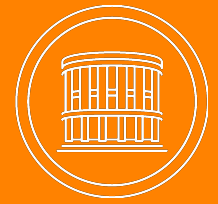
FAKULTA MATEMATIKY,
FYZIKY A INFORMATIKY
Univerzita Komenského
v Bratislave

Nad čím si (ešte) stále lámeme vo fyzike hlavu

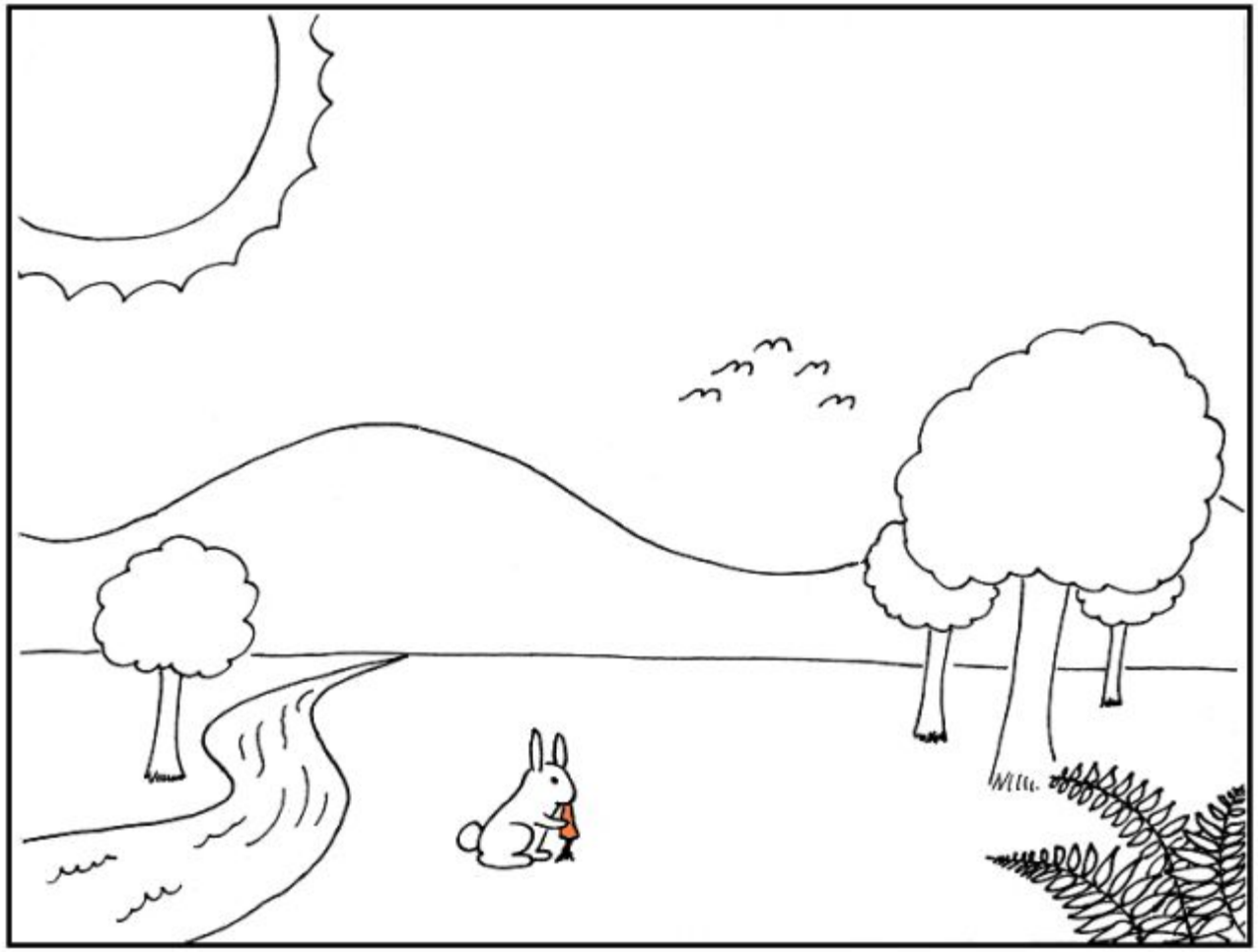
Juraj Tekel
Katedra teoretickej fyziky



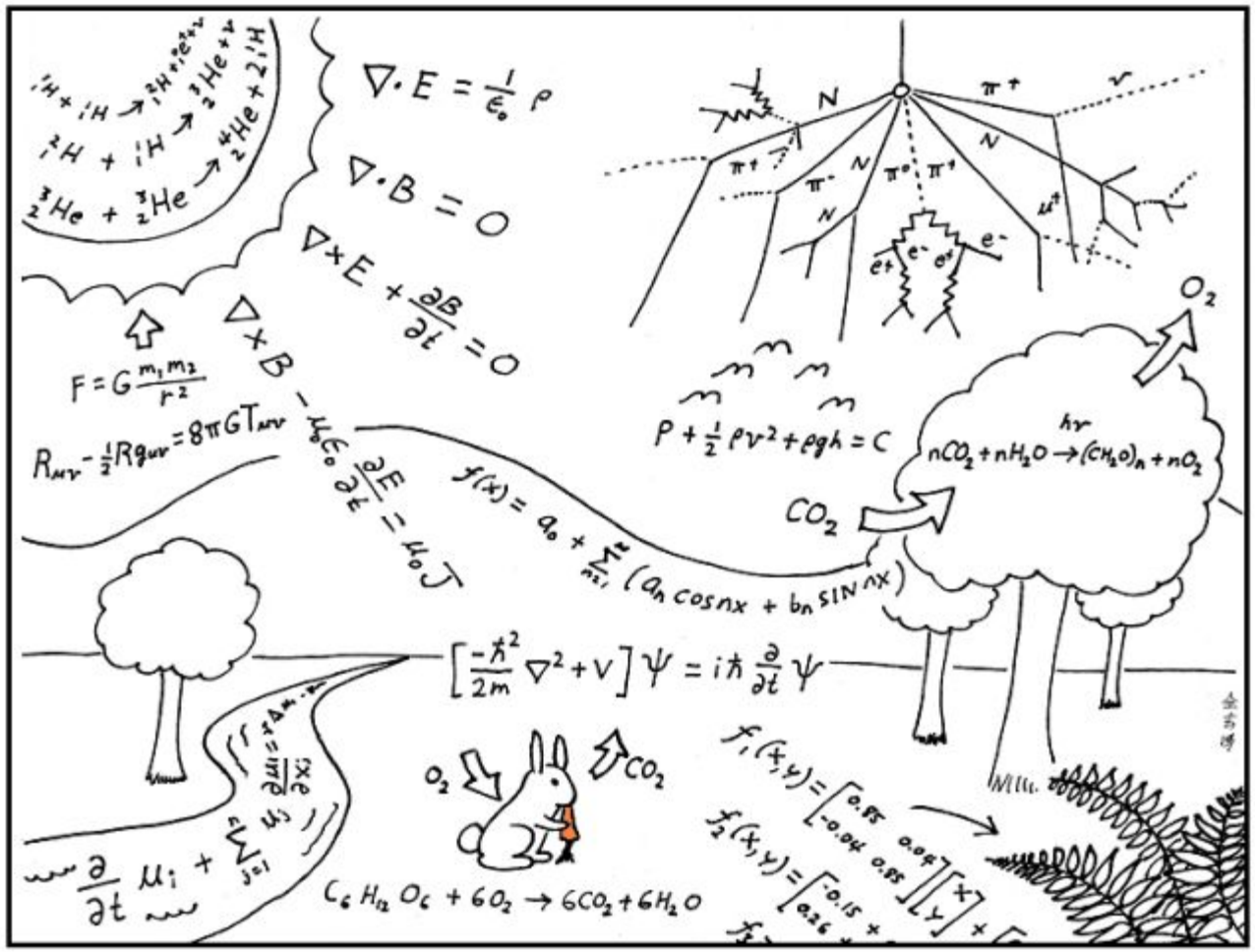
19. 11. 2024, Týždeň globálneho vzdelávania, Gymnázium Ivana Kupca, Hlohovec

Čo je to tá teoretická fyzika?


E=mc²
E=mb²

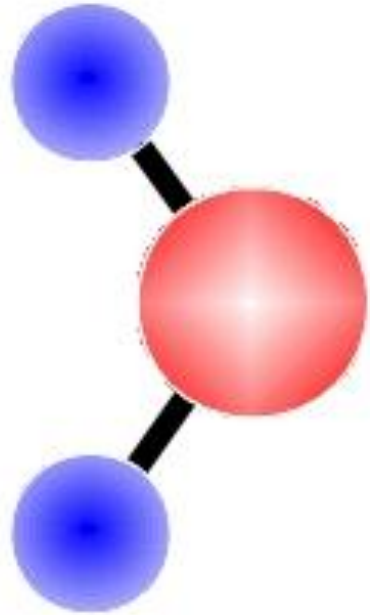


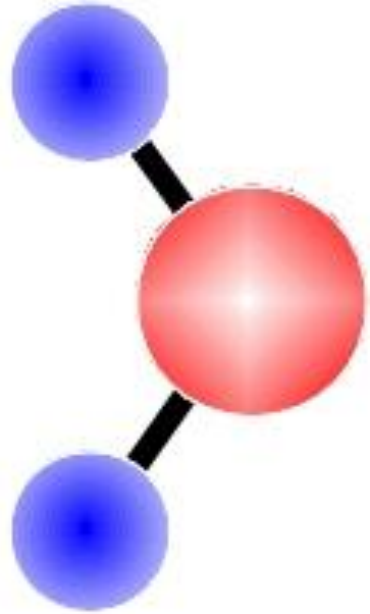
obr.: http://abstrusegoose.com/275

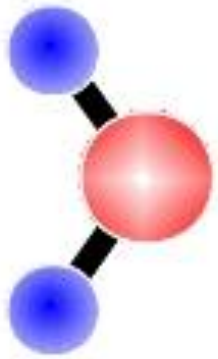


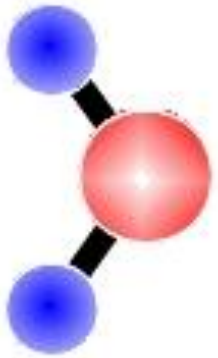
obr.: http://abstrusegoose.com/275

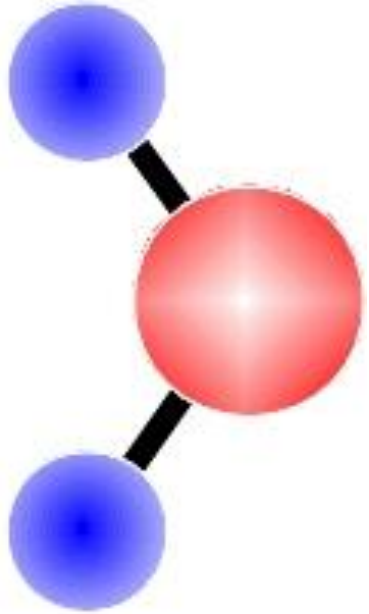
Teória tuhých látok

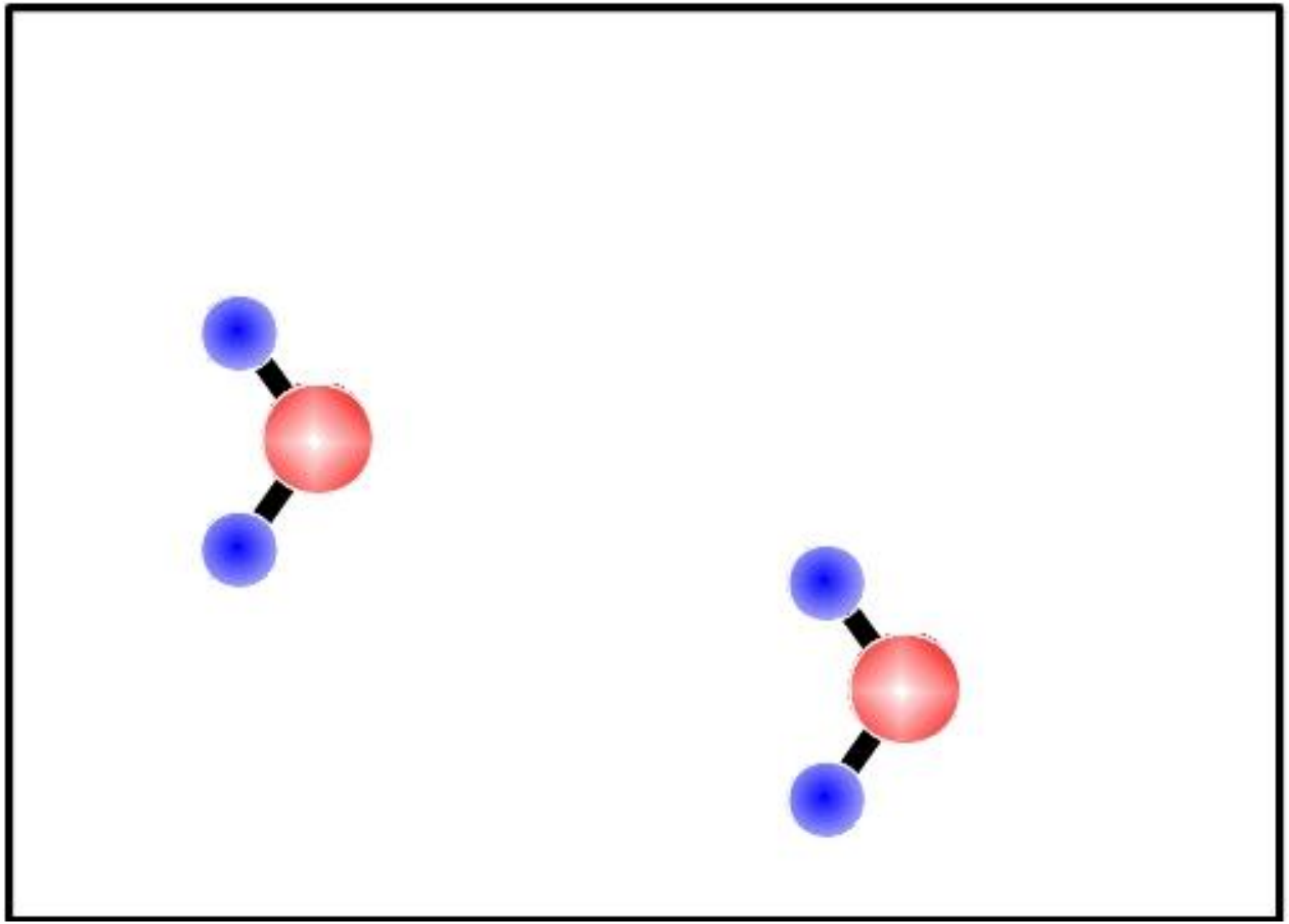


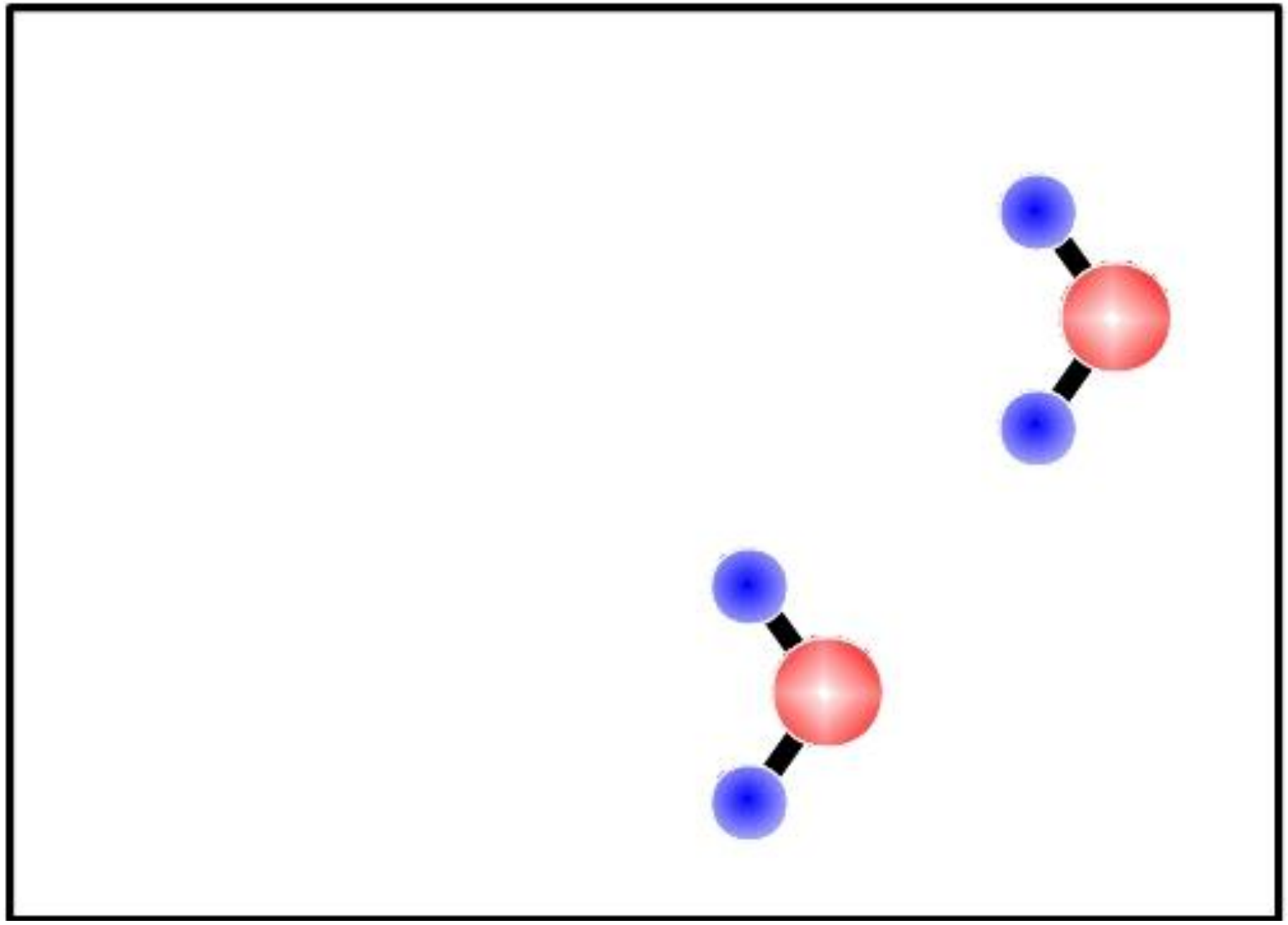


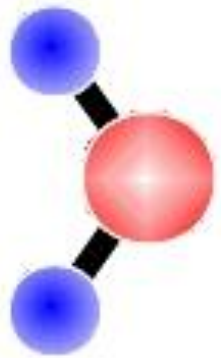


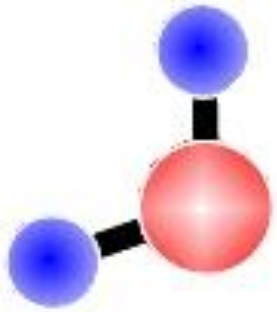


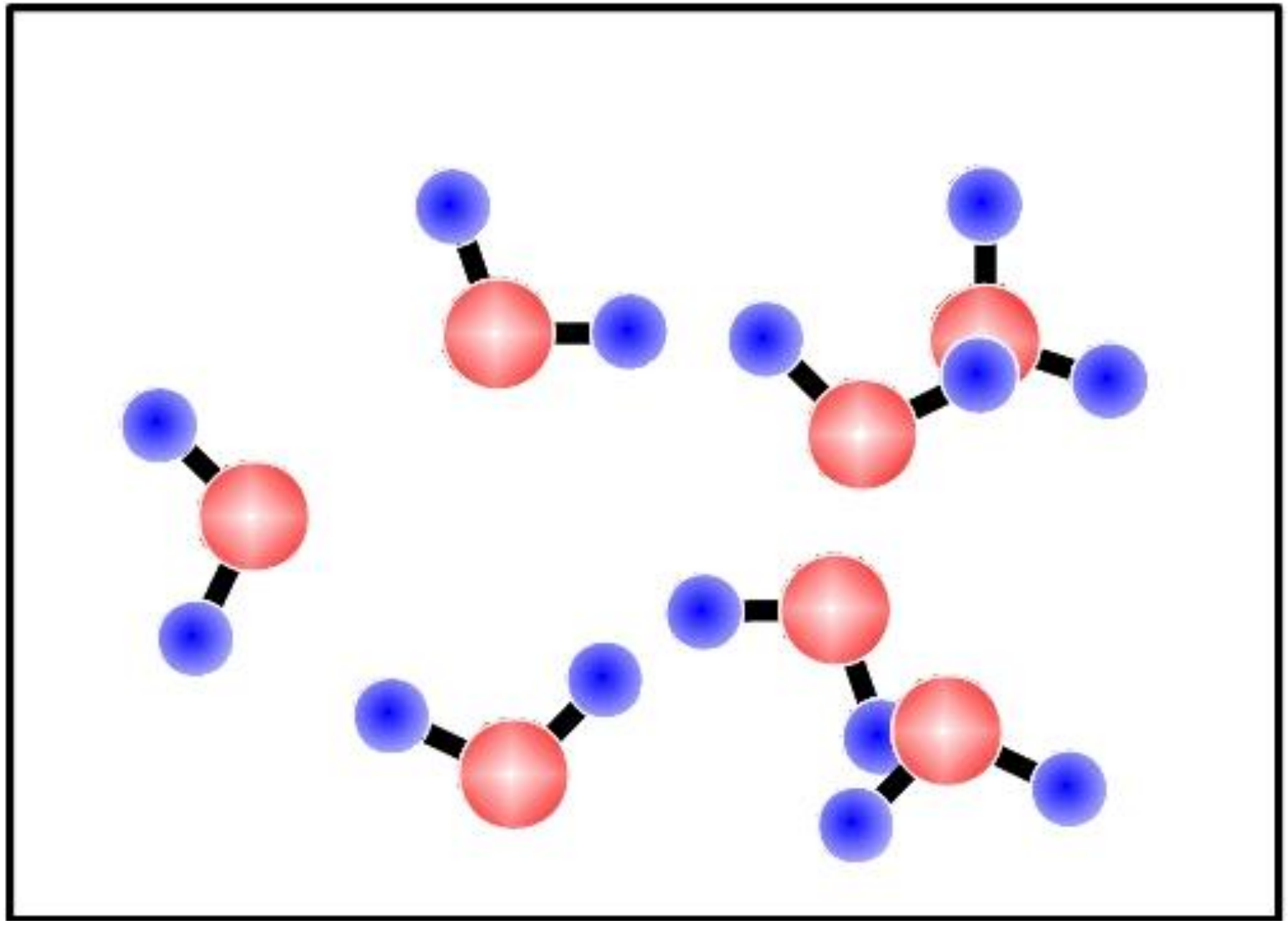


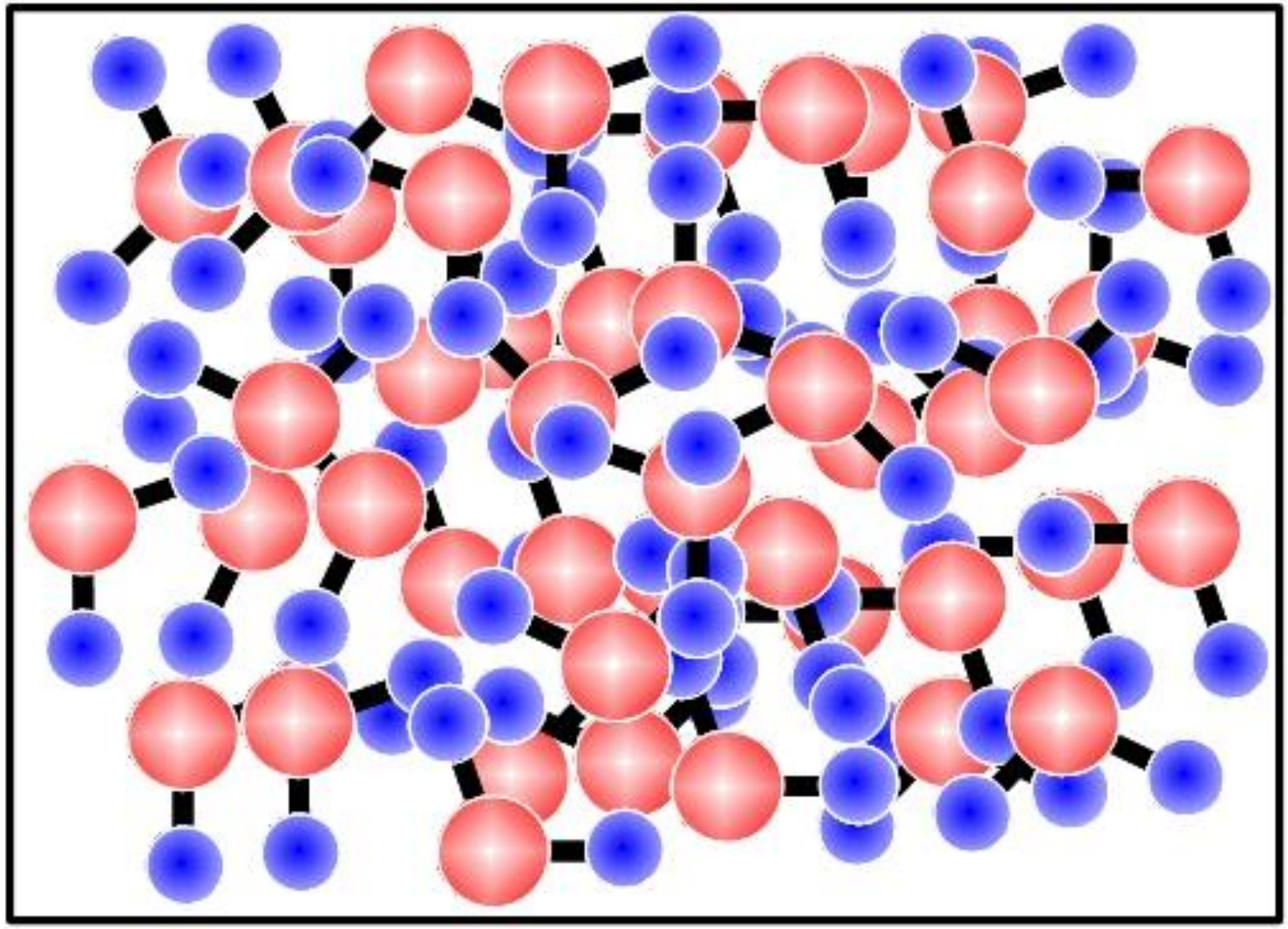


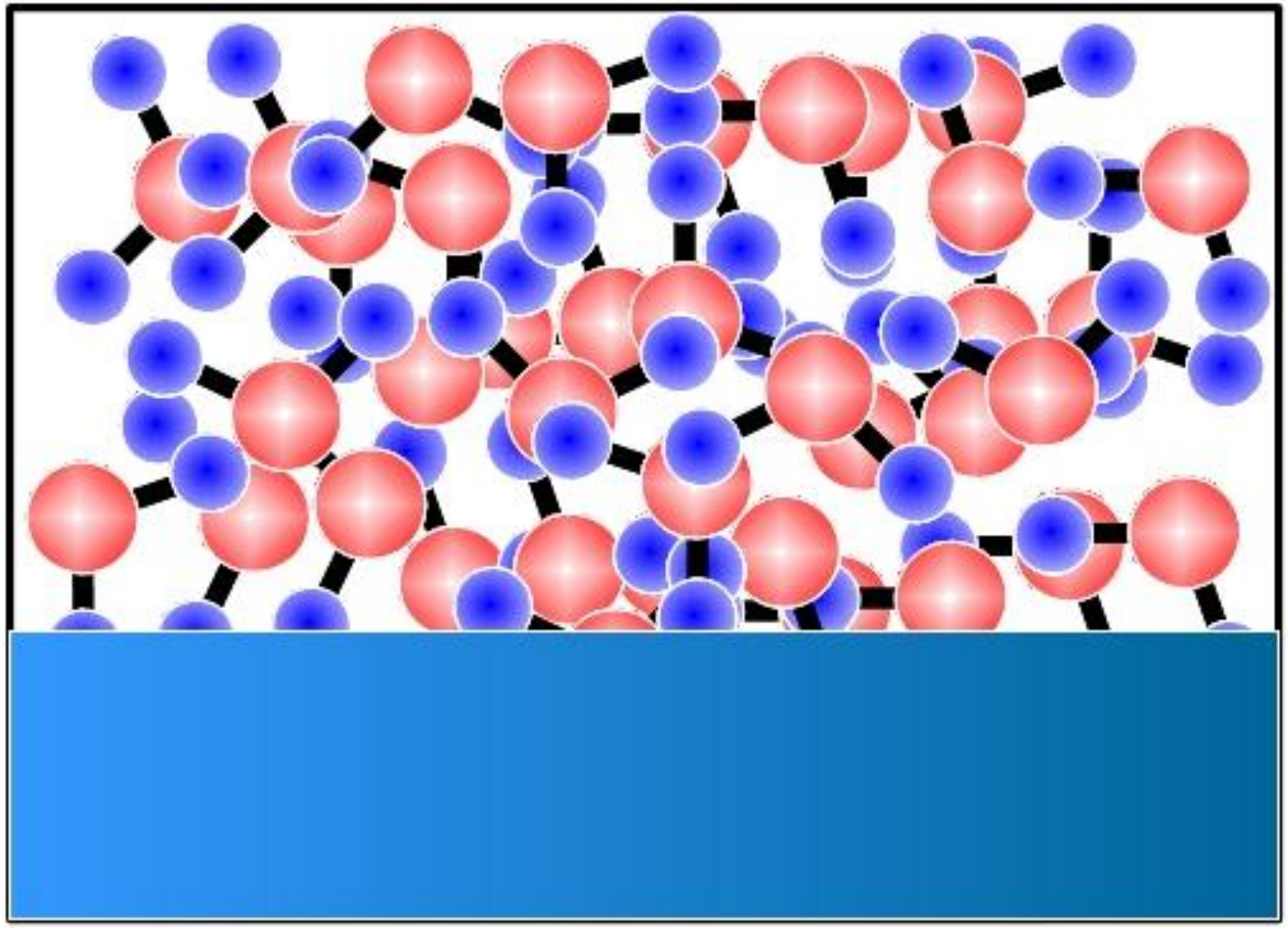


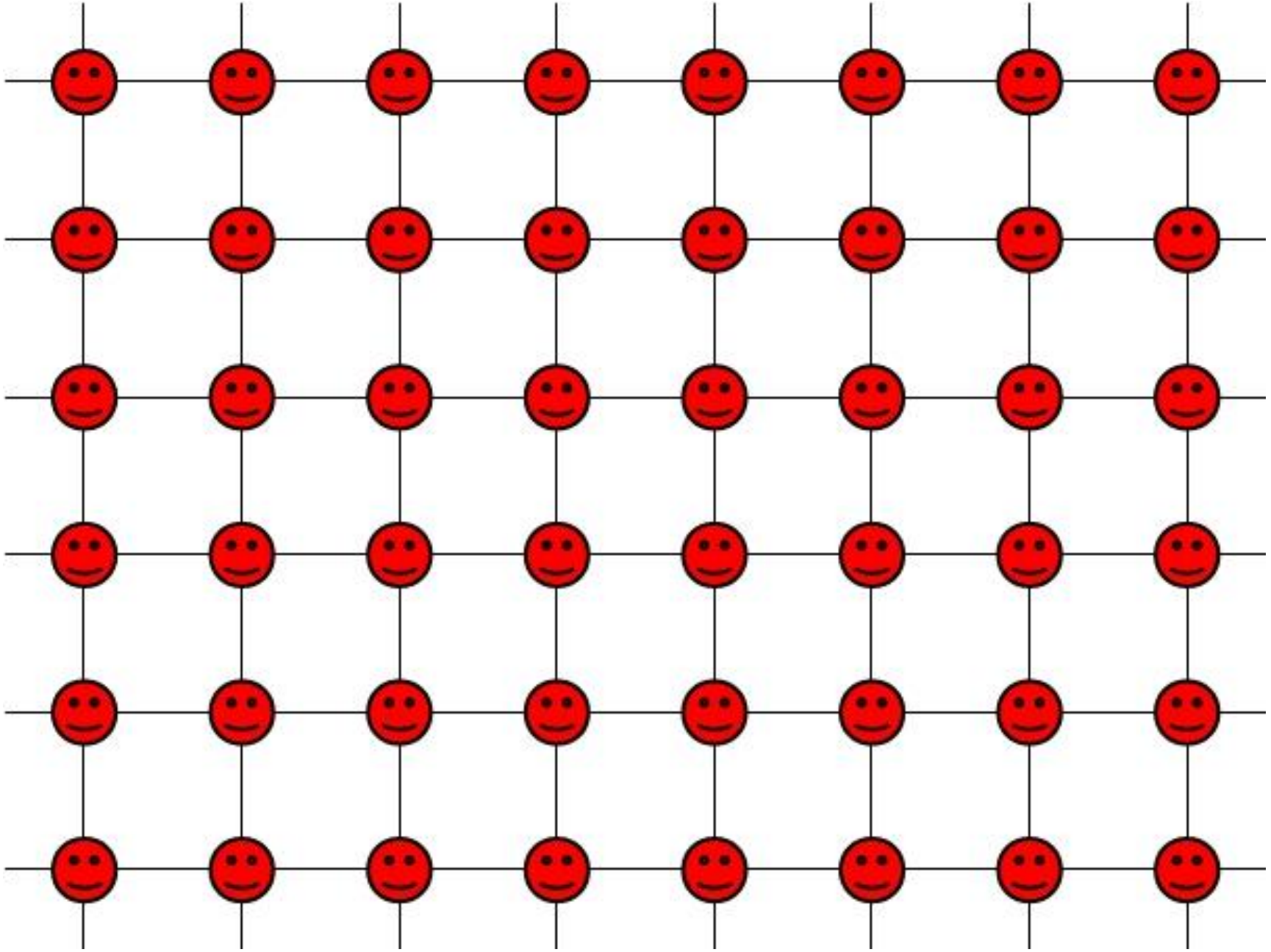


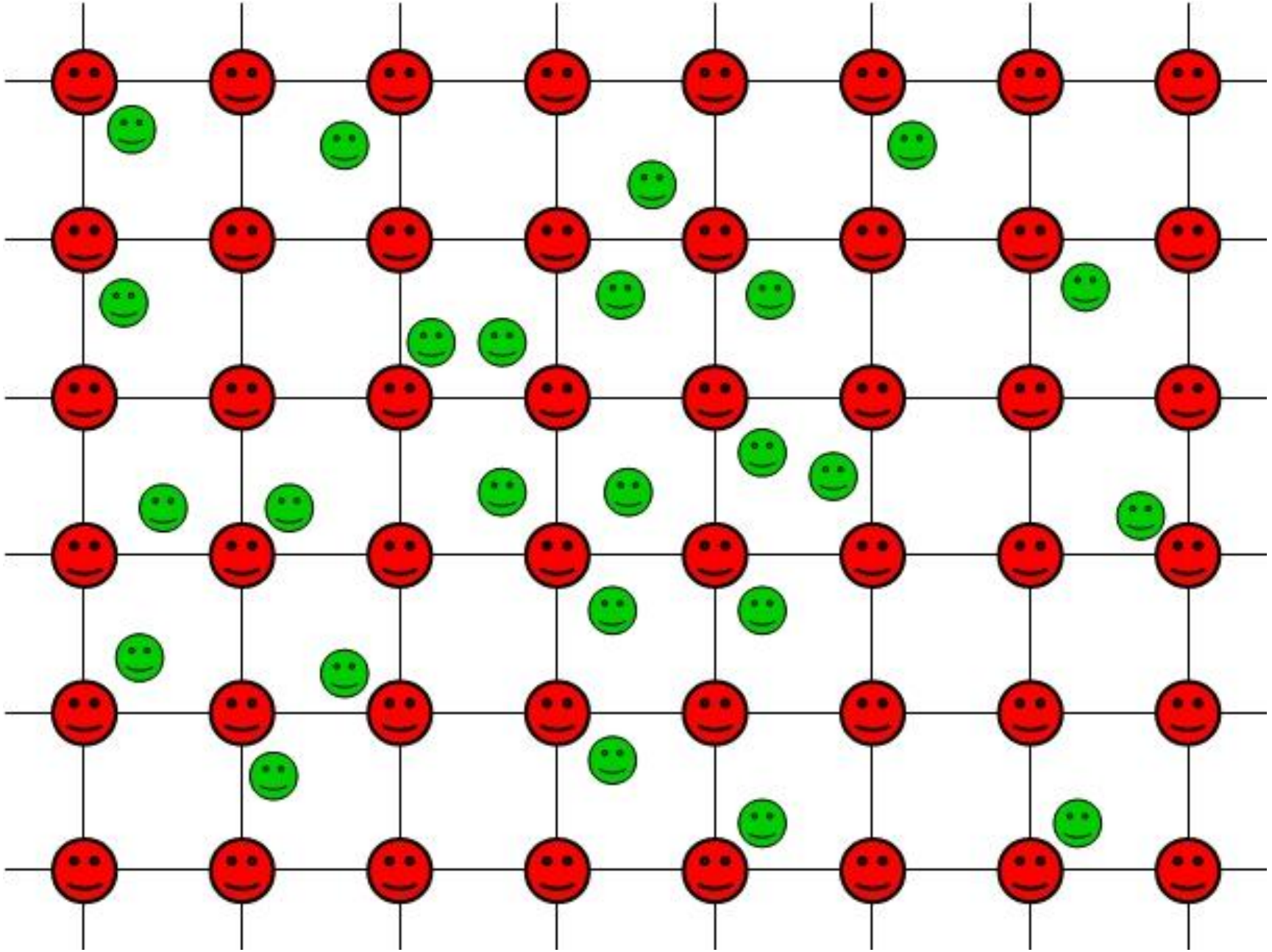


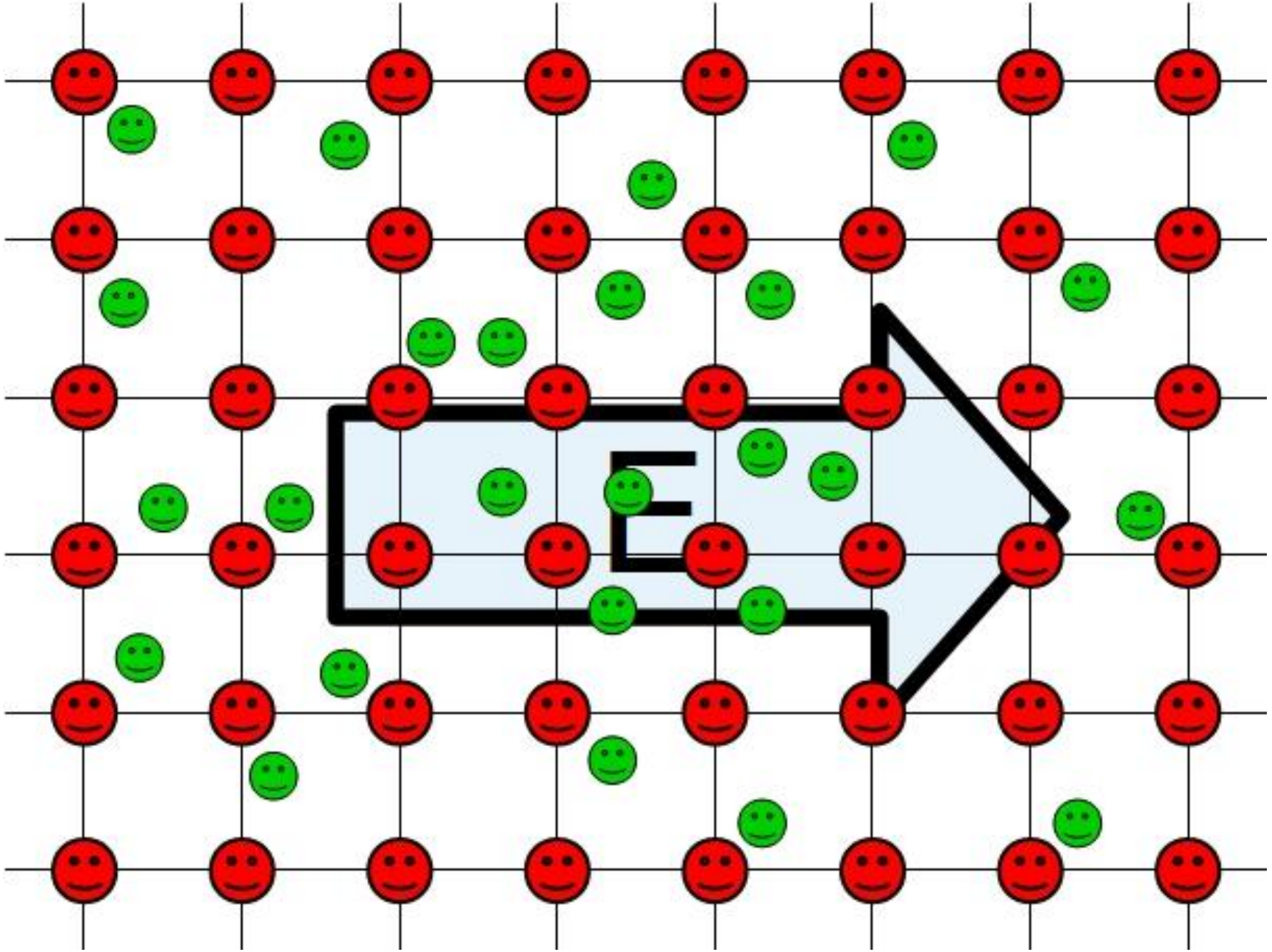








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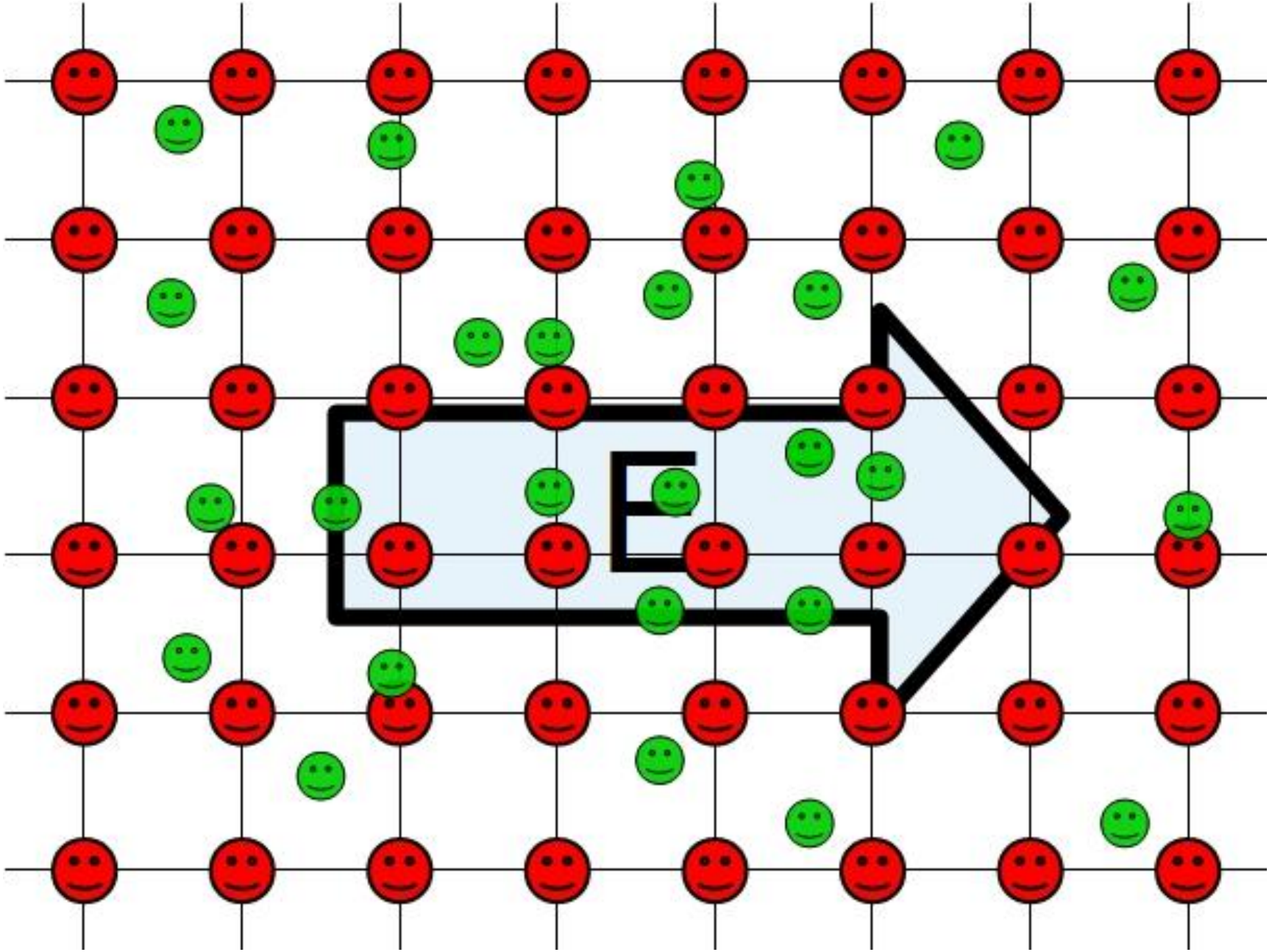
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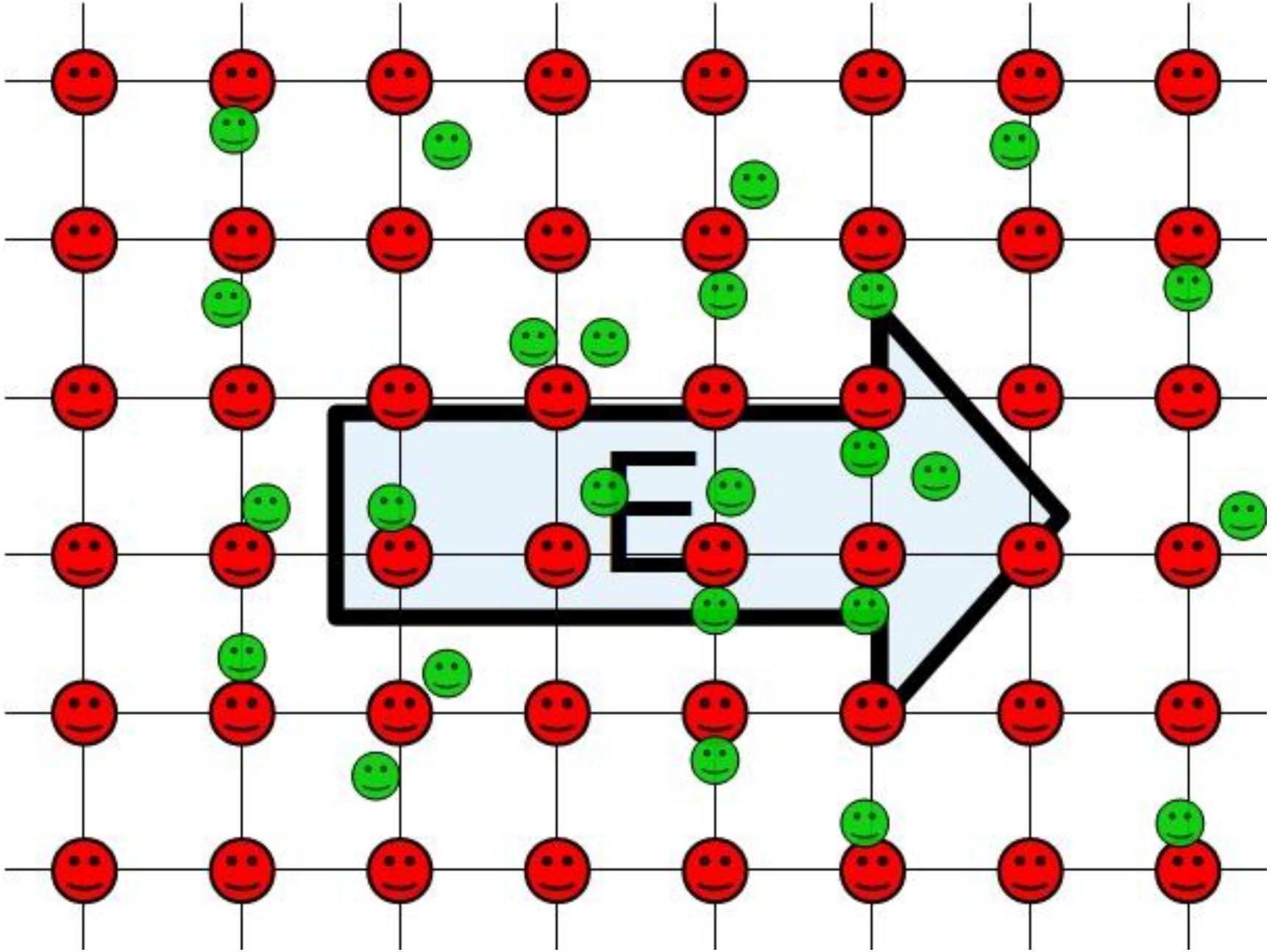
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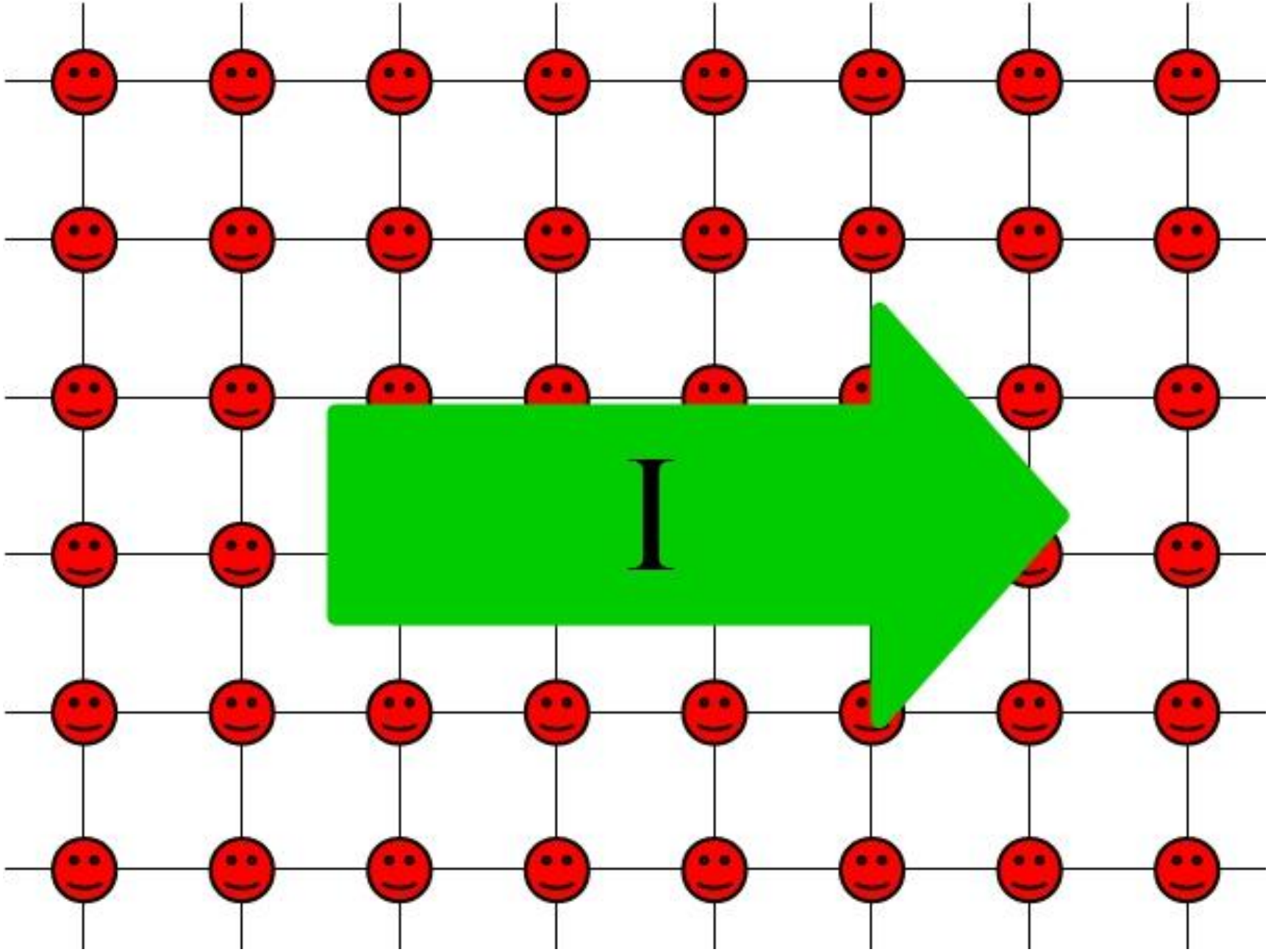
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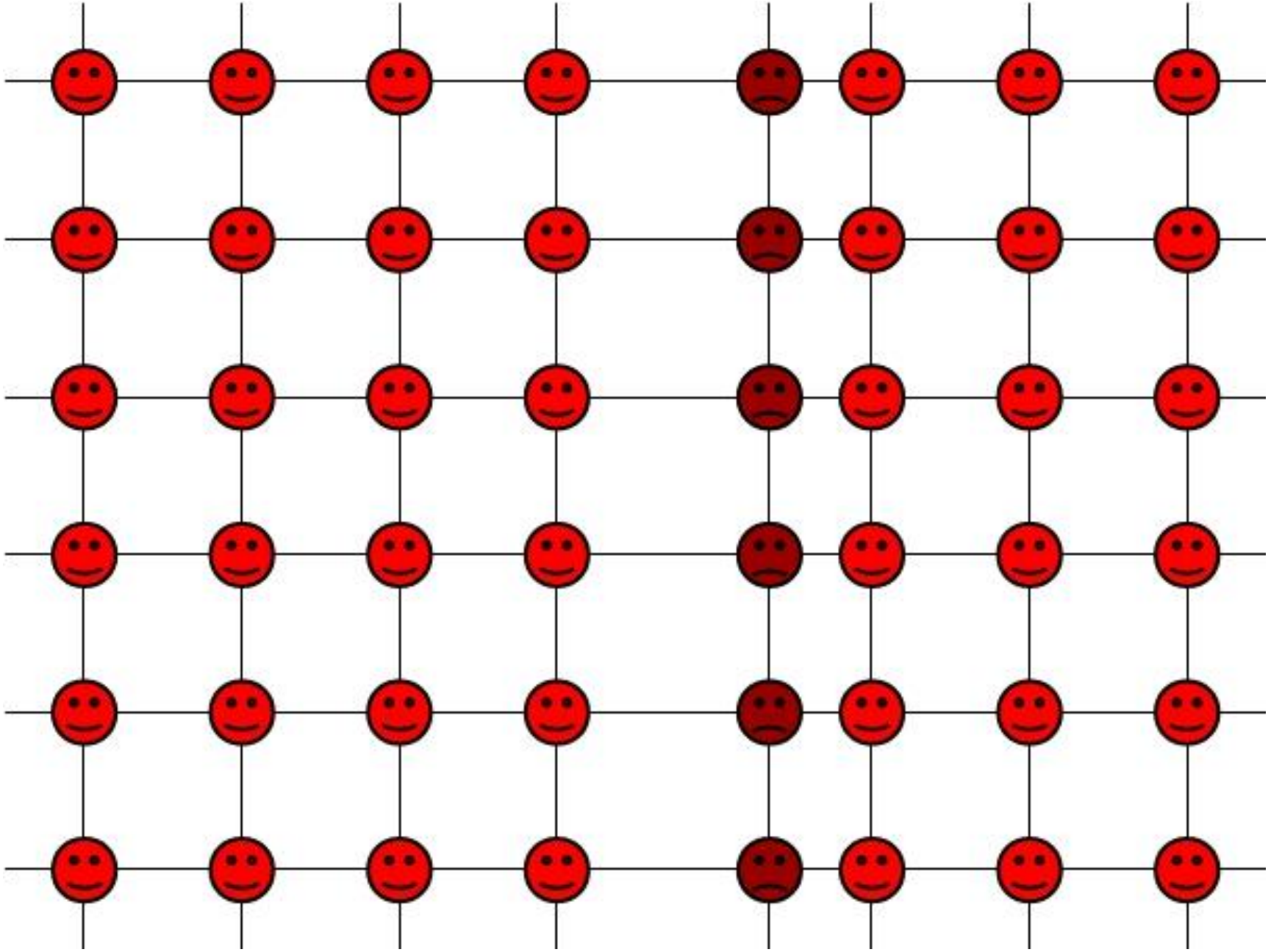
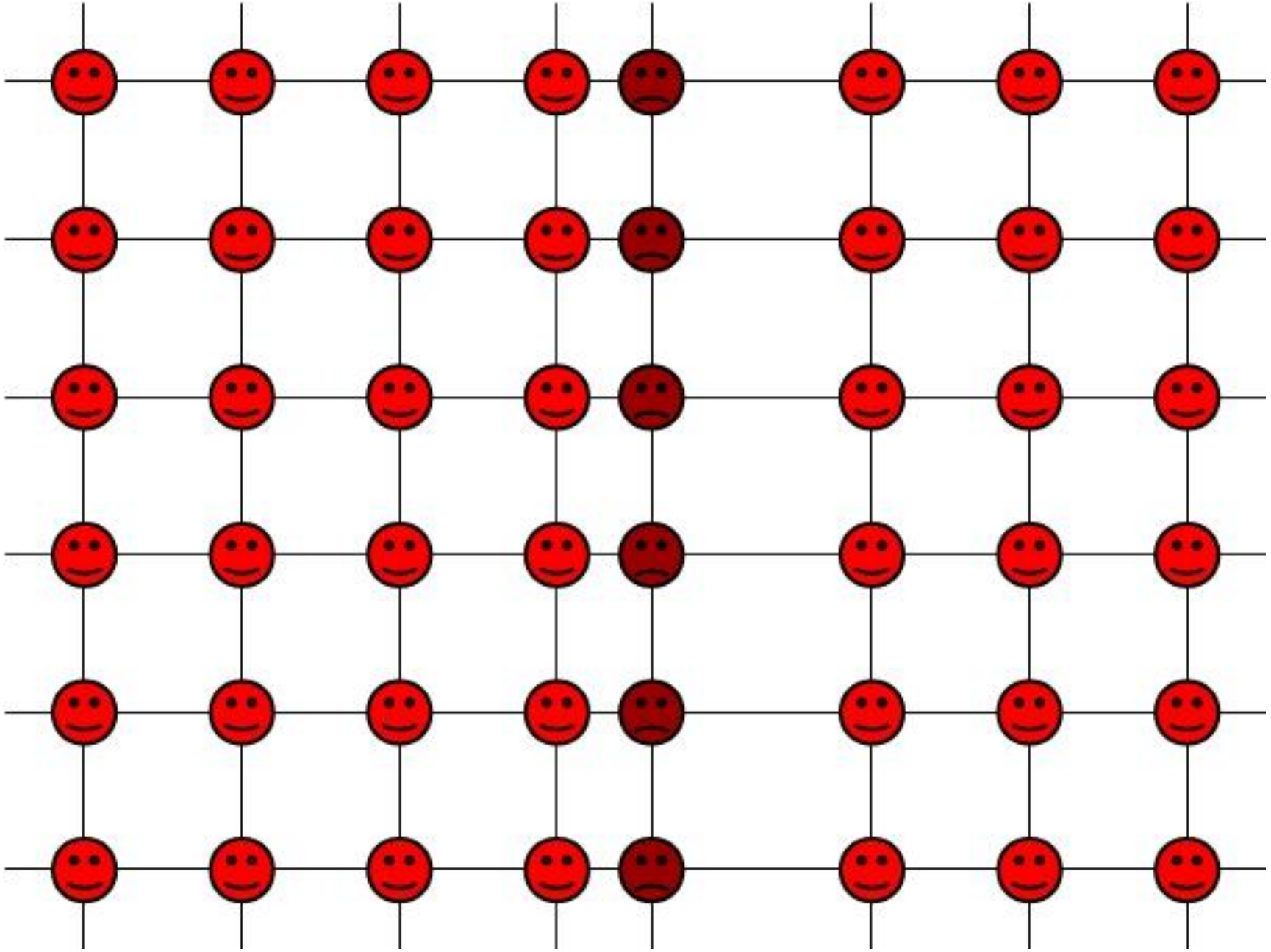
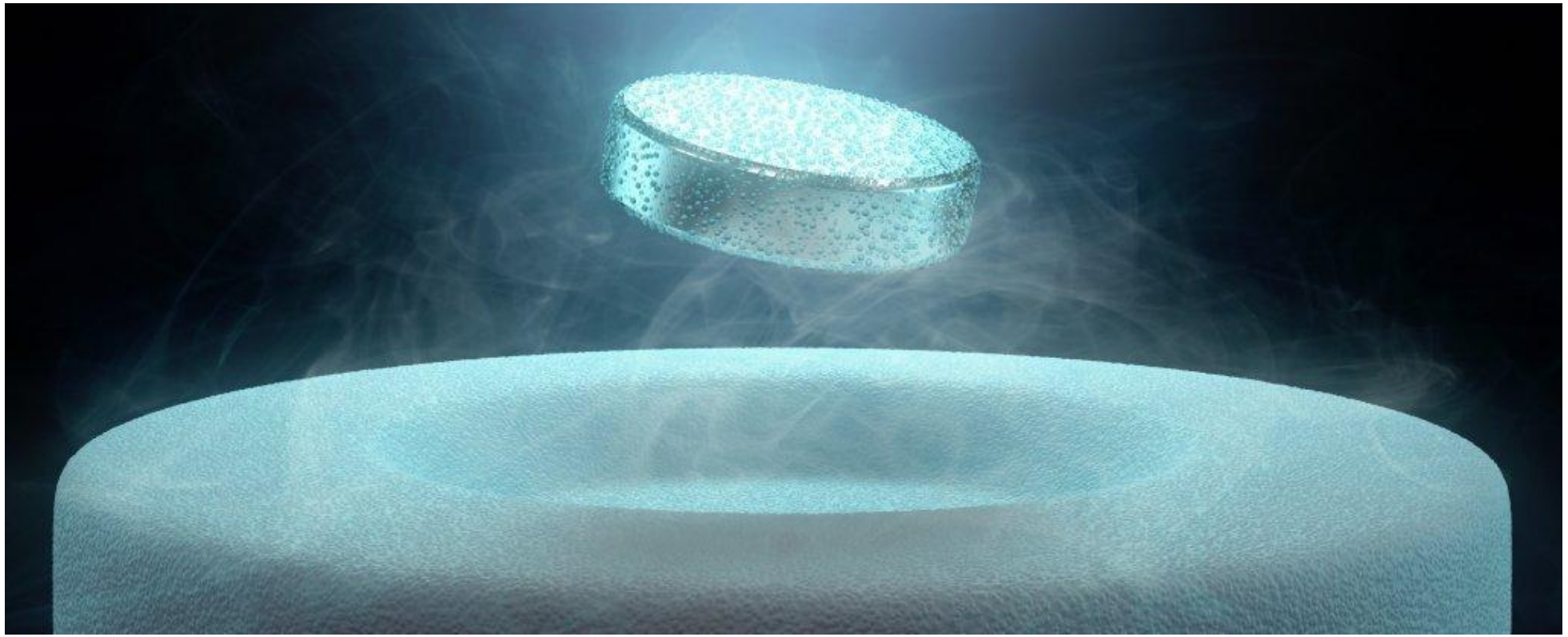
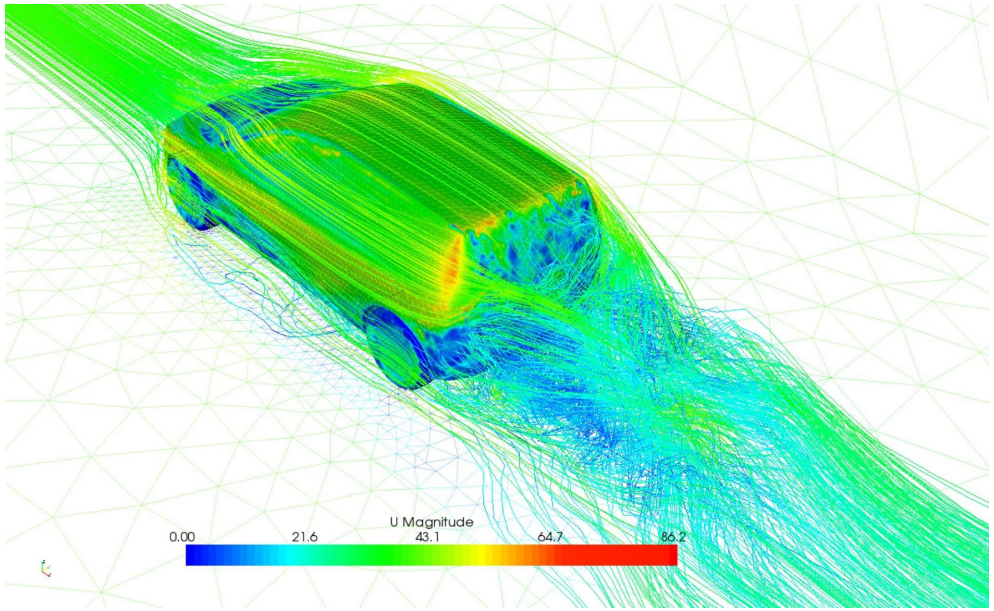






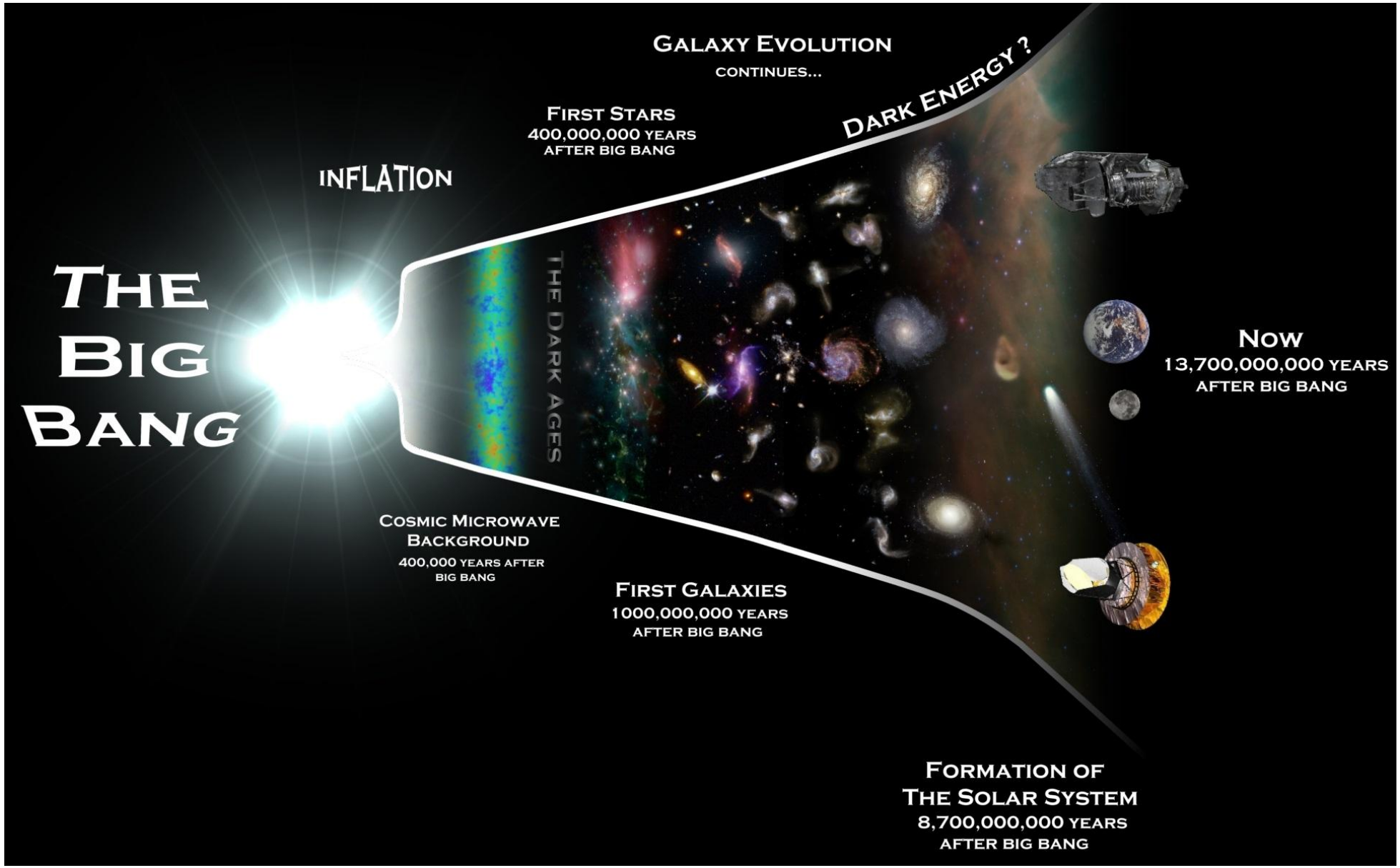
Vysokoteplotná supravodivosť

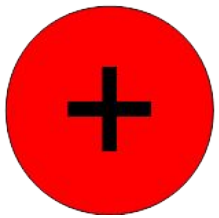

U Magnitude
0.00
21.6
43.1
64.7
86.2

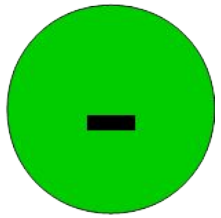
Turbulencia

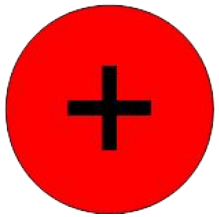

SAXO BANK
Tinkoff
SAXO
S-WORKS
SHIV
WORKS

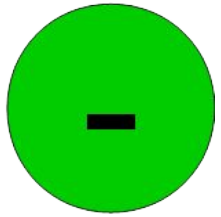
Kozmológia

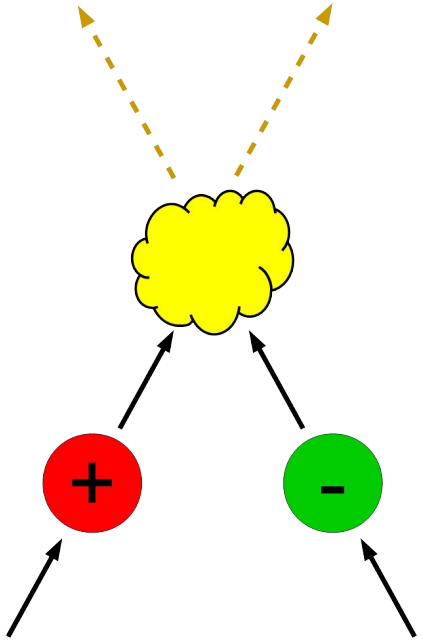

THE BIG BANG
INFLATION
FIRST STARS
400,000,000 YEARS
AFTER BIG BANG
GALAXY EVOLUTION
CONTINUES...
DARK ENERGY ?
THE DARK AGES
COSMIC MICROWAVE
BACKGROUND
400,000 YEARS AFTER
BIG BANG
FIRST GALAXIES
1000,000,000 YEARS
AFTER BIG BANG
NOW
13,700,000,000 YEARS
AFTER BIG BANG
FORMATION OF
THE SOLAR SYSTEM
8,700,000,000 YEARS
AFTER BIG BANG

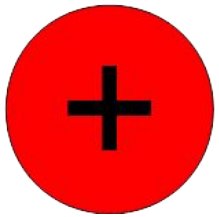


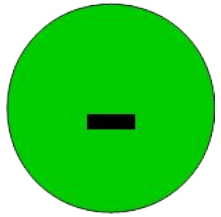


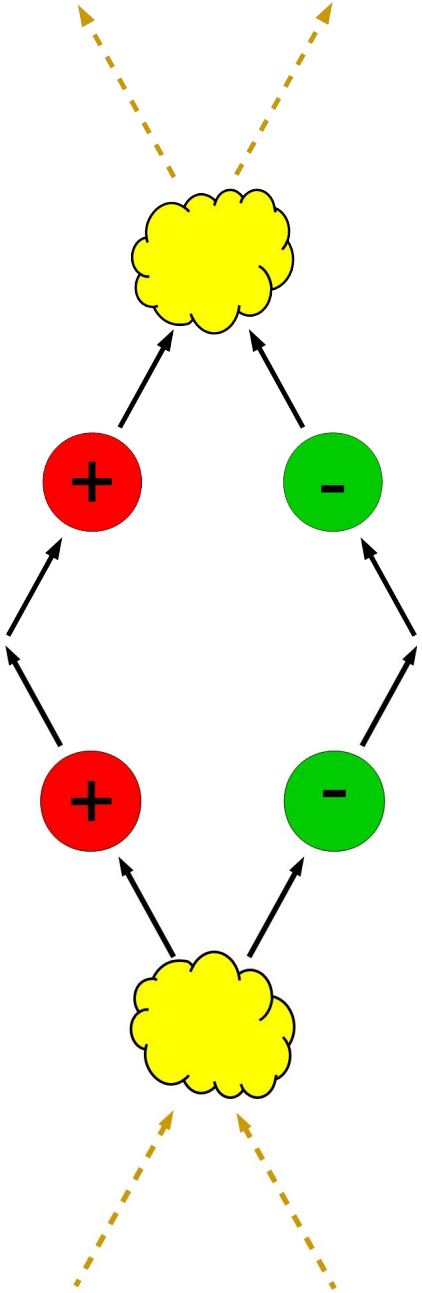


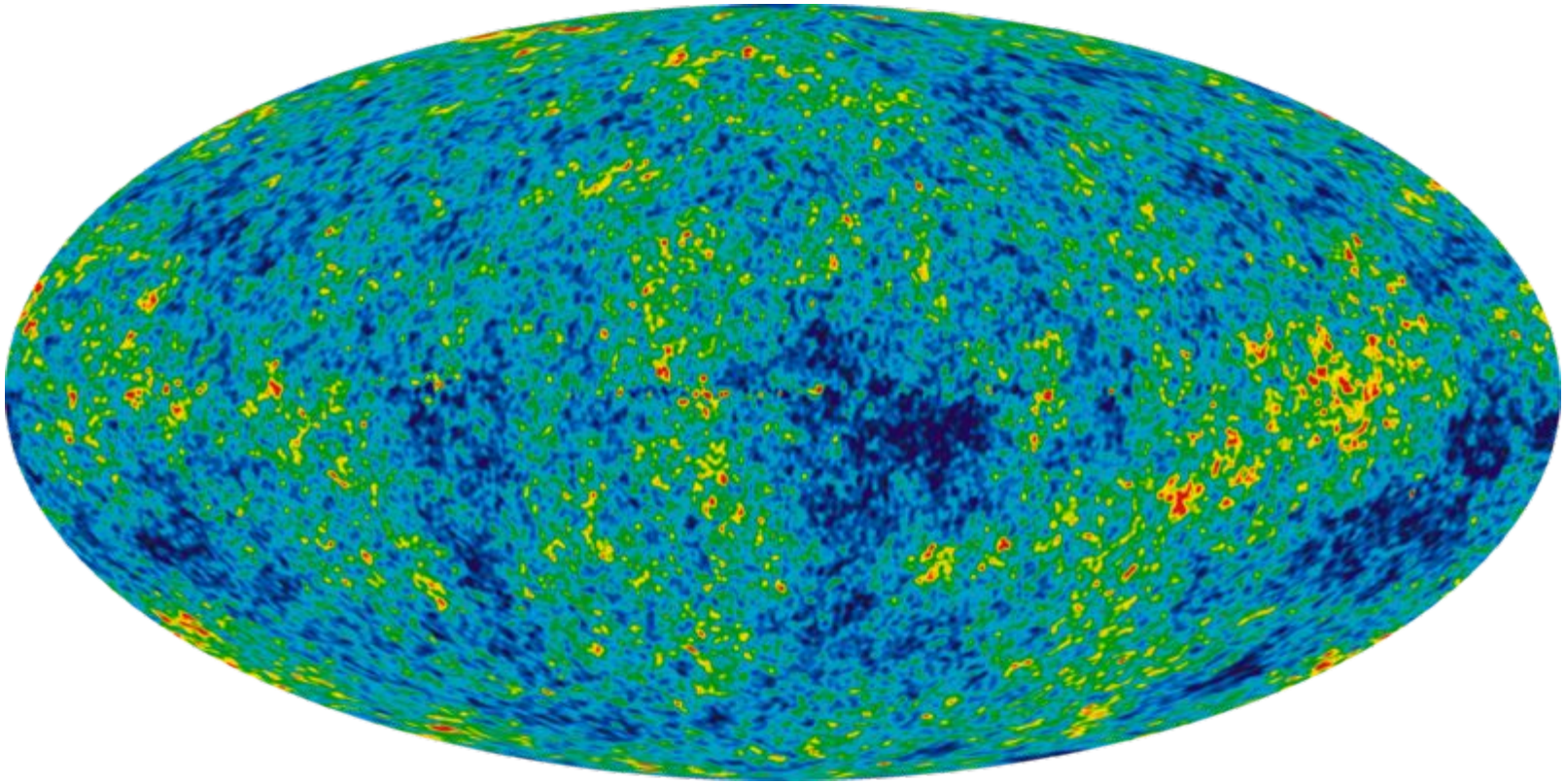




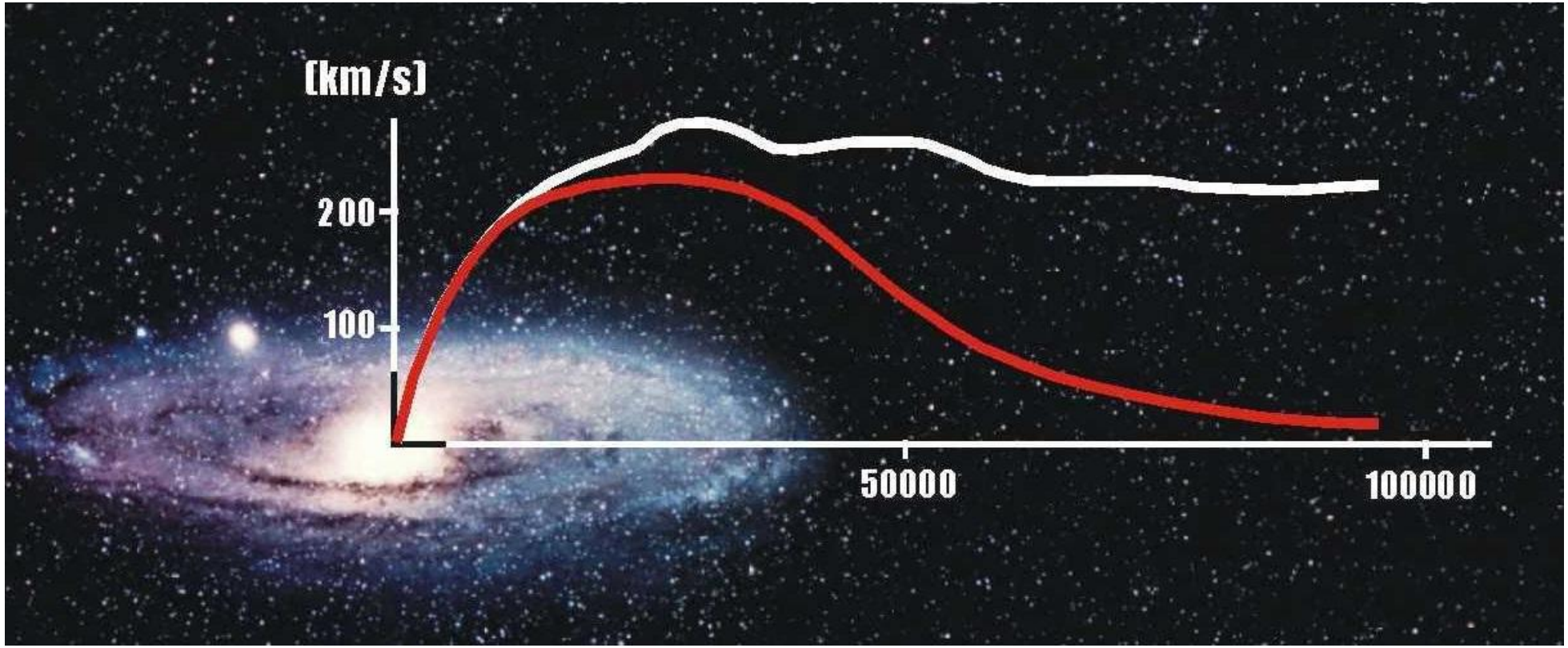








Asymetria medzi hmotou a antihmotou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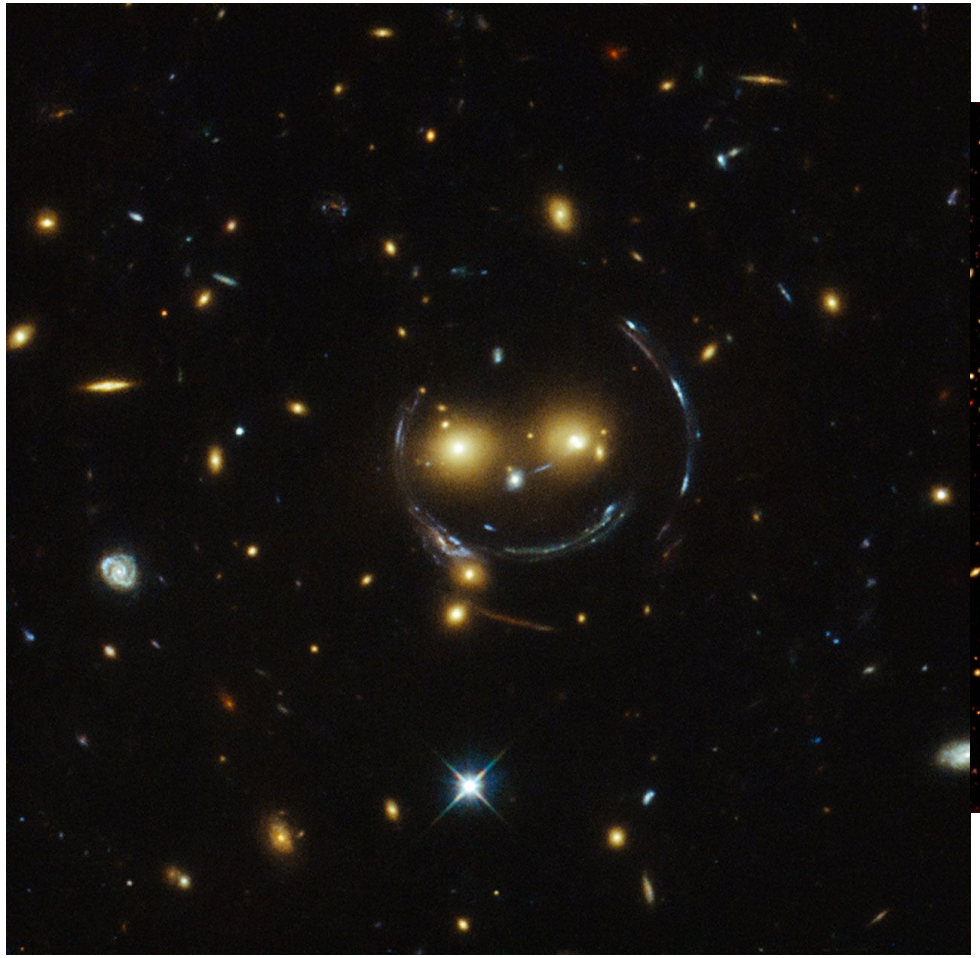
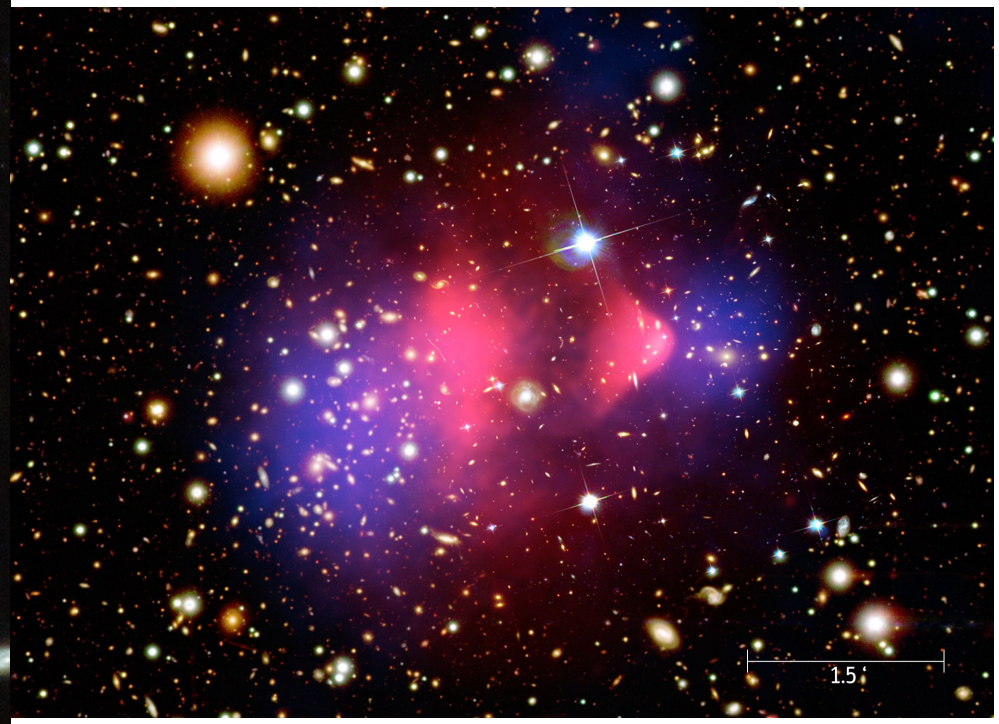
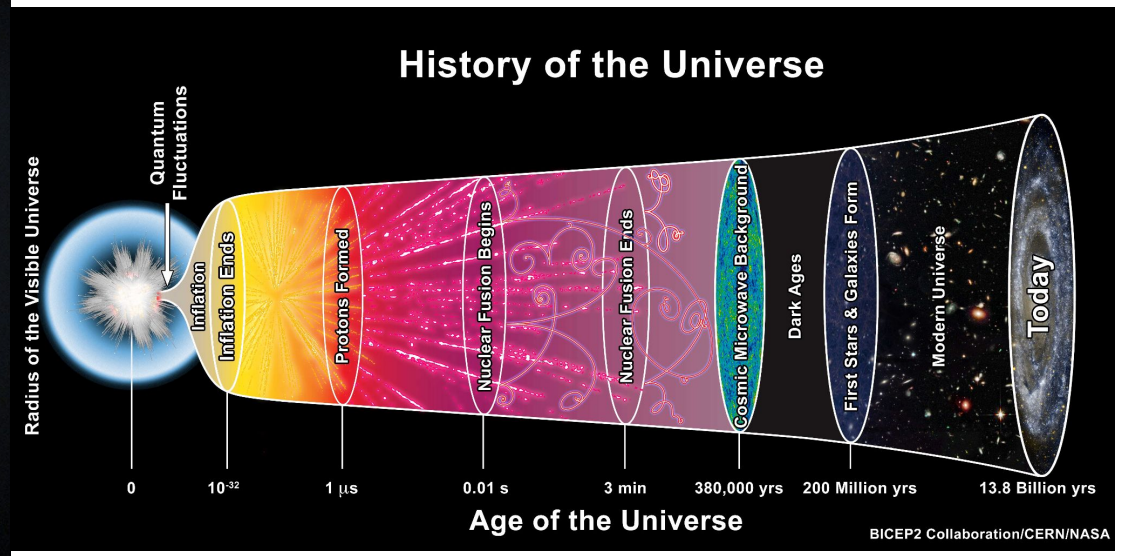
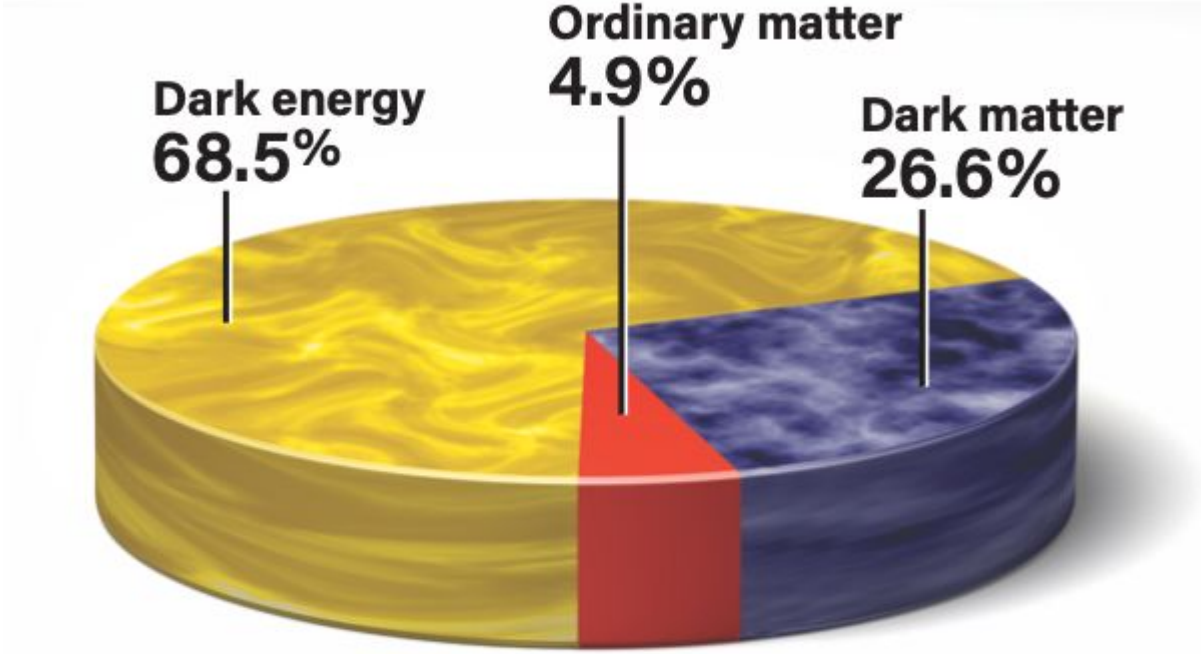
200
100
50000
100000

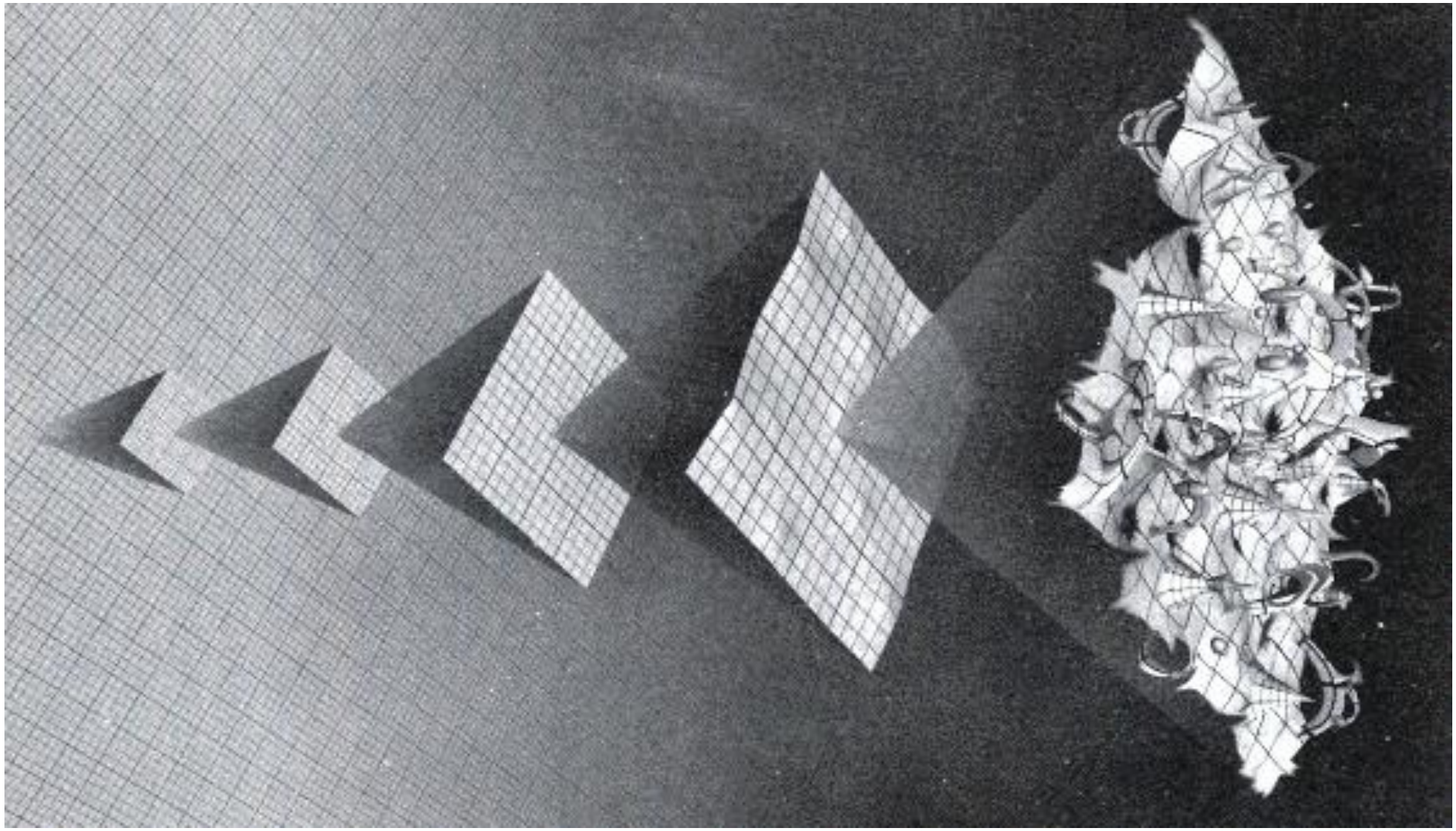



1.5 ‘

Povaha tmavej hmoty

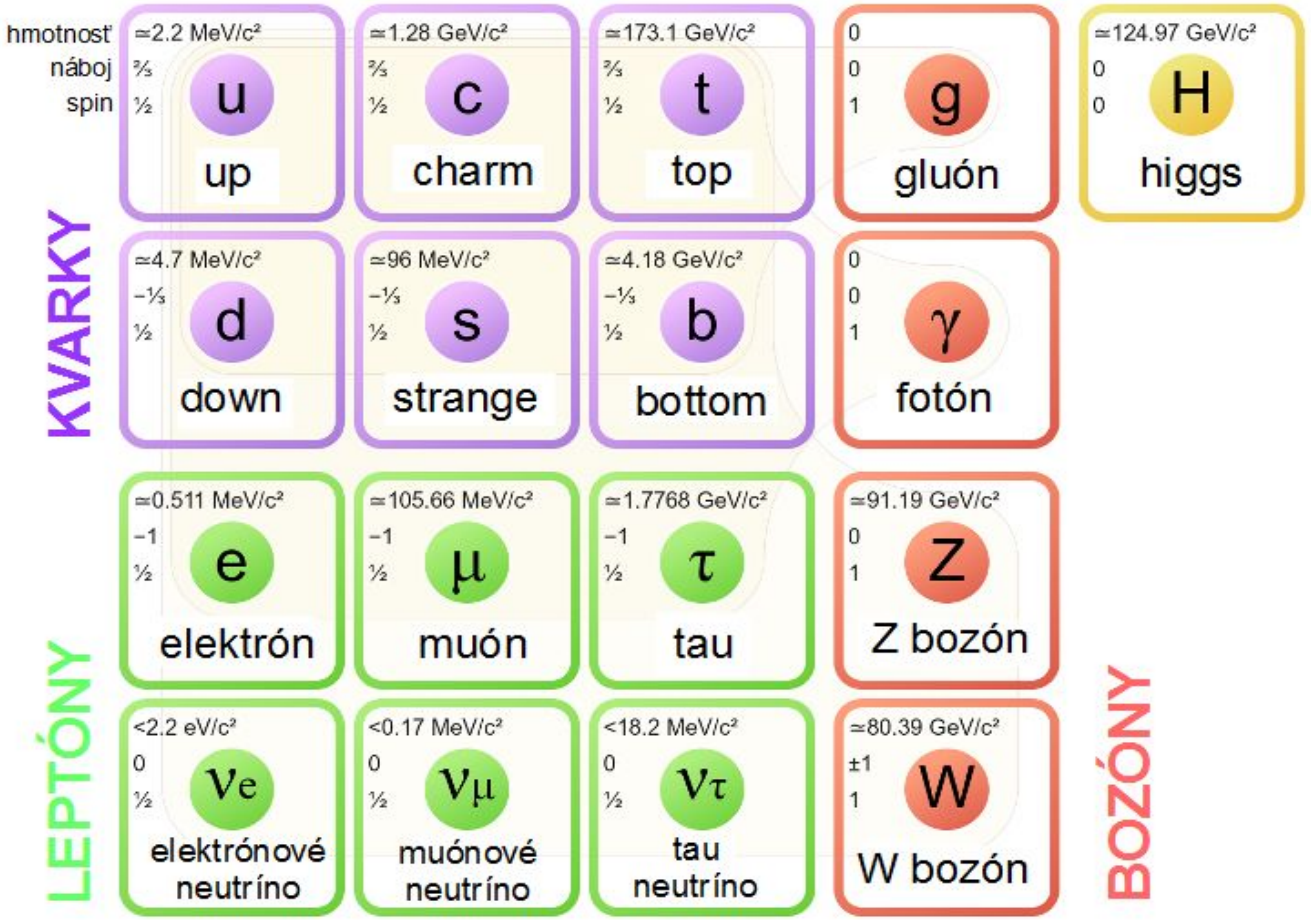

History of the Universe
Radius of the Visible Universe
Quantum Fluctuations
Inflation
Inflation Ends
Protons Formed
Nuclear Fusion Begins
Nuclear Fusion Ends
Cosmic Microwave Background
Dark Ages
First Stars & Galaxies Form
Modern Universe
Today
0
10-32
1 μs
0.01 s
3 min
380,000 yrs
200 Million yrs
13.8 Billion yrs
Age of the Universe
BICEP2 Collaboration/CERN/NASA

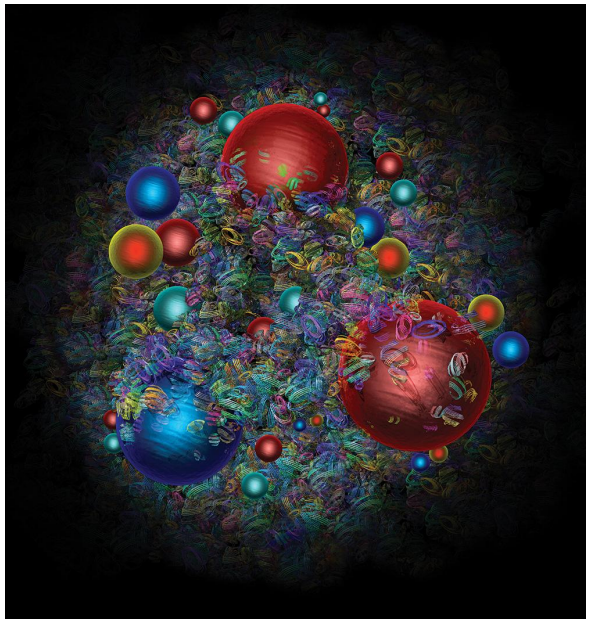

Ordinary matter
4.9%
Dark energy
68.5%
Dark matter
26.6%



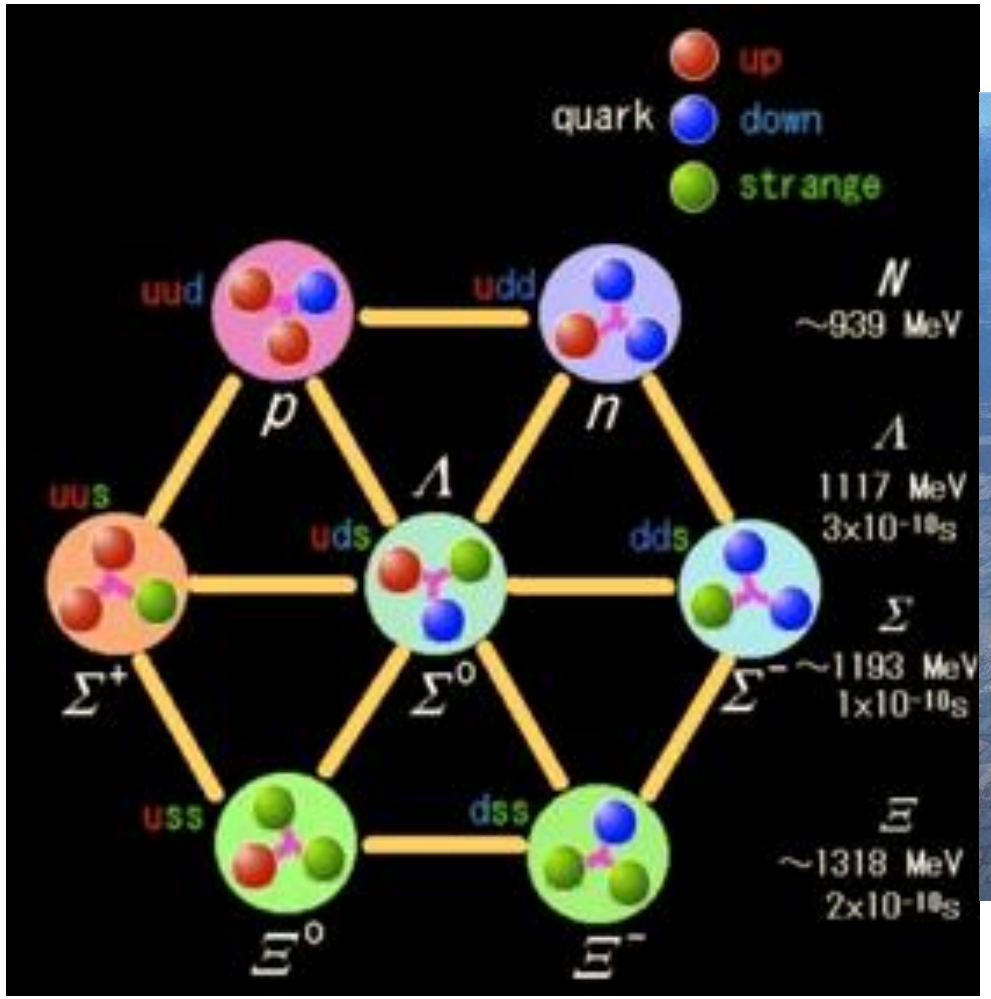
Kozmologická konštanta a tmavá energia

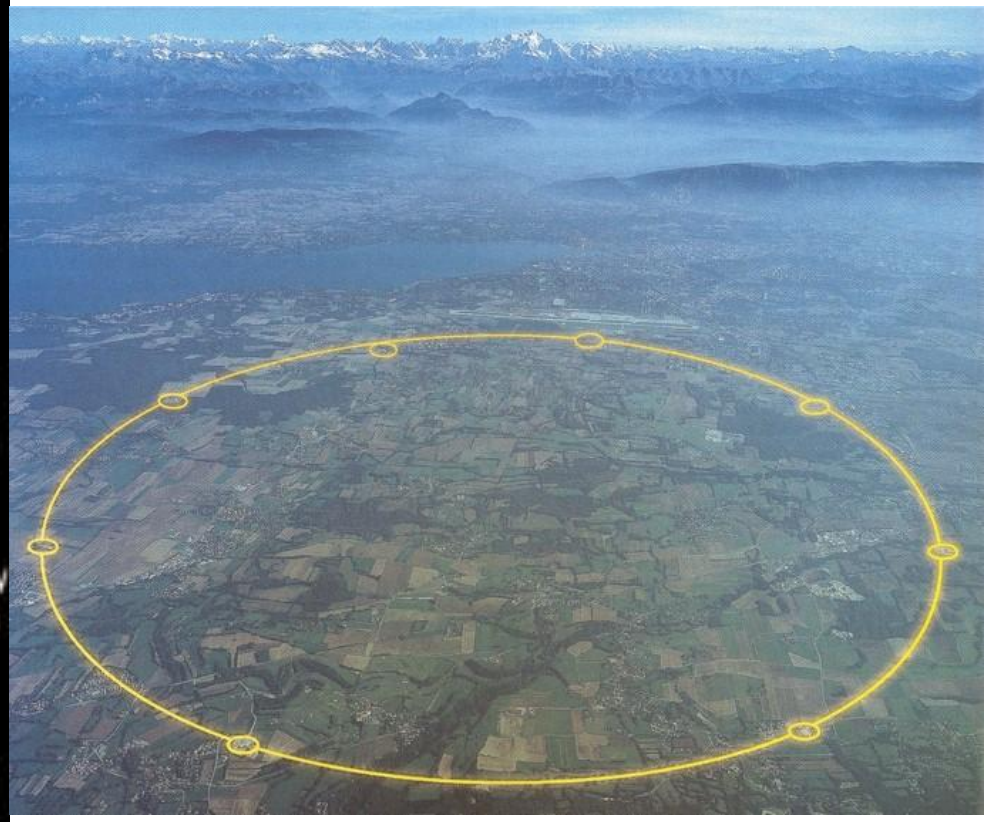
Částicová fyzika





obr.: quark.sk; D Dominguez/CERN


up
quark
down
strange
uud
udd
p
n
N
~939 MeV
Λ
1117 MeV
3x10-10s
uus
uds
dds
Σ
~1193 MeV
1x10-10s
Σ+
Σ0
Σ-
uss
dss
Ξ
~1318 MeV
2x10-10s
Ξ0
Ξ-



$$
\begin{aligned}
\mathcal{L} \;=\; & -\frac{1}{4}B_{\mu\nu}B^{\mu\nu} - \frac{1}{8}tr(\mathbf{W}_{\mu\nu}\mathbf{W}^{\mu\nu}) - \frac{1}{2}tr(\mathbf{G}_{\mu\nu}\mathbf{G}^{\mu\nu}) \\
& + (\bar{\nu}_L, \bar{e}_L)\,\tilde{\sigma}^{\mu} i D_{\mu} \begin{pmatrix} \nu_L \\ e_L \end{pmatrix} + \bar{e}_R \sigma^{\mu} i D_{\mu} e_R + \bar{\nu}_R \sigma^{\mu} i D_{\mu} \nu_R + (\text{h.c.}) \\
& - \frac{\sqrt{2}}{v}\left[(\bar{\nu}_L, \bar{e}_L)\,\phi M^{e} e_R + \bar{e}_R \bar{M}^{e} \bar{\phi} \begin{pmatrix} \nu_L \\ e_L \end{pmatrix} \right] \\
& - \frac{\sqrt{2}}{v}\left[(-\bar{e}_L, \bar{\nu}_L)\,\phi^{*} M^{\nu} \nu_R + \bar{\nu}_R \bar{M}^{\nu} \phi^{T} \begin{pmatrix} -e_L \\ \nu_L \end{pmatrix} \right] \\
& + (\bar{u}_L, \bar{d}_L)\,\tilde{\sigma}^{\mu} i D_{\mu} \begin{pmatrix} u_L \\ d_L \end{pmatrix} + \bar{u}_R \sigma^{\mu} i D_{\mu} u_R + \bar{d}_R \sigma^{\mu} i D_{\mu} d_R + (\text{h.c.}) \\
& - \frac{\sqrt{2}}{v}\left[(\bar{u}_L, \bar{d}_L)\,\phi M^{d} d_R + \bar{d}_R \bar{M}^{d} \bar{\phi} \begin{pmatrix} u_L \\ d_L \end{pmatrix} \right] \\
& - \frac{\sqrt{2}}{v}\left[(-\bar{d}_L, \bar{u}_L)\,\phi^{*} M^{u} u_R + \bar{u}_R \bar{M}^{u} \phi^{T} \begin{pmatrix} -d_L \\ u_L \end{pmatrix} \right] \\
& + \overline{(D_{\mu}\phi)} D^{\mu}\phi - m_h^2 [\bar{\phi}\phi - v^2/2]^2 / 2v^2 .
\end{aligned}
$$

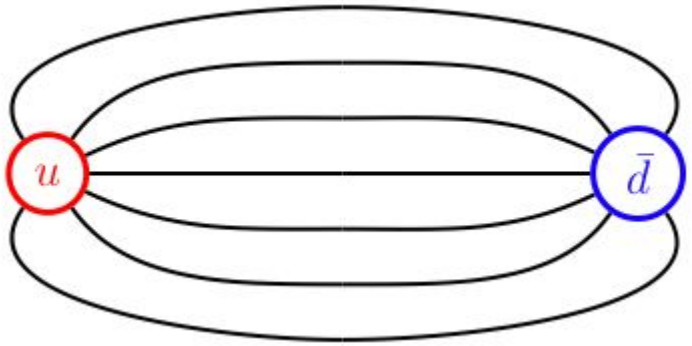
$$D_\mu \begin{pmatrix} \nu_L \\ e_L \end{pmatrix} = \left[\partial_\mu - \frac{ig_1}{2} B_\mu + \frac{ig_2}{2} \mathbf{W}_\mu \right] \begin{pmatrix} \nu_L \\ e_L \end{pmatrix},$$

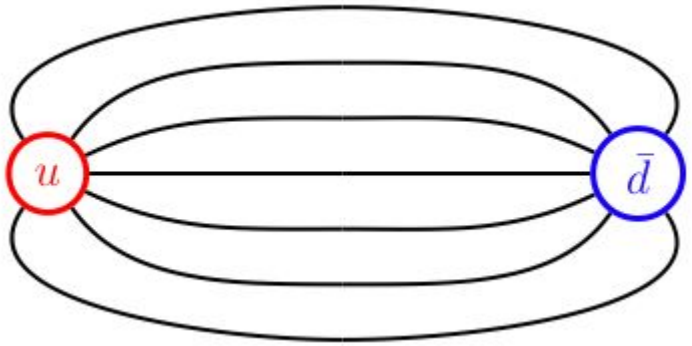
$$D_\mu \nu_R = \partial_\mu \nu_R, \quad D_\mu e_R = \left[\partial_\mu - i g_1 B_\mu \right] e_R,$$

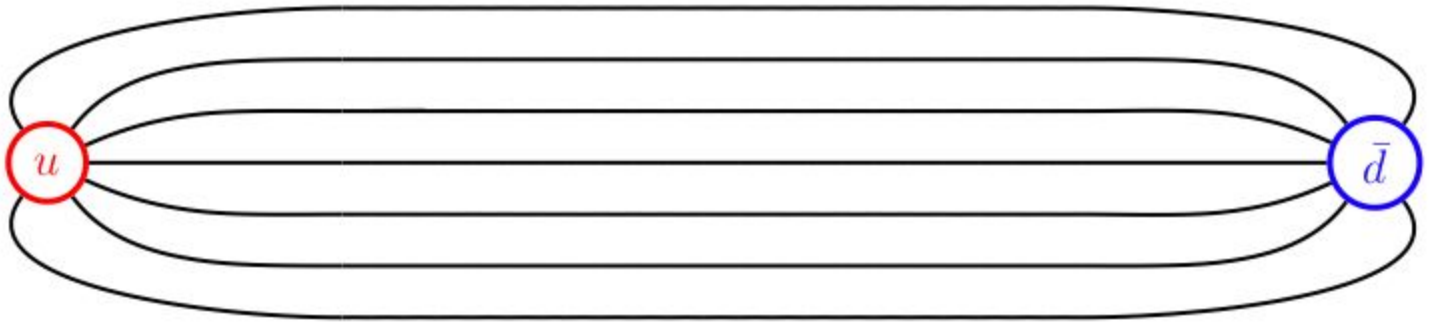
$$D_\mu u_R = \left[\partial_\mu + \frac{i2g_1}{3} B_\mu + ig\mathbf{G}_\mu \right] u_R, \quad D_\mu d_R = \left[\partial_\mu - \frac{ig_1}{3} B_\mu + ig\mathbf{G}_\mu \right] d_R,$$

$$D_\mu \begin{pmatrix} u_L \\ d_L \end{pmatrix} = \left[\partial_\mu + \frac{ig_1}{6} B_\mu + \frac{ig_2}{2} \mathbf{W}_\mu + ig\mathbf{G}_\mu \right] \begin{pmatrix} u_L \\ d_L \end{pmatrix},$$

$$D_\mu \phi = \left[\partial_\mu + \frac{ig_1}{2} B_\mu + \frac{ig_2}{2} \mathbf{W}_\mu \right] \phi.$$


u
$\bar{d}$


u
$\bar{d}$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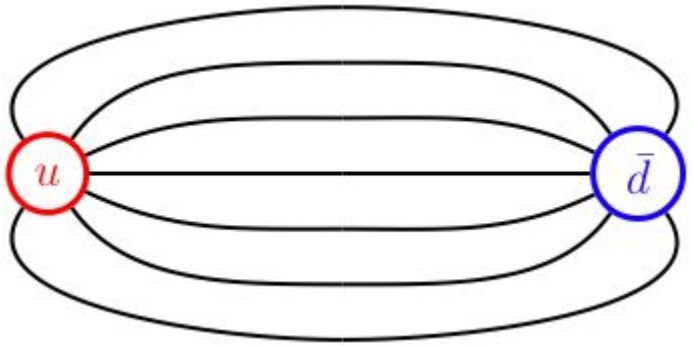
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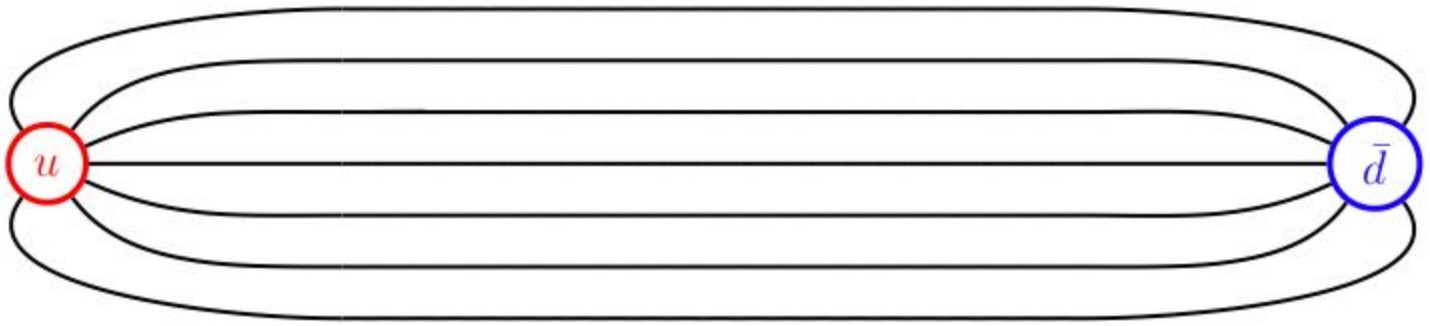
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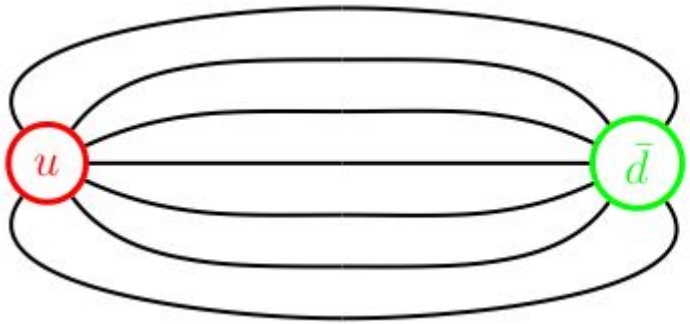
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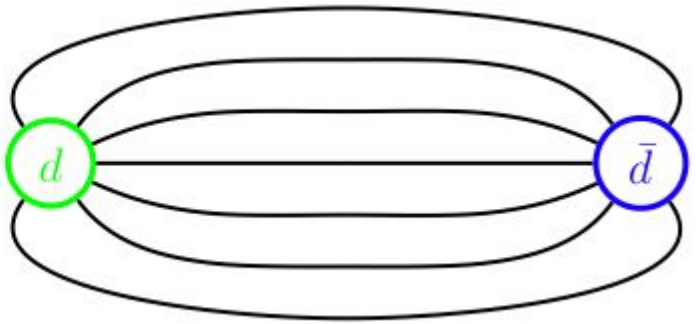
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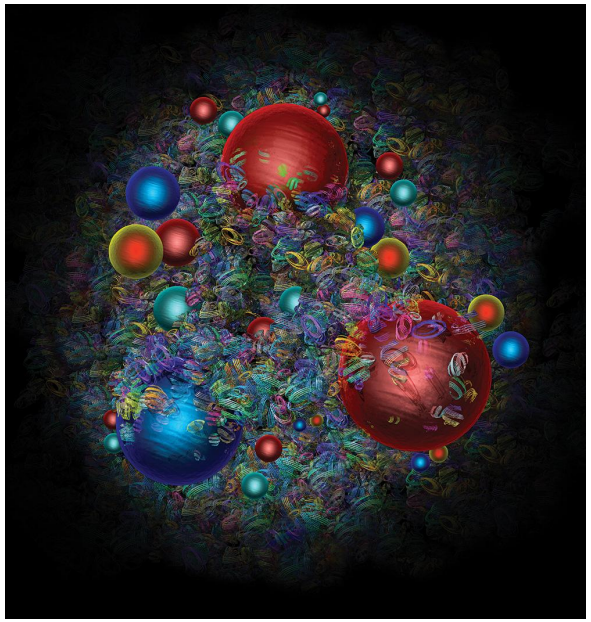
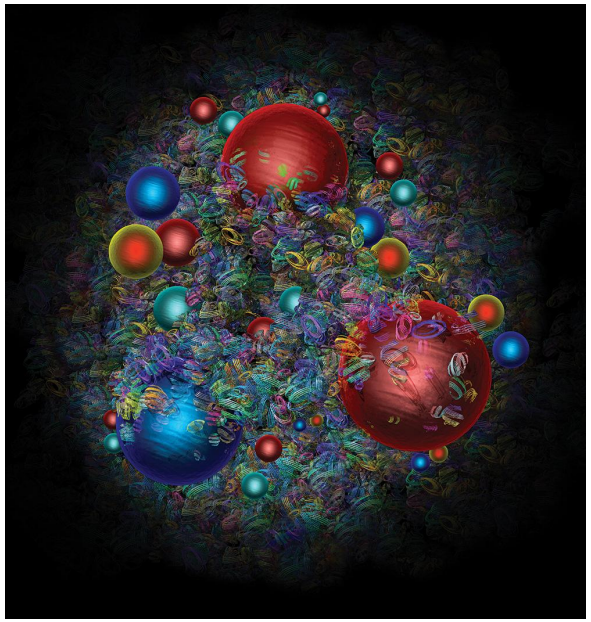
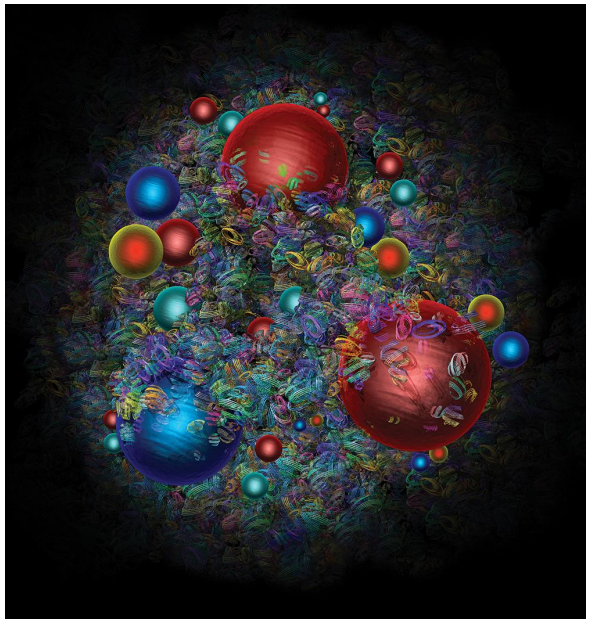
Uväznenie kvarkov

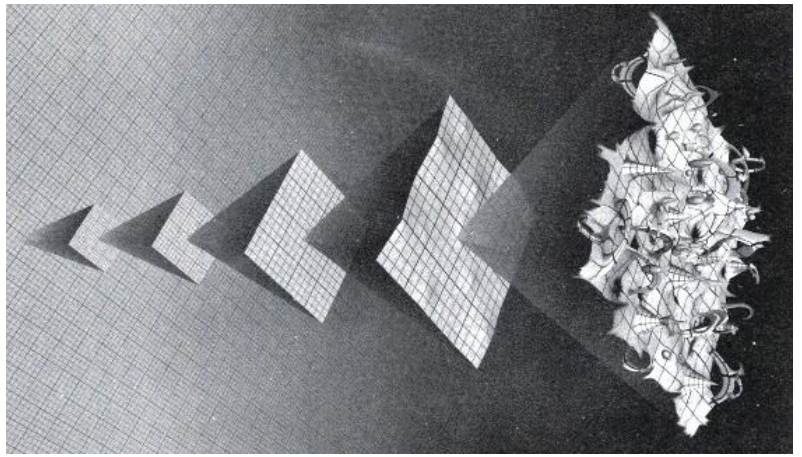
Fyzika za štandardným modelom



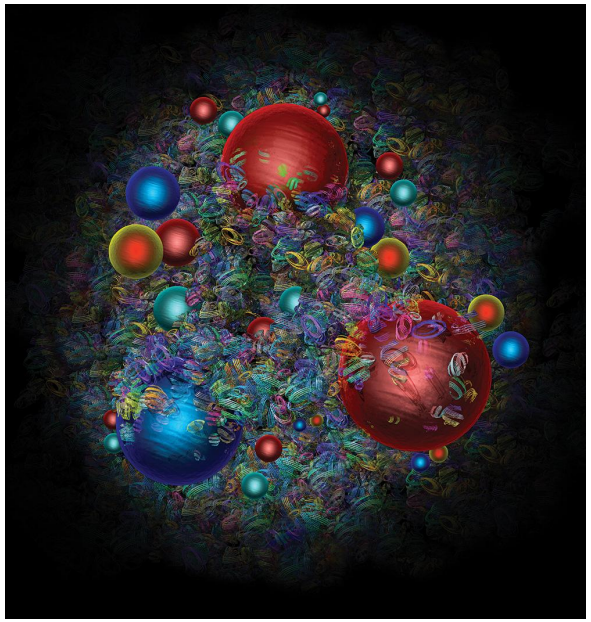


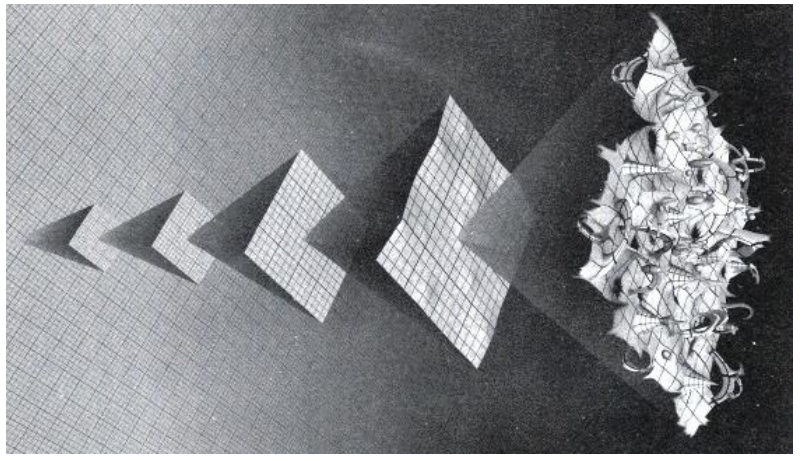
hmotnosť náboj spin	≃2.2 MeV/c² ⅔ ½ u up	≃1.28 GeV/c² ⅔ ½ c charm	≃173.1 GeV/c² ⅔ ½ t top	0 0 1 g gluón	≃124.97 GeV/c² 0 0 H higgs
KVARKY	≃4.7 MeV/c² −⅓ ½ d down	≃96 MeV/c² −⅓ ½ s strange	≃4.18 GeV/c² −⅓ ½ b bottom	0 0 1 γ fotón	
LEPTÓNY	≃0.511 MeV/c² −1 ½ e elektrón	≃105.66 MeV/c² −1 ½ μ muón	≃1.7768 GeV/c² −1 ½ τ tau	≃91.19 GeV/c² 0 1 Z Z bozón	BOZÓNY
	<2.2 eV/c² 0 ½ νe elektrónové neutríno	<0.17 MeV/c² 0 ½ νμ muónové neutríno	<18.2 MeV/c² 0 ½ ντ tau neutríno	≃80.39 GeV/c² ±1 1 W W bozón	



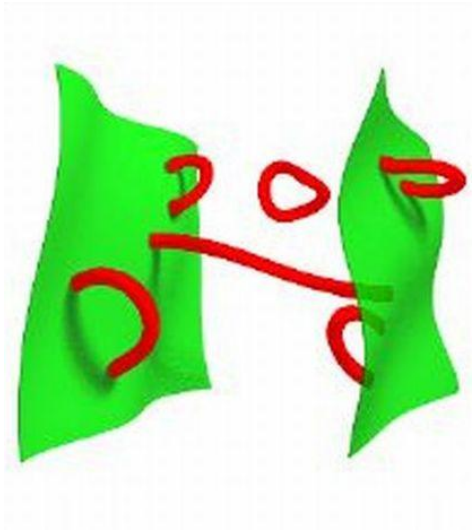


hmotnosť náboj spin					
KVARKY	≃2.2 MeV/c² ⅔ ½ u up	≃1.28 GeV/c² ⅔ ½ c charm	≃173.1 GeV/c² ⅔ ½ t top	0 0 1 g gluón	≃124.97 GeV/c² 0 0 H higgs
	≃4.7 MeV/c² −⅓ ½ d down	≃96 MeV/c² −⅓ ½ s strange	≃4.18 GeV/c² −⅓ ½ b bottom	0 0 1 γ fotón	
LEPTÓNY	≃0.511 MeV/c² −1 ½ e elektrón	≃105.66 MeV/c² −1 ½ μ muón	≃1.7768 GeV/c² −1 ½ τ tau	≃91.19 GeV/c² 0 1 Z Z bozón	BOZÓNY
	<2.2 eV/c² 0 ½ νe elektrónové neutríno	<0.17 MeV/c² 0 ½ νμ muónové neutríno	<18.2 MeV/c² 0 ½ ντ tau neutríno	≃80.39 GeV/c² ±1 1 W W bozón	

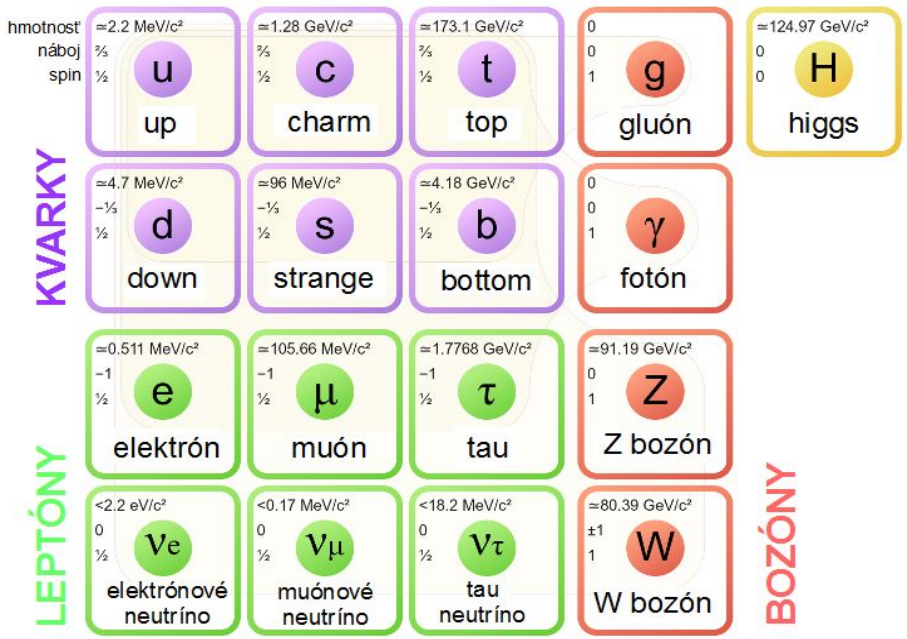




hmotnosť / náboj / spin					
	≃2.2 MeV/c² ⅔ ½ u up	≃1.28 GeV/c² ⅔ ½ c charm	≃173.1 GeV/c² ⅔ ½ t top	0 0 1 g gluón	≃124.97 GeV/c² 0 0 H higgs
KVARKY	≃4.7 MeV/c² −⅓ ½ d down	≃96 MeV/c² −⅓ ½ s strange	≃4.18 GeV/c² −⅓ ½ b bottom	0 0 1 γ fotón	
LEPTÓNY	≃0.511 MeV/c² −1 ½ e elektrón	≃105.66 MeV/c² −1 ½ μ muón	≃1.7768 GeV/c² −1 ½ τ tau	≃91.19 GeV/c² 0 1 Z Z bozón	BOZÓNY
	<2.2 eV/c² 0 ½ νe elektrónové neutríno	<0.17 MeV/c² 0 ½ νμ muónové neutríno	<18.2 MeV/c² 0 ½ ντ tau neutríno	≃80.39 GeV/c² ±1 1 W W bozón	



Supersymetria


hmotnosť
náboj
spin
KVARKY
LEPTÓNY
BOZÓNY
≃2.2 MeV/c²
⅔
½
u
up
≃1.28 GeV/c²
⅔
½
c
charm
≃173.1 GeV/c²
⅔
½
t
top
0
0
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g
gluón
≃124.97 GeV/c²
0
0
H
higgs
≃4.7 MeV/c²
−⅓
½
d
down
≃96 MeV/c²
−⅓
½
s
strange
≃4.18 GeV/c²
−⅓
½
b
bottom
0
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fotón
≃0.511 MeV/c²
−1
½
e
elektrón
≃105.66 MeV/c²
−1
½
μ
muón
≃1.7768 GeV/c²
−1
½
τ
tau
≃91.19 GeV/c²
0
1
Z
Z bozón
<2.2 eV/c²
0
½
νe
elektrónové neutríno
<0.17 MeV/c²
0
½
νμ
muónové neutríno
<18.2 MeV/c²
0
½
ντ
tau neutríno
≃80.39 GeV/c²
±1
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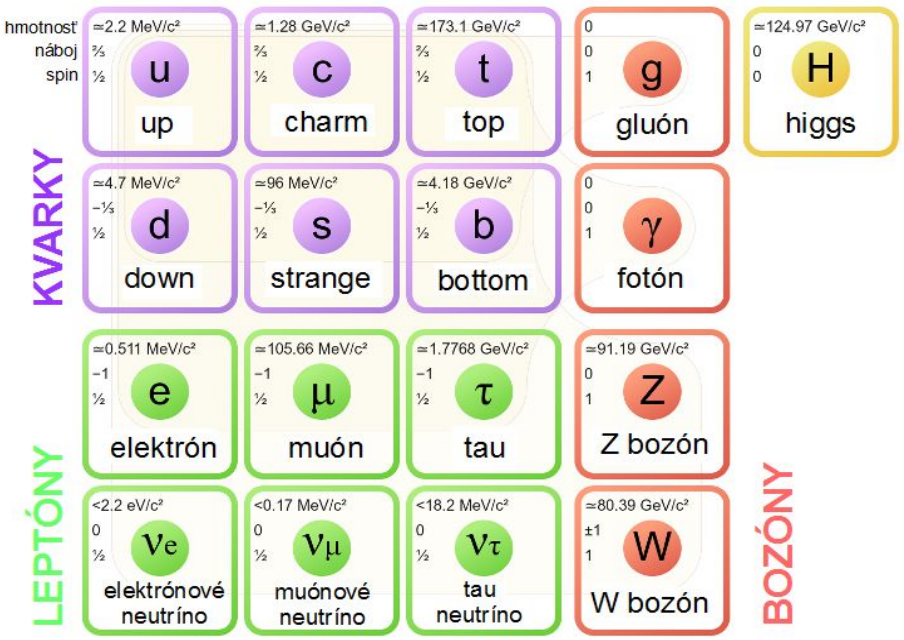
W
W bozón


hmotnosť
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spin
≃2.2 MeV/c²
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gluón
≃124.97 GeV/c²
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higgs
KVARKY
≃4.7 MeV/c²
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≃1.7768 GeV/c²
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½
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tau
≃91.19 GeV/c²
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Z bozón
<2.2 eV/c²
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νe
elektrónové neutríno
<0.17 MeV/c²
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νμ
muónové neutríno
<18.2 MeV/c²
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ντ
tau neutríno
≃80.39 GeV/c²
±1
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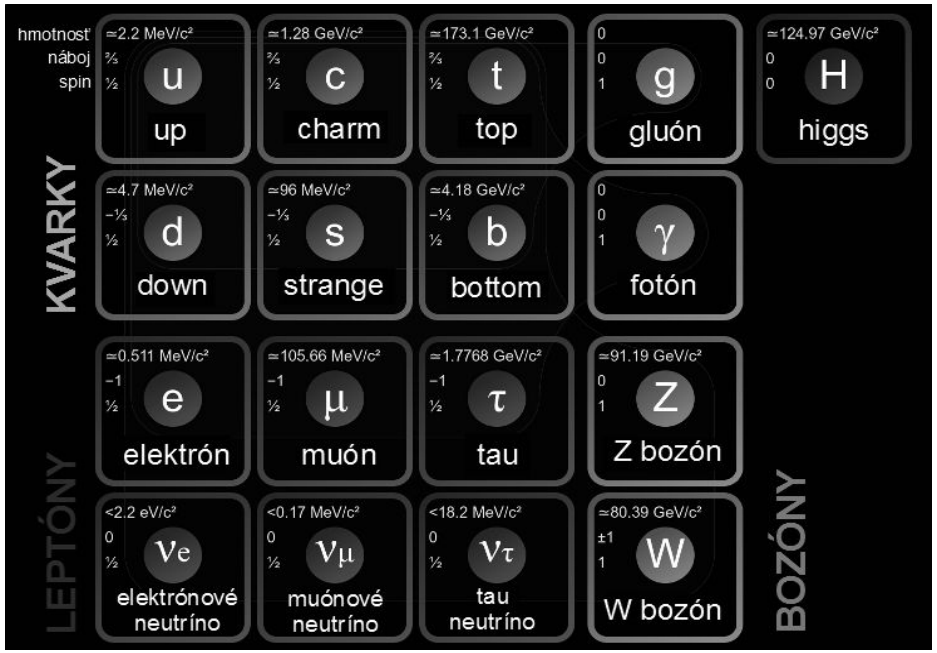
W bozón
BOZÓNY


hmotnosť
náboj
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LEPTÓNY
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≃91.19 GeV/c²
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Z bozón
<2.2 eV/c²
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elektrónové neutríno
<0.17 MeV/c²
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muónové neutríno
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½
ντ
tau neutríno
≃80.39 GeV/c²
±1
1
W
W bozón
BOZÓNY

Hovorili sme o:

- Vysokoteplotná supravodivosť
- Turbulencia
- Asymetria medzi hmotou a antihmotou
- Povaha tmavej hmoty
- Kozmologická konštanta a tmavá energia
- Uväznenie kvarkov
- Fyzika za štandardným modelom
- Supersymetria

Fyzika a veda všeobecne nie sú ani zďaleka vyriešenou záležitosťou.

Fyzika a veda všeobecne nie sú ani zďaleka vyriešenou záležitosťou.

Stále je veľmi veľa veľmi zaujímavých problémov, ktoré čakajú na vyriešenie.

Ďakujem za pozornosť!