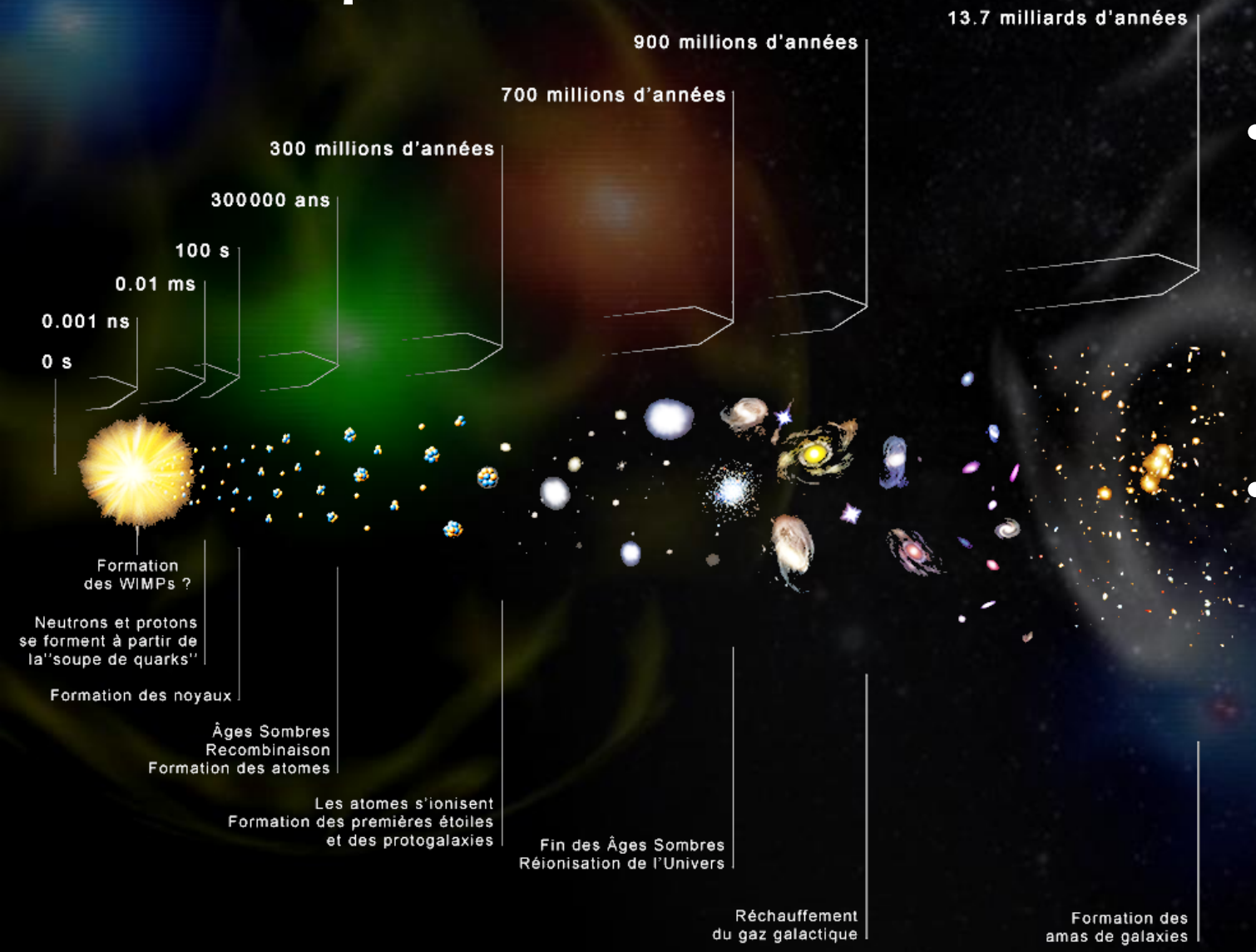



Particules élémentaires

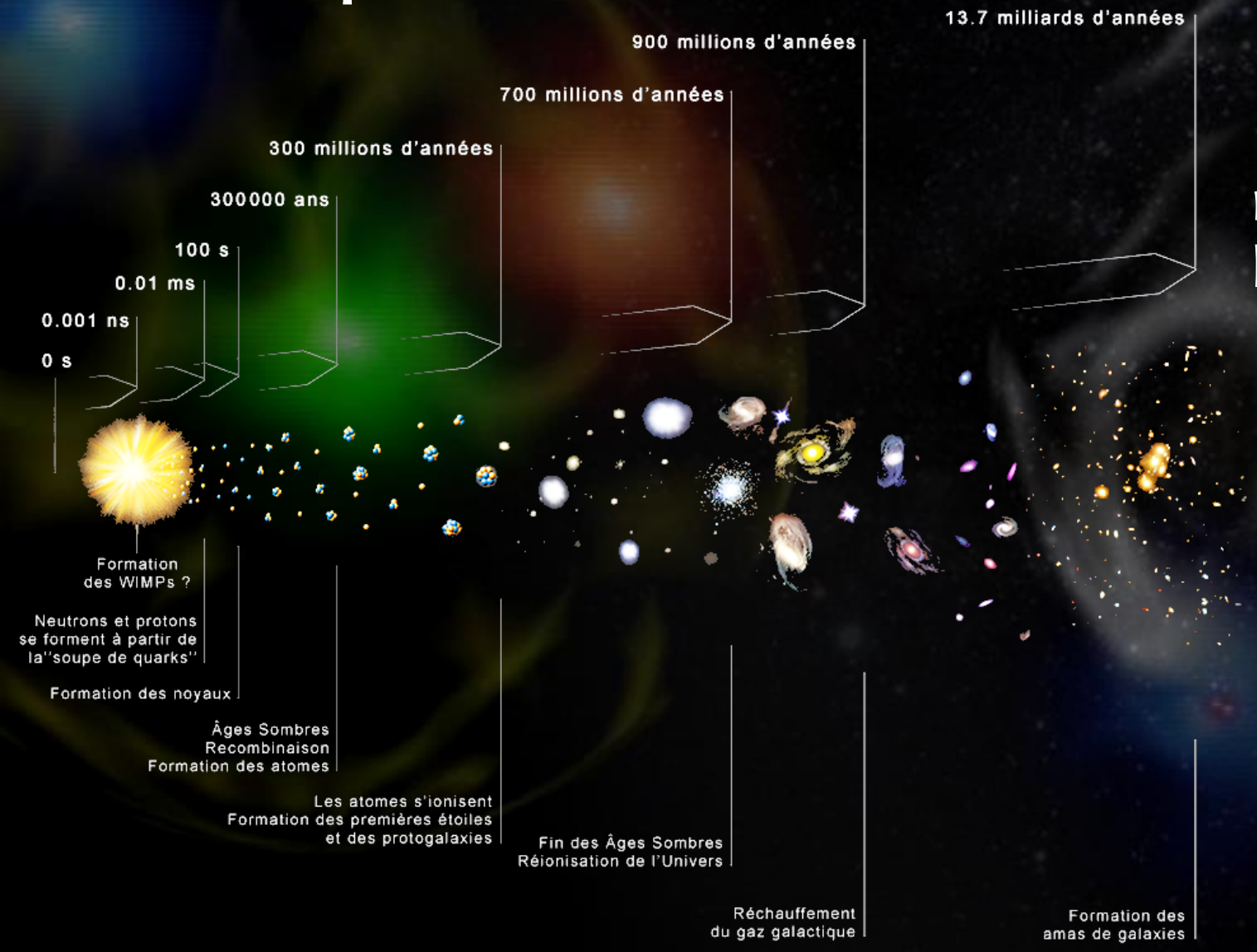
- Toutes les autres particules élémentaires sont instables
- Plus lourdes → beaucoup d'énergie pour les voir/produire : $E = mc^2$
- On les a découvertes petit à petit
  - μ : 1936 : Anderson, Caltech
    « Qui a commandé ça ? », I.I. Rabi
  - t : 1995 : Fermilab, Chicago
  - H : 2012 : LHC, CERN : Nobel 2015

Des particules à l'Univers : le Big Bang



- Recréer les conditions des premiers instants de l'Univers (plasma de quarks et de gluons) : expérience ALICE au LHC
- Observer la lumière émise lors de la recombinaison (fond diffus cosmologique) : satellite Planck

Des particules à l'Univers : le Big Bang

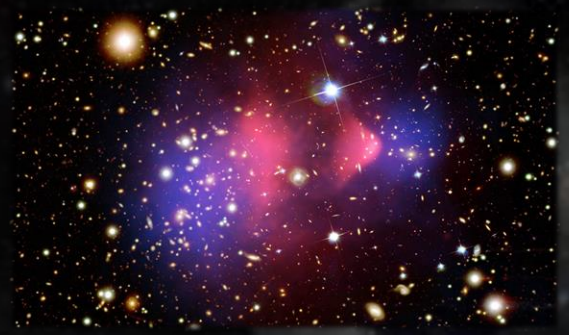


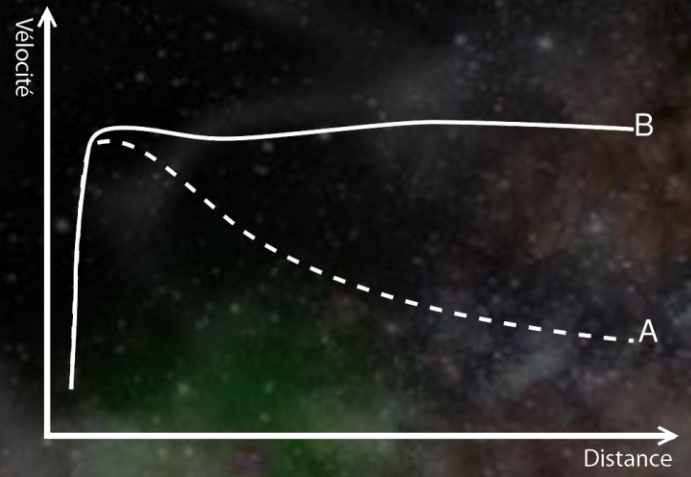
D'autres expériences espèrent remonter encore plus loin dans le temps :

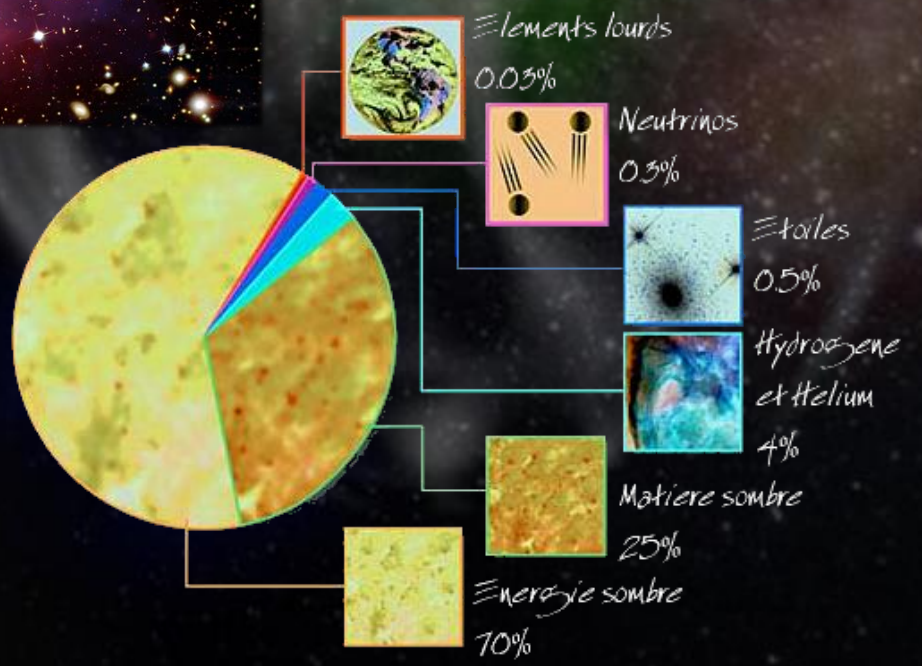
- Mesure du fond diffus de neutrinos : 10^{-4} s
- Mesure des ondes gravitationnelles primordiales : 10^{-30} s

Problèmes des théories actuelles

- Masse manquante
  - Courbe de rotation des galaxies
  - Amas du Boulet (lentille gravitationnelle
- Expansion accélérée de l'Univers
- → Matière noire et énergie noire ?
- → Gravité modifiée ?

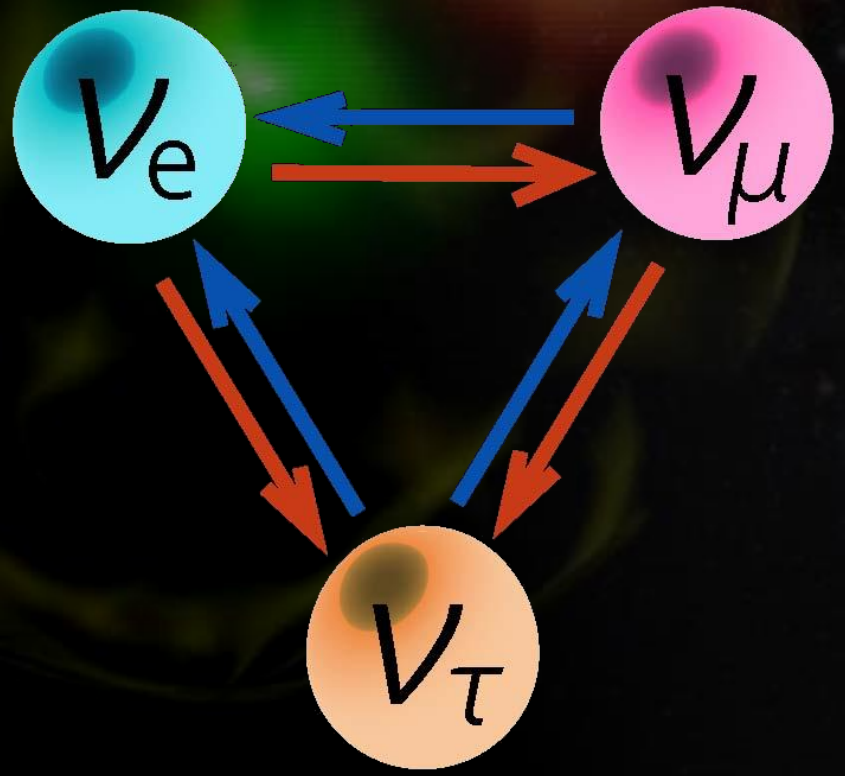


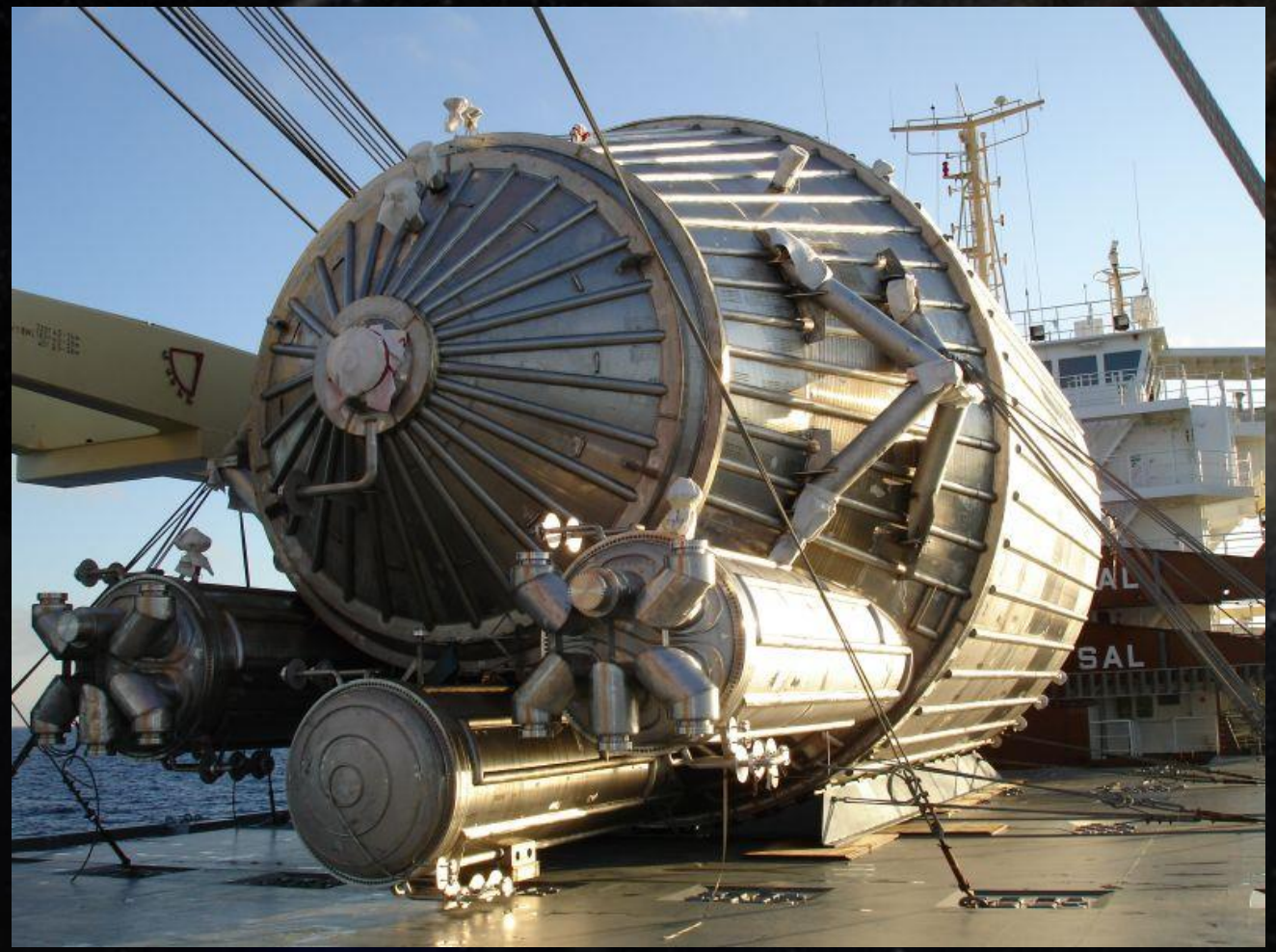




Problèmes des théories actuelles

- Oscillation des neutrinos
- Masse des neutrinos





Spectromètre de KATRIN
(expérience de mesure de la masse du neutrino)

Problèmes des théories actuelles

- Unification des trois forces nucléaires

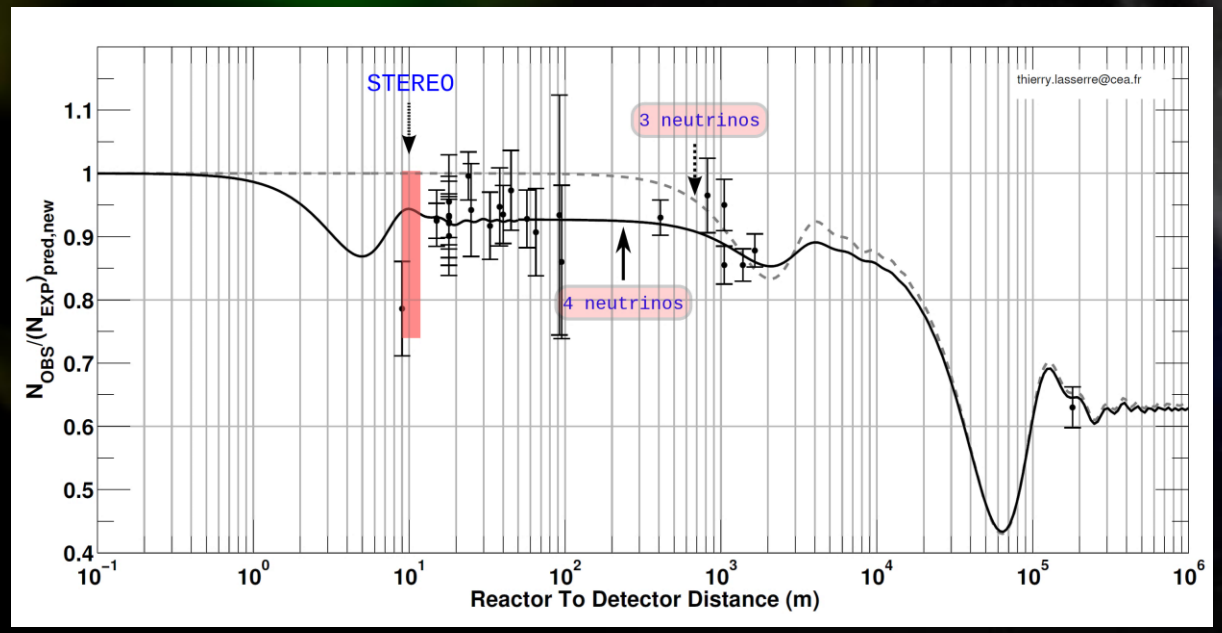
- Unification avec la gravité

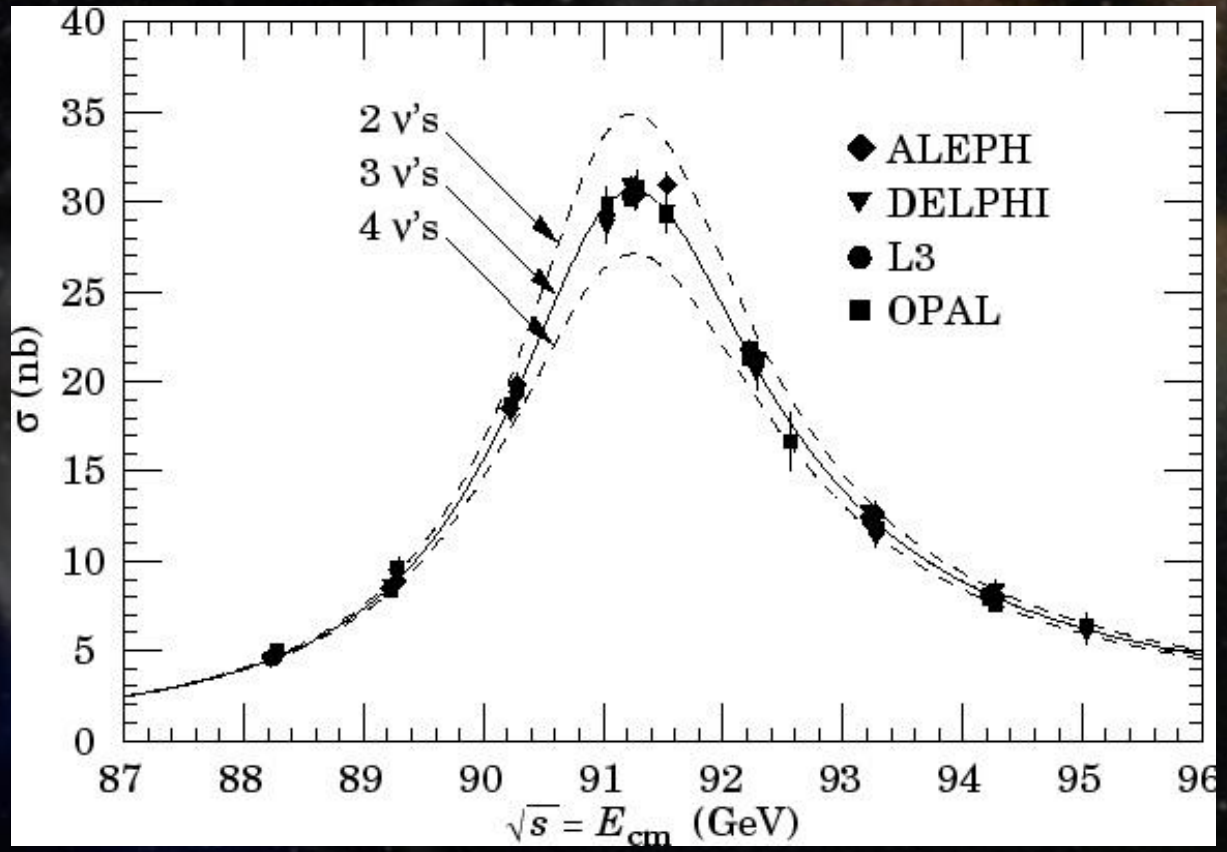
Problèmes des théories actuelles

- Absence apparente d'antimatière dans l'Univers
- → Asymétrie matière antimatière primordiale ?
- → Anti-gravité ?

Problèmes des théories actuelles

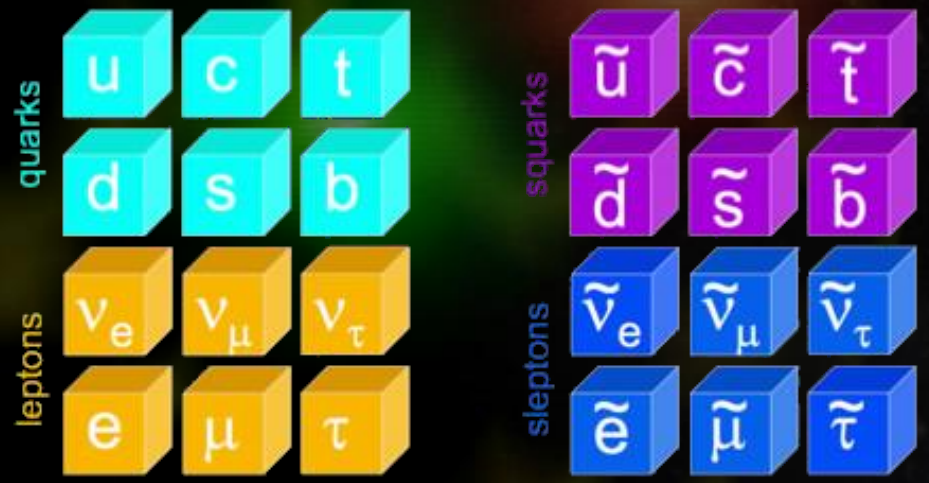
- Nombre de familles
- Neutrino stérile
- Neutrino de Dirac ou de Majorana

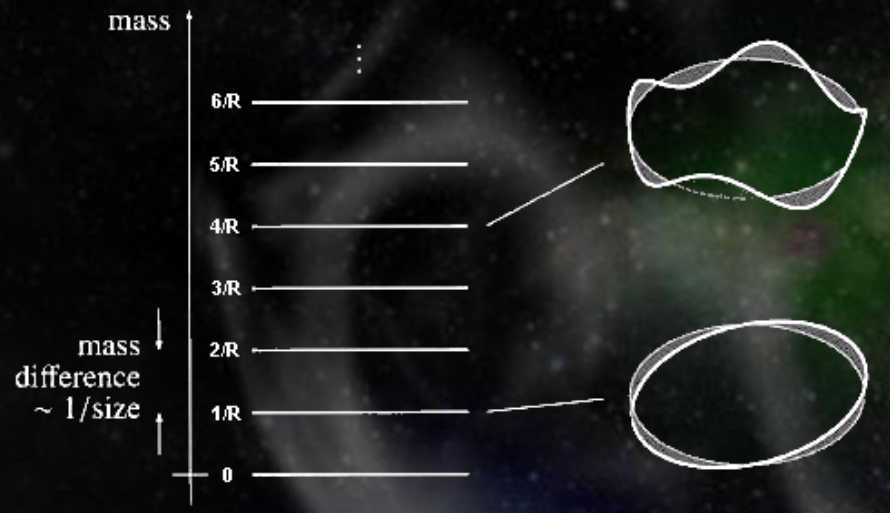




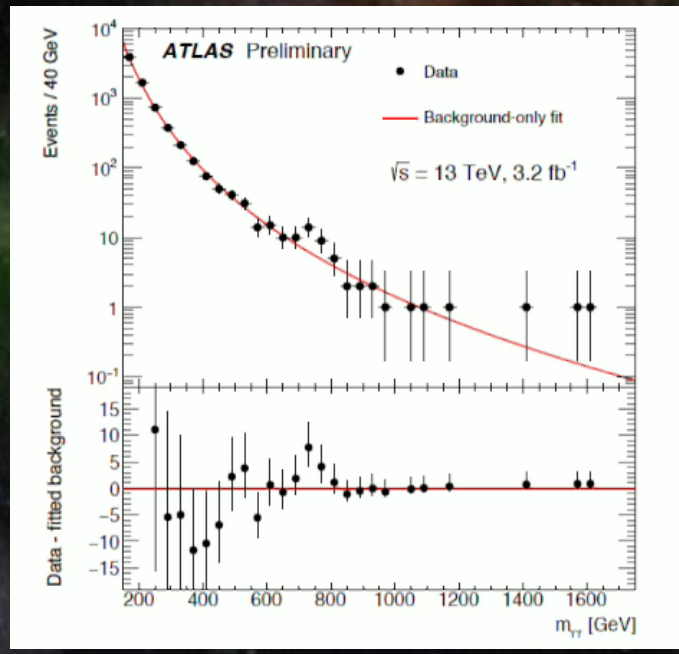
Problèmes des théories actuelles

- Nouvelles symétrie ?





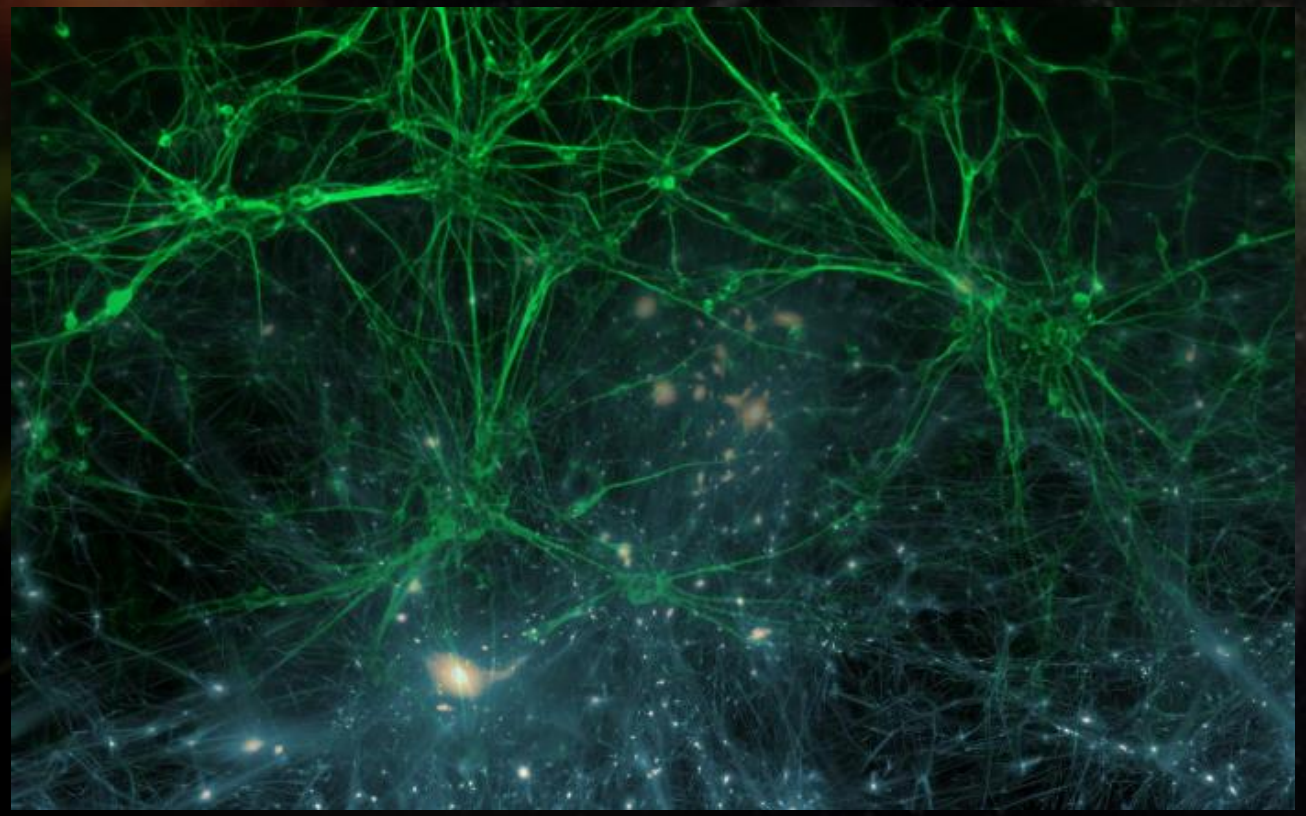
- Nouvelles particules ?



- Boson-fermion (SuSy)
- Lepton-quark (technicolor)
- Électron et quarks composites ?
- Higgs composite ?

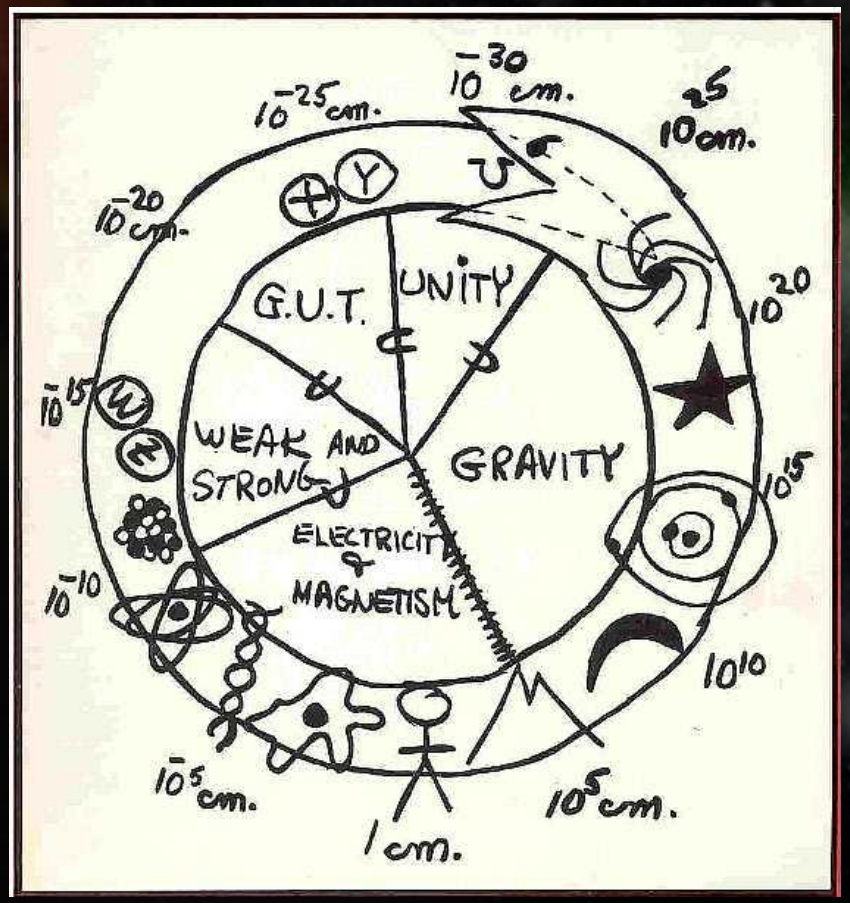
Conclusion

- Etudier un infini revient à étudier l'autre dans de nombreux problèmes physiques



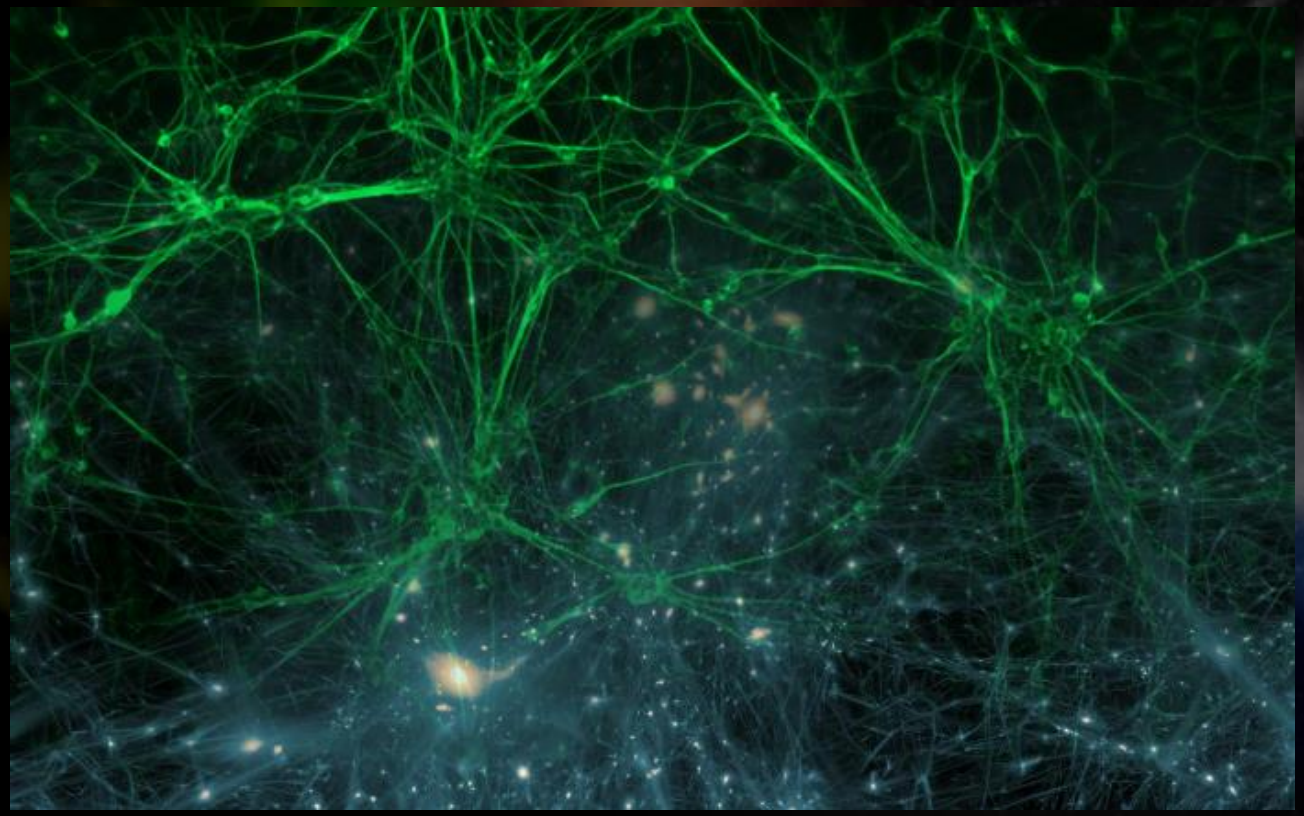
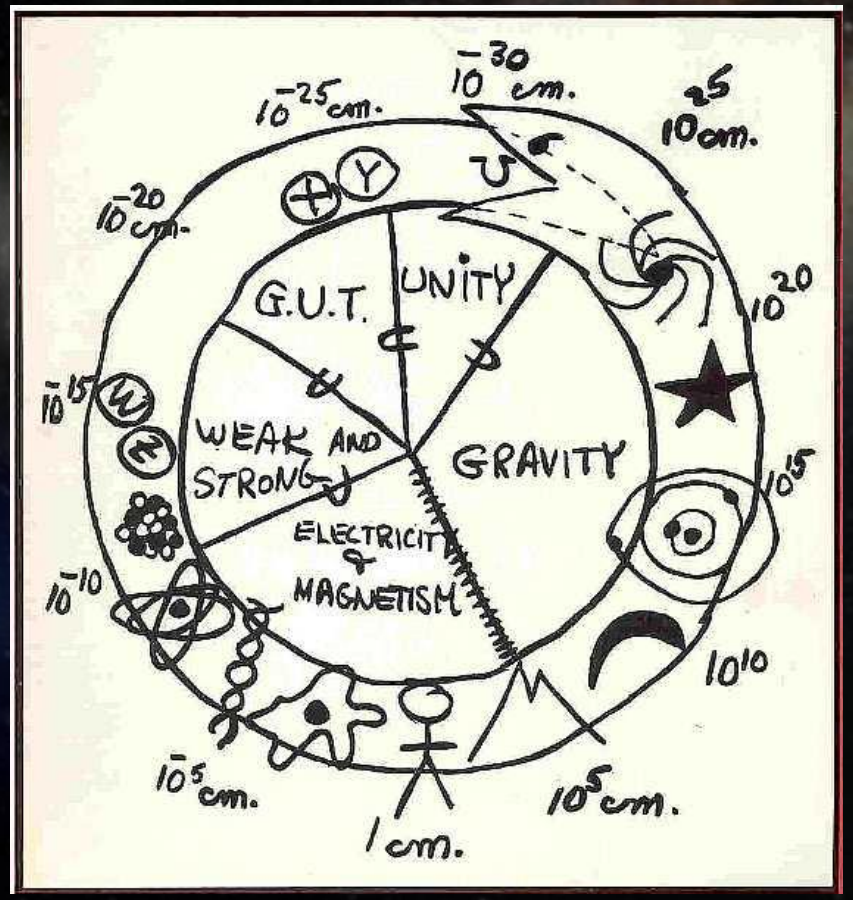
Conclusion

- Existe-t-il une théorie permettant de relier les deux ?



Conclusion

Etudier un infini revient à étudier l'autre dans de nombreux problèmes physiques



Existe-t-il une théorie permettant de relier les deux ?