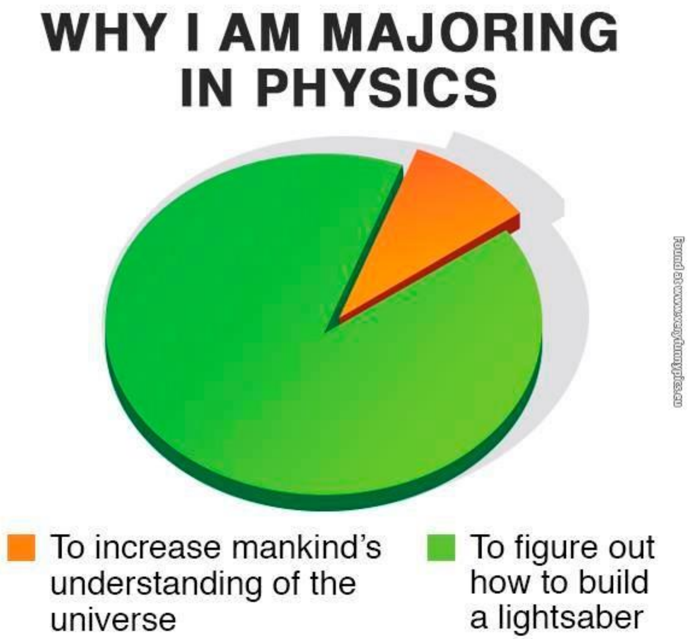
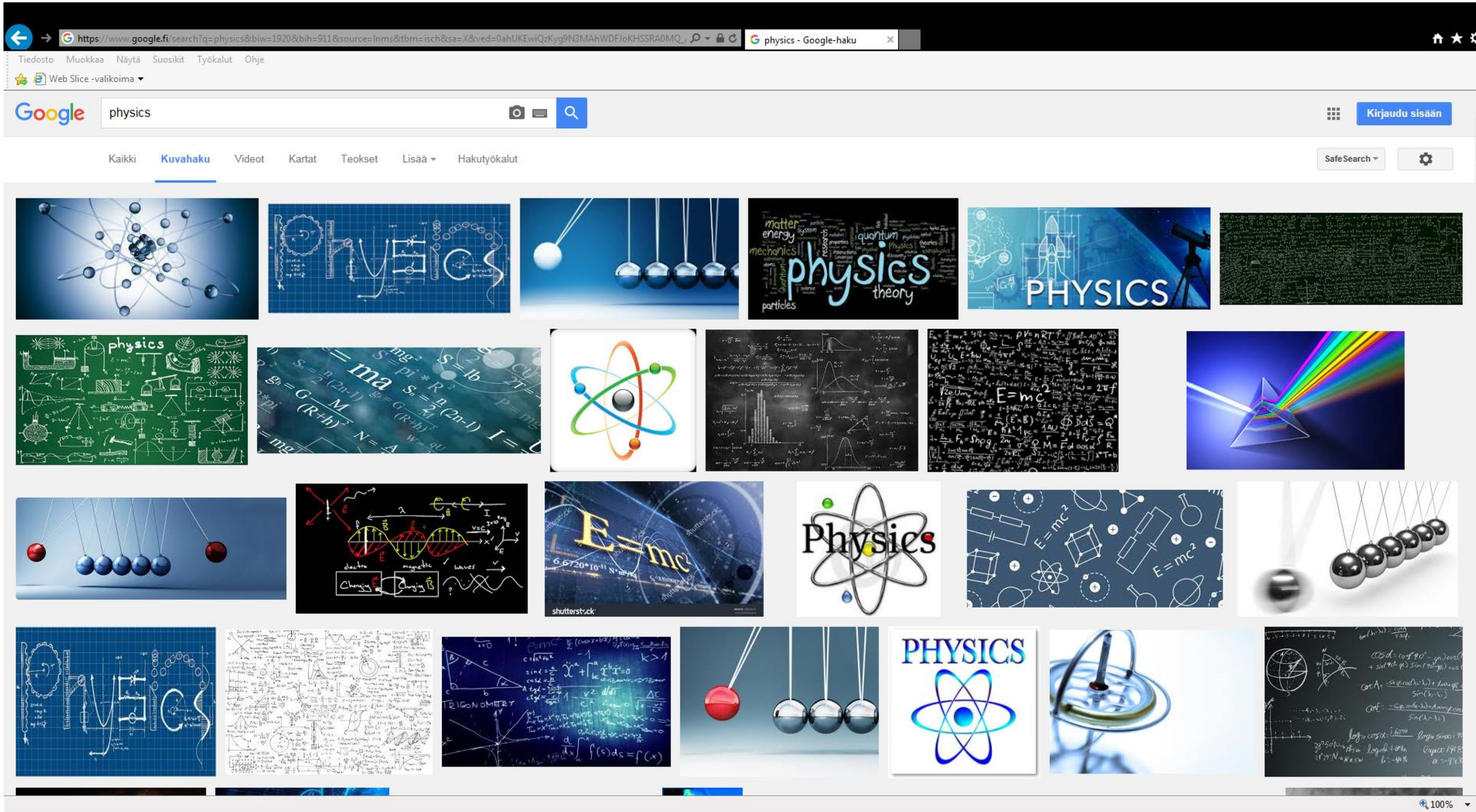
CERN-matka 2016 - 2017

UUTTA FYSIIKKAA



Janne Tapiovaara
Rauman Lyseon lukio

http://imglulz.com/wp-content/uploads/2015/02/keep-calm-and-let-it-go.jpg


https://www.google.fi/search?q=physics&biw=1920&bih=911&source=lnms&tbm=isch&sa=X&ved=0ahUKEwiQzKyg9N3MAhWDFJoKHSSRA0MQ_
physics - Google-haku
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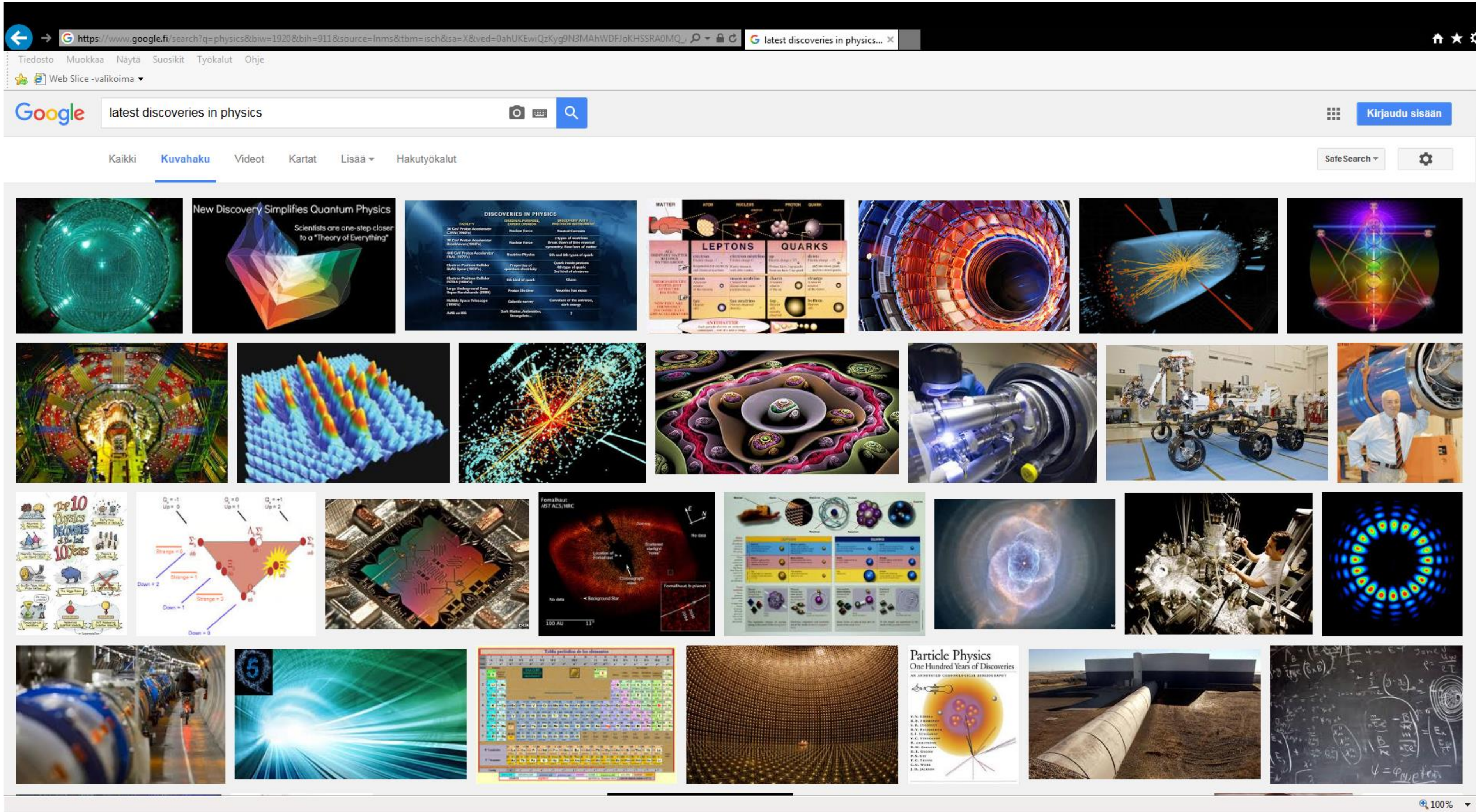
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latest discoveries in physics...
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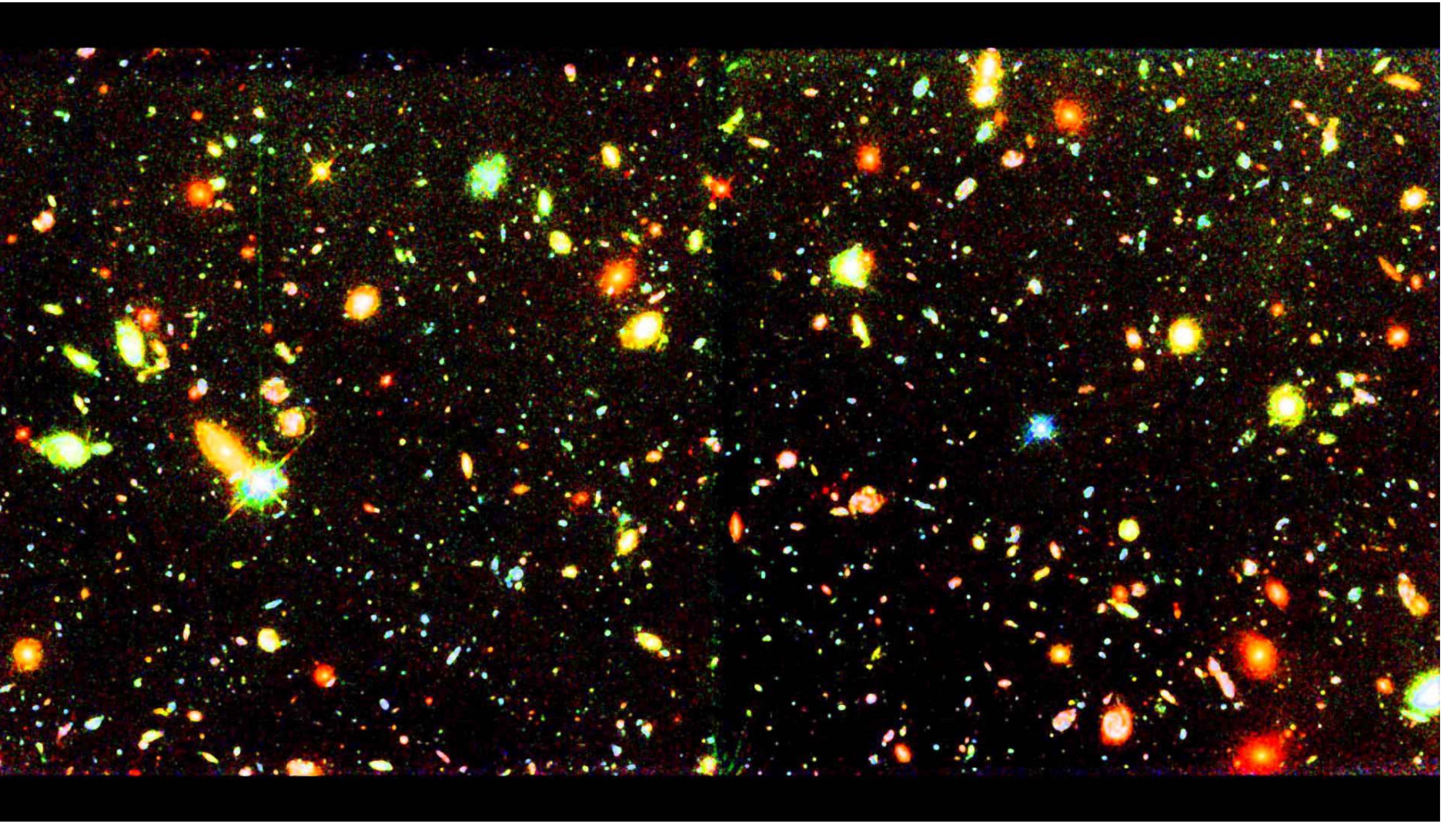
SafeSearch
New Discovery Simplifies Quantum Physics
Scientists are one-step closer to a "Theory of Everything"
DISCOVERIES IN PHYSICS
LEPTONS
QUARKS
Particle Physics
One Hundred Years of Discoveries
100%

FYSIIKKA ON KOKEELLINEN LUONNONTIEDE, JOKA **PYRKII** SELITTÄMÄÄN LUONNONILMIÖITÄ

Hubble deep space



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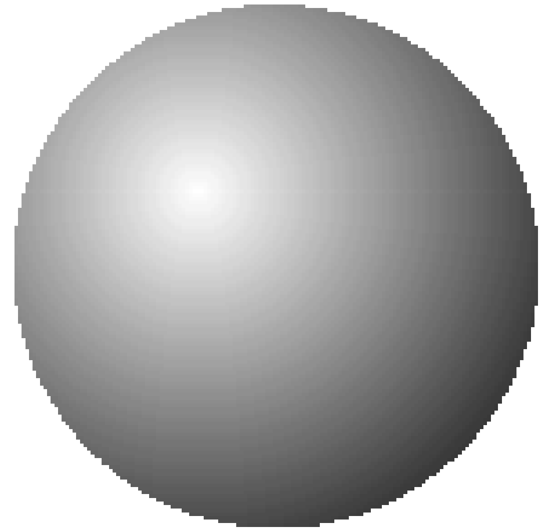
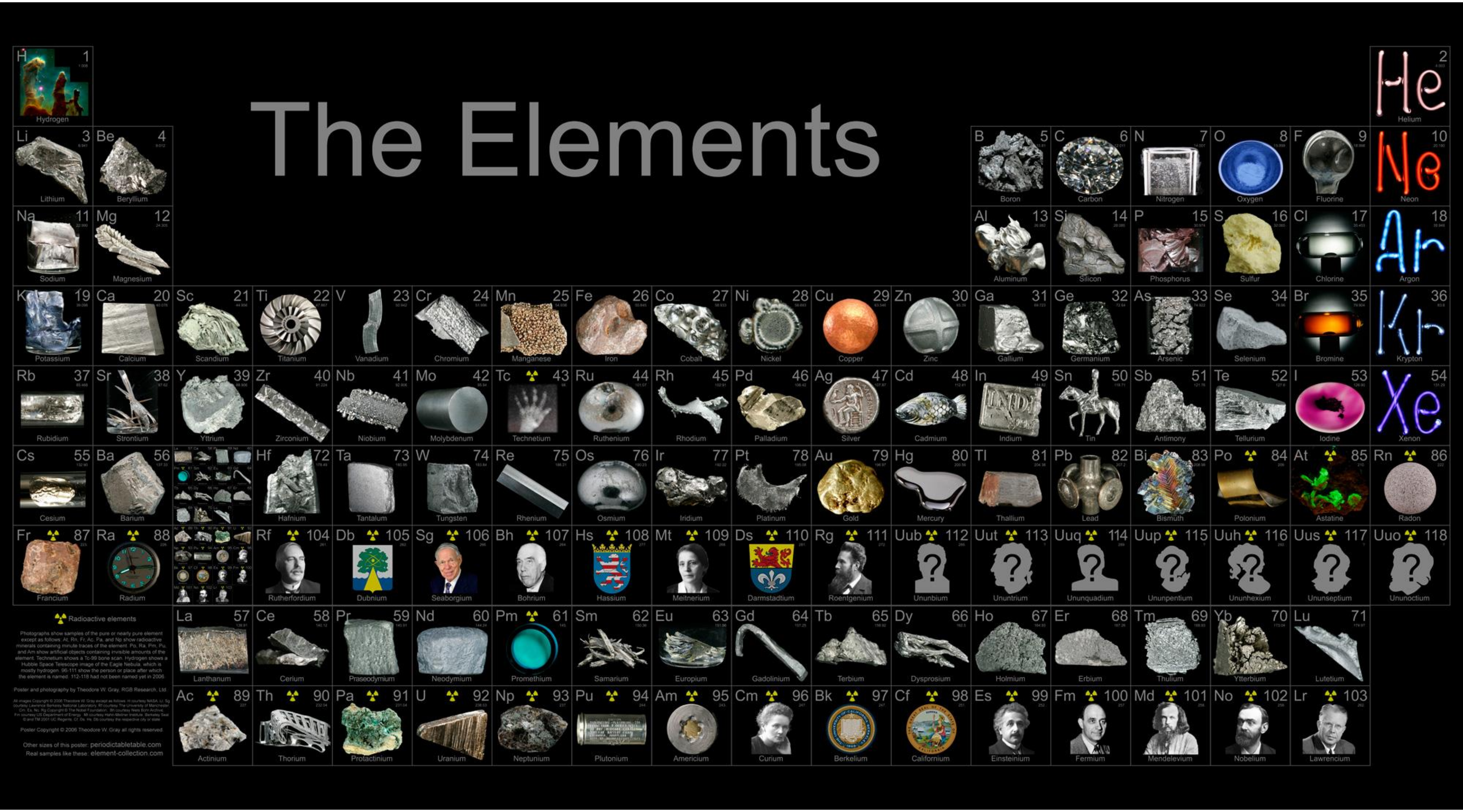


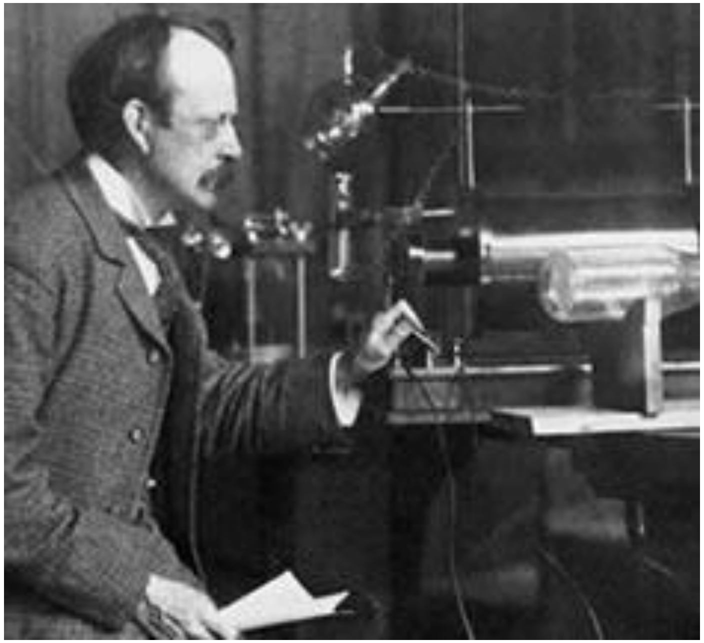
Democritus
(400 B.C.)

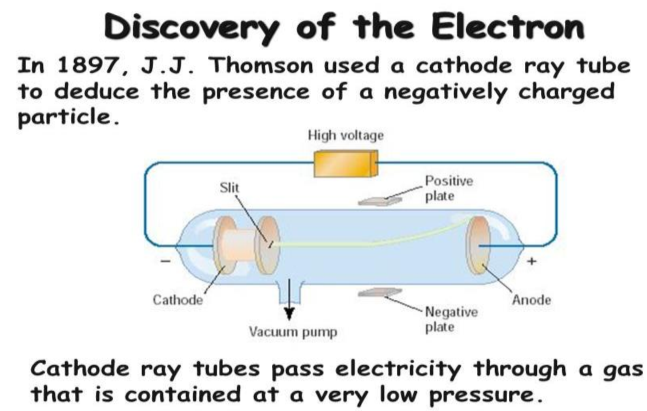
1) https://the-history-of-the-atom.wikispaces.com/file/view/demo.jpg/183311765/163x159/demo.jpg
2) https://the-history-of-the-atom.wikispaces.com/file/view/demo__atom_model.gif/183311563/demo__atom_model.gif

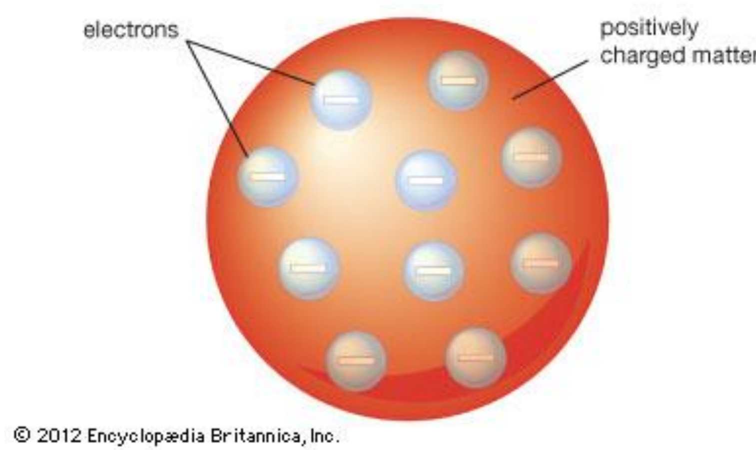


http://www.extremetech.com/wp-content/uploads/2013/08/periodic-table-of-elements-pictorial.jpg

THOMSON



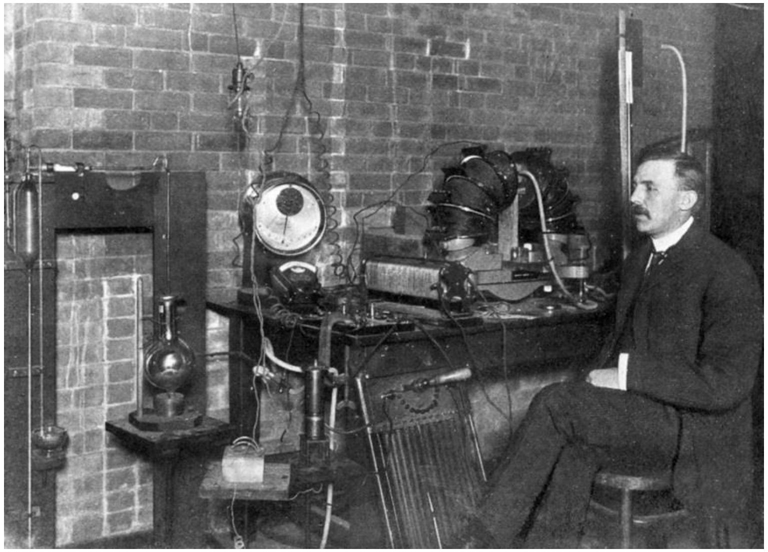


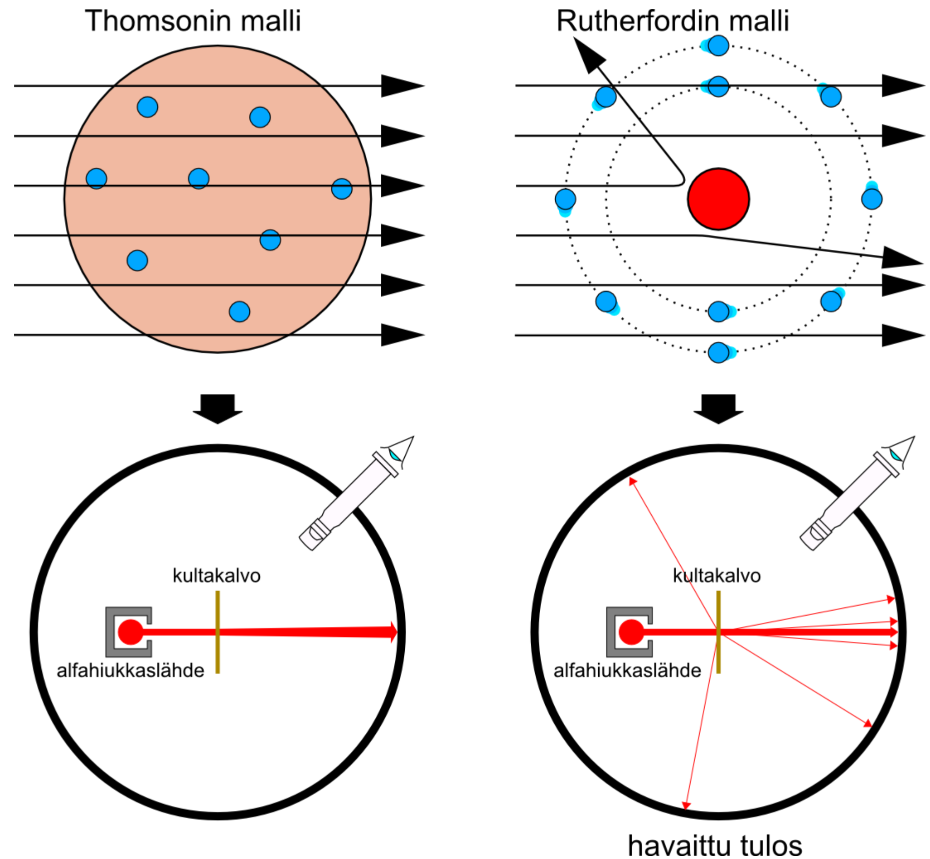


Positiivisesti varautuneen hyytelömäisen aineen sisällä negatiivisia elektroneja.

1) http://www-outreach.phy.cam.ac.uk/camphy/electron/side6_electron.jpg
2) http://images.slideplayer.com/8/2323609/slides/slide_7.jpg
3) http://media-2.web.britannica.com/eb-media/72/22472-004-3E9C843B.jpg

RUTHERFORD

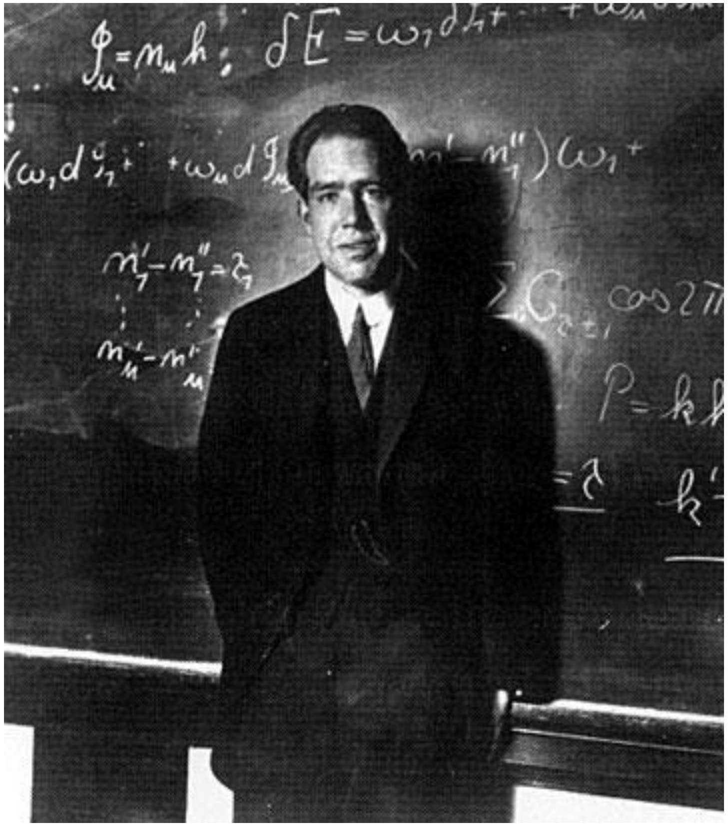


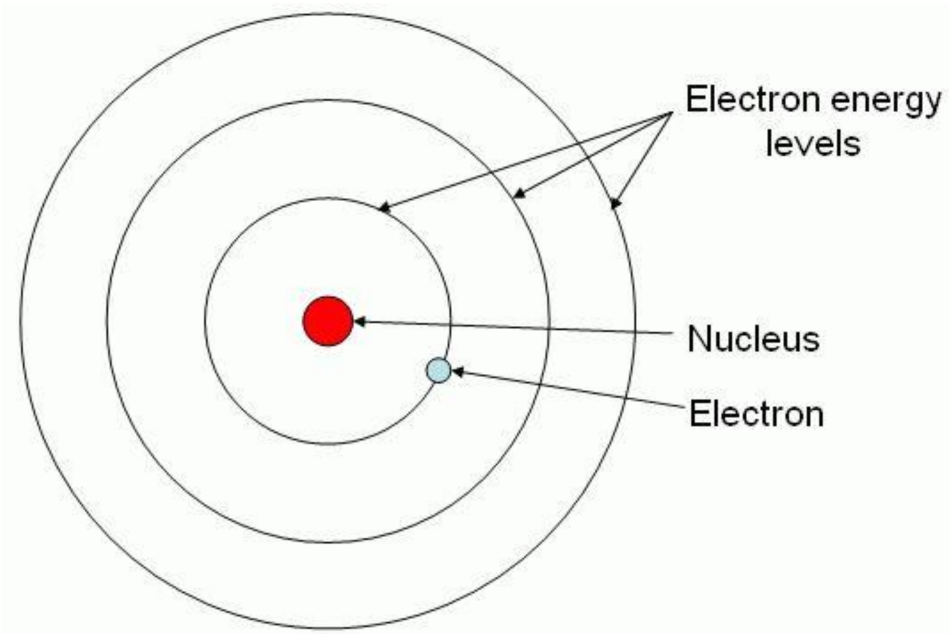


Lähes koko massa ytimessä ja atomin koon määrittää sen ympärillä oleva elektroniverho

1)https://upload.wikimedia.org/wikipedia/commons/d/d1/Ernest_Rutherford_1905.jpg
2) http://opinnot.internetix.fi/fi/muikku2materiaalit/lukio/fy/fy8/3_atomin_ydin_ja_radioaktiivisuus/301/fi_embedded/image22.png

BOHR

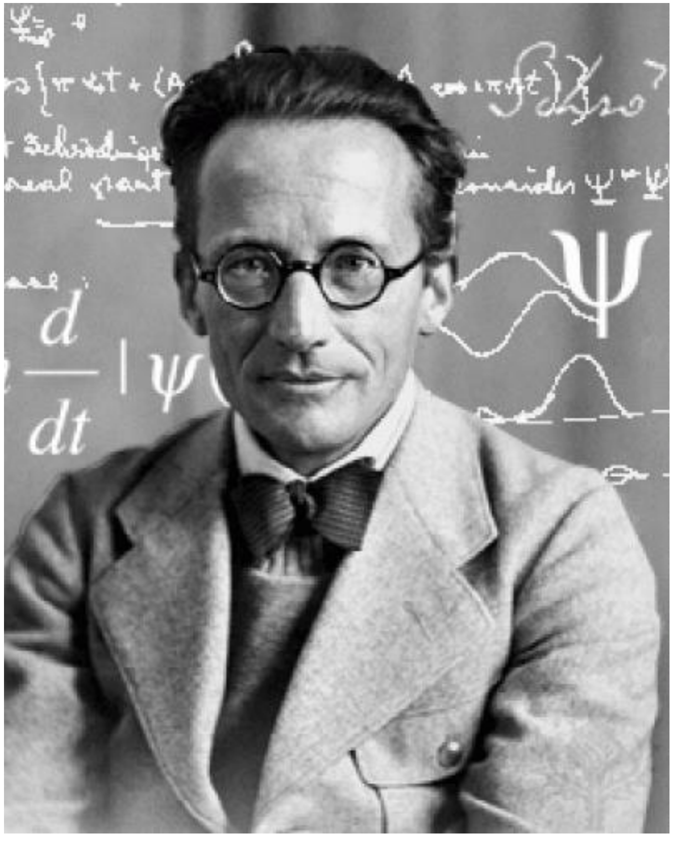


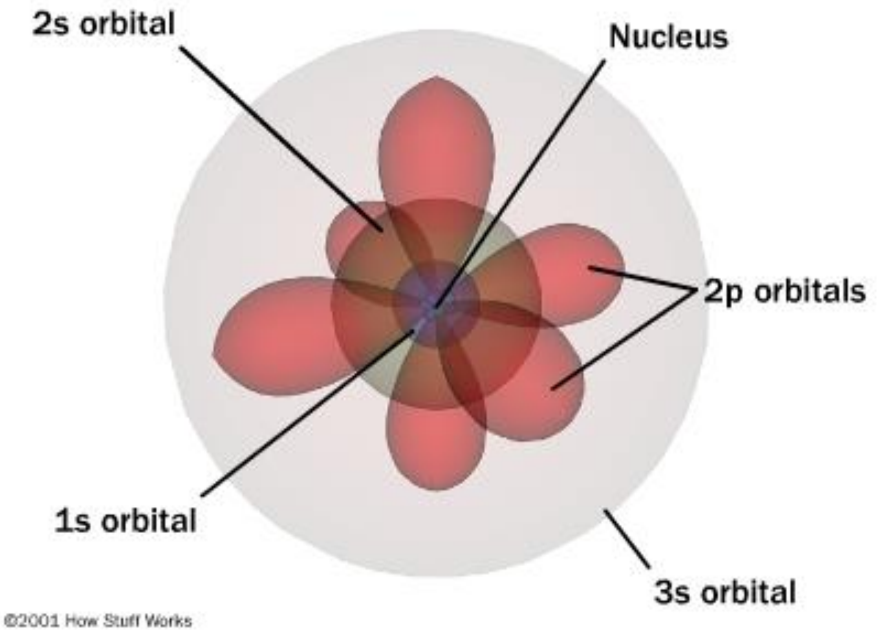


Elektroni voi kiertää ydintä vain tietyillä ympyränmuotoisilla radoilla

1) http://www.atomicarchive.com/Images/bio/B23.jpg
2) https://s-media-cache-ak0.pinimg.com/736x/a0/cd/6d/a0cd6da6e213e48ccadeed3c6ea55247.jpg

SCHRÖDINGER

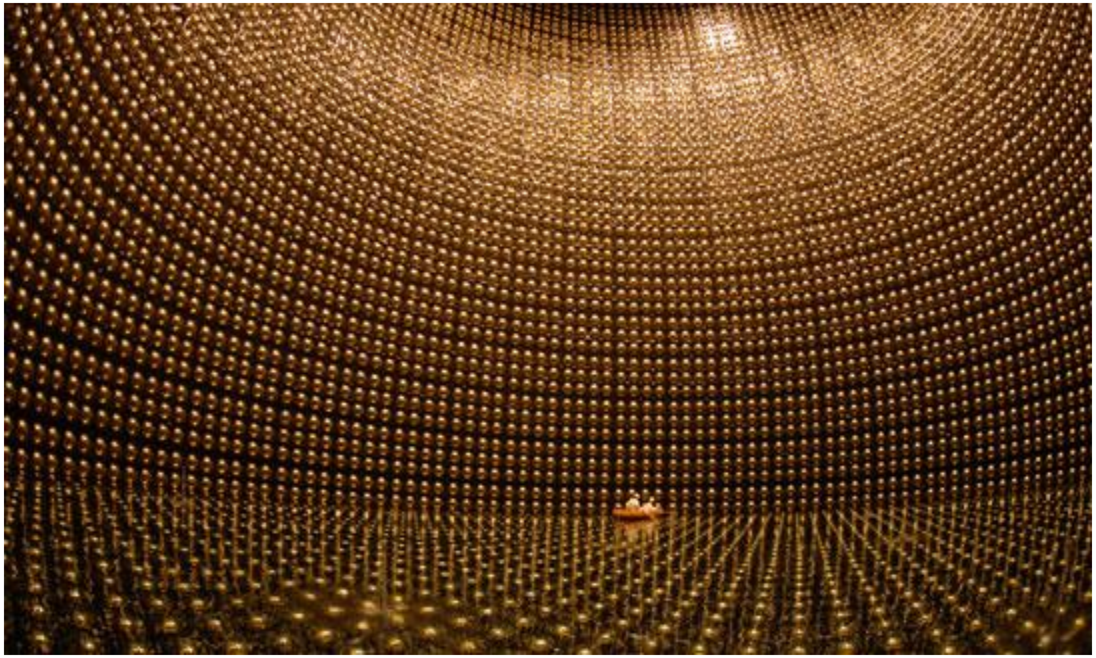




KVANTTIMEKAANINEN: Elektronit muodostavat ytimen ympärille todennäköisyyspilviä ja aalto- hiukkasdualismi

1) http://stanfordflipside.com/images/204Schrodinger.gif
2) http://4.bp.blogspot.com/-LYf_1bY_UWs/TsslYcrsTpI/AAAAAAAAALE/QeGoBoWQKjw/s1600/Schrodinger.jpg

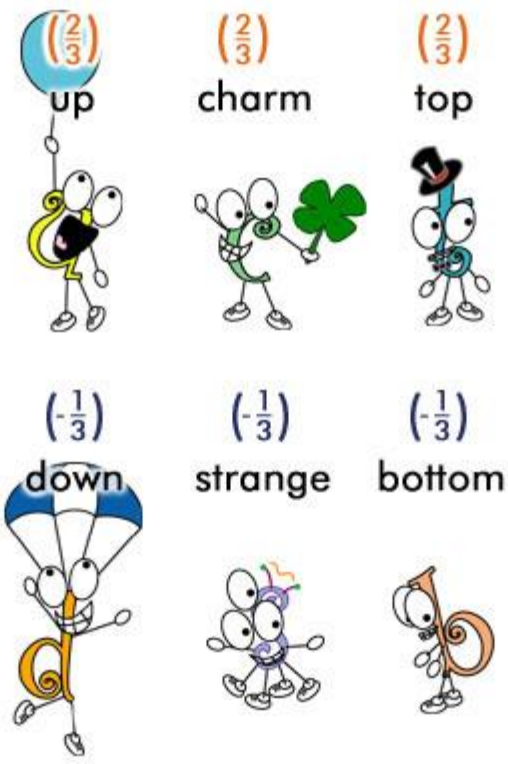
REINES



Kulkevat vapaana ja eivät välitä vähääkään toisista alkeishiukkasista tai muista olioista.
Noin 0,3 % näkyvästä aineesta.

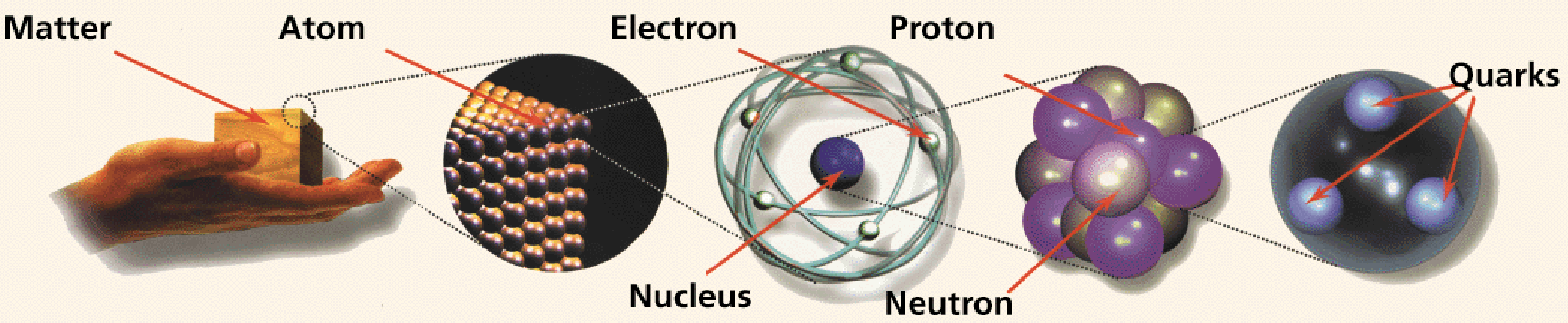
1) https://upload.wikimedia.org/wikipedia/commons/thumb/7/72/Frederick_Reines.jpg/220px-Frederick_Reines.jpg
2) http://scitechdaily.com/images/lsnd-neutrino-detector.jpg

MURRAY GELL-MANN



Tämän hetken pienin ”rakennuspalikka”

1) http://home.cern/sites/home.web.cern.ch/files/image/inline-images/old/murray-gell-mann-at-atlas-in-january-2012.jpg
2) http://particleadventure.org/images/page-elements/all.jpg



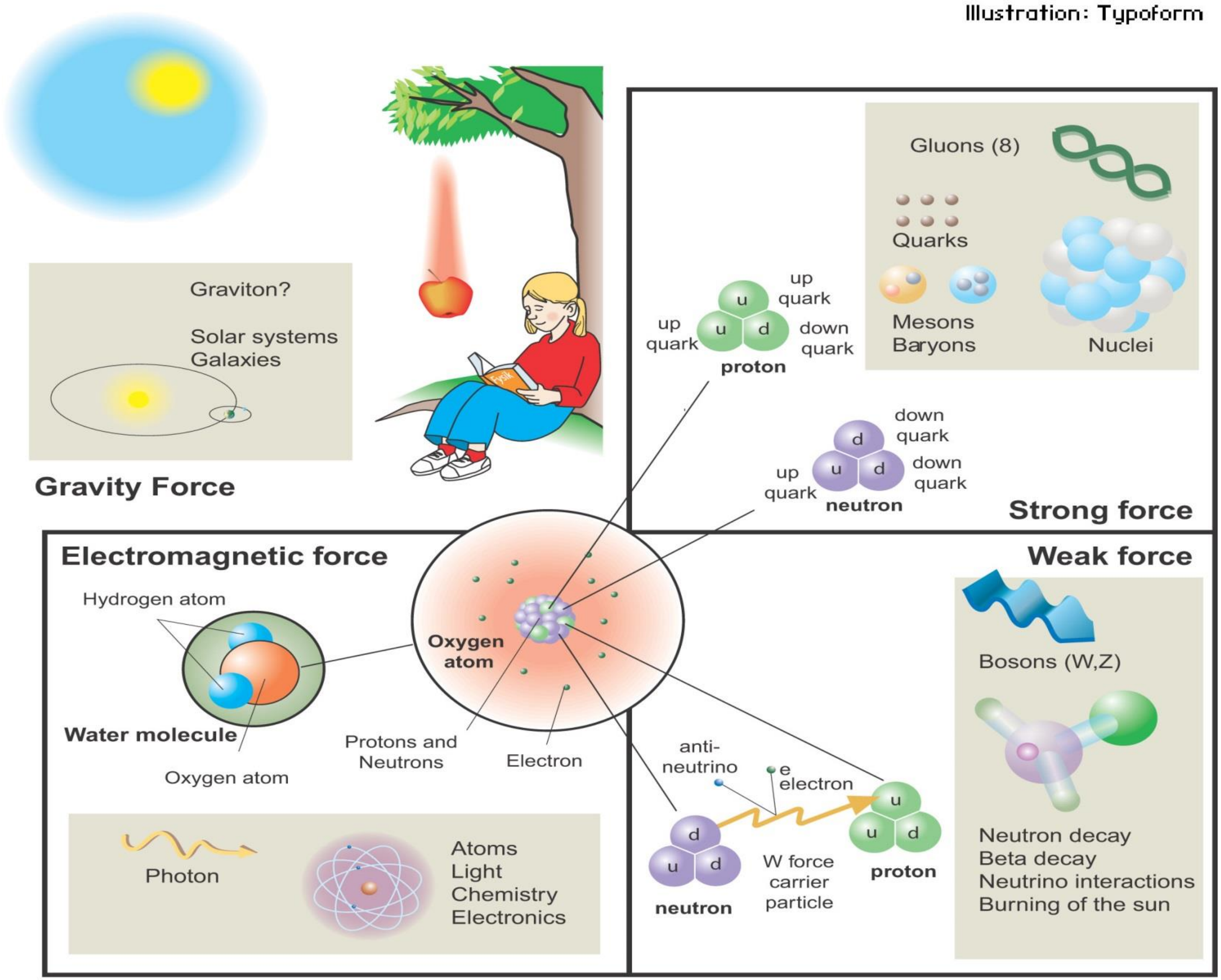
Matter Particles

All ordinary particles belong to this group

These particles existed just after the Big Bang. Now they are found only in cosmic rays and accelerators.

	LEPTONS		QUARKS	
FIRST FAMILY	**Electron** Responsible for electricity and chemical reactions; it has a charge of −1	**Electron neutrino** Particle with no electric charge, and possibly no mass; billions fly through your body every second	**Up** Has an electric charge of plus two-thirds; protons contain two, neutrons contain one	**Down** Has an electric charge of minus one-third; protons contain one, neutrons contain two
SECOND FAMILY	**Muon** A heavier relative of the electron; it lives for two-millionths of a second	**Muon neutrino** Created along with muons when some particles decay	**Charm** A heavier relative of the up; found in 1974	**Strange** A heavier relative of the down; found in 1974
THIRD FAMILY	**Tau** heavier still; it is extremely unstable. It was discovered in 1975	**Tau neutrino** Not yet discovered but believed to exist	**Top** Heavier still; found in 1995	**Bottom** Heavier still; measuring bottom quarks is an important test of electroweak theory

http://homepage.smc.edu/wissmann_paul/anatomy2textbook/quarks.gif



Video

https://www.nobelprize.org/nobel_prizes/physics/laureates/2004/phypub1highen.jpg

Standard Model of

FUNDAMENTAL PARTICLES AND INTERACTIONS

The Standard Model summarizes the current knowledge in Particle Physics. It is the quantum theory that includes the theory of strong interactions (quantum chromodynamics or QCD) and the unified theory of weak and electromagnetic interactions (electroweak). Gravity is included on this chart because it is one of the fundamental interactions even though not part of the "Standard Model."

FERMIONS

matter constituents
spin = 1/2, 3/2, 5/2, ...

Leptons spin = 1/2

Flavor	Mass GeV/c^2	Electric charge
ν_e electron neutrino	$<1\times10^{-8}$	0
e electron	0.000511	–1
ν_μ muon neutrino	<0.0002	0
μ muon	0.106	–1
ν_τ tau neutrino	<0.02	0
τ tau	1.7771	–1

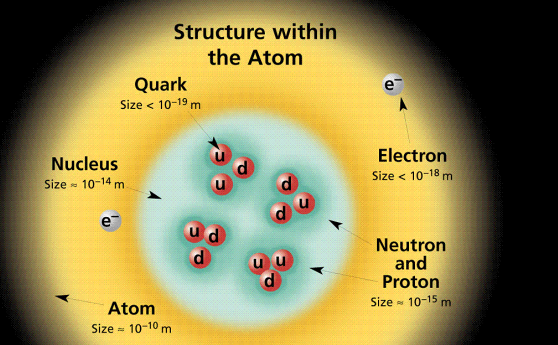
Quarks spin = 1/2

Flavor	Approx. Mass GeV/c^2	Electric charge
u up	0.003	2/3
d down	0.006	–1/3
c charm	1.3	2/3
s strange	0.1	–1/3
t top	175	2/3
b bottom	4.3	–1/3

Spin is the intrinsic angular momentum of particles. Spin is given in units of $\hbar$, which is the quantum unit of angular momentum, where $\hbar = h/2\pi = 6.58\times10^{-25}$ GeV s $= 1.05\times10^{-34}$ J s.

Electric charges are given in units of the proton's charge. In SI units the electric charge of the proton is 1.60×10^{-19} coulombs.

The **energy** unit of particle physics is the electronvolt (eV), the energy gained by one electron in crossing a potential difference of one volt. **Masses** are given in GeV/c^2 (remember $E = mc^2$), where 1 GeV $= 10^9$ eV $= 1.60\times10^{-10}$ joule. The mass of the proton is 0.938 GeV/c^2 $= 1.67\times10^{-27}$ kg.



If the protons and neutrons in this picture were 10 cm across, then the quarks and electrons would be less than 0.1 mm in size and the entire atom would be about 10 km across.

BOSONS

force carriers
spin = 0, 1, 2, ...

Unified Electroweak spin = 1

Name	Mass GeV/c^2	Electric charge
γ photon	0	0
W^-	80.4	–1
W^+	80.4	+1
Z^0	91.187	0

Strong (color) spin = 1

Name	Mass GeV/c^2	Electric charge
g gluon	0	0

Color Charge

Each quark carries one of three types of "strong charge," also called "color charge." These charges have nothing to do with the colors of visible light. There are eight possible types of color charge for gluons. Just as electrically-charged particles interact by exchanging photons, in strong interactions color-charged particles interact by exchanging gluons. Leptons, photons, and ***W*** and ***Z*** bosons have no strong interactions and hence no color charge.

Quarks Confined in Mesons and Baryons

One cannot isolate quarks and gluons; they are confined in color-neutral particles called **hadrons**. This confinement (binding) results from multiple exchanges of gluons among the color-charged constituents. As color-charged particles (quarks and gluons) move apart, the energy in the color-force field between them increases. This energy eventually is converted into additional quark-antiquark pairs (see figure below). The quarks and antiquarks then combine into hadrons; these are the particles seen to emerge. Two types of hadrons have been observed in nature: **mesons** $q\bar{q}$ and **baryons** qqq.

Residual Strong Interaction

The strong binding of color-neutral protons and neutrons to form nuclei is due to residual strong interactions between their color-charged constituents. It is similar to the residual electrical interaction that binds electrically neutral atoms to form molecules. It can also be viewed as the exchange of mesons between the hadrons.

PROPERTIES OF THE INTERACTIONS

Property \ Interaction	Gravitational	Weak (Electroweak)	Electromagnetic (Electroweak)	Strong: Fundamental	Strong: Residual
Acts on:	Mass – Energy	Flavor	Electric Charge	Color Charge	See Residual Strong Interaction Note
Particles experiencing:	All	Quarks, Leptons	Electrically charged	Quarks, Gluons	Hadrons
Particles mediating:	Graviton (not yet observed)	W^+ W^- Z^0	γ	Gluons	Mesons
Strength relative to electromag for two u quarks at: 10^{-18} m	10^{-41}	0.8	1	25	Not applicable to quarks
Strength relative to electromag for two u quarks at: 3×10^{-17} m	10^{-41}	10^{-4}	1	60	Not applicable to quarks
Strength relative to electromag for two protons in nucleus	10^{-36}	10^{-7}	1	Not applicable to hadrons	20

Baryons qqq and Antibaryons $\bar{q}\bar{q}\bar{q}$

Baryons are fermionic hadrons. There are about 120 types of baryons.

Symbol	Name	Quark content	Electric charge	Mass GeV/c^2	Spin
p	proton	uud	1	0.938	1/2
$\bar{p}$	anti-proton	$\bar{u}\bar{u}\bar{d}$	–1	0.938	1/2
n	neutron	udd	0	0.940	1/2
Λ	lambda	uds	0	1.116	1/2
Ω^-	omega	sss	–1	1.672	3/2

Mesons $q\bar{q}$

Mesons are bosonic hadrons. There are about 140 types of mesons.

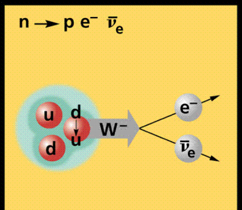
Symbol	Name	Quark content	Electric charge	Mass GeV/c^2	Spin
π^+	pion	$u\bar{d}$	+1	0.140	0
K^-	kaon	$s\bar{u}$	–1	0.494	0
ρ^+	rho	$u\bar{d}$	+1	0.770	1
B^0	B-zero	$d\bar{b}$	0	5.279	0
η_c	eta-c	$c\bar{c}$	0	2 .980	0

Matter and Antimatter

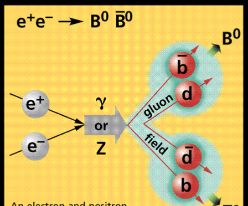
For every particle type there is a corresponding antiparticle type, denoted by a bar over the particle symbol (unless + or – charge is shown). Particle and antiparticle have identical mass and spin but opposite charges. Some electrically neutral bosons (e.g., Z^0, γ, and $\eta_c = c\bar{c}$, but not $K^0 = d\bar{s}$) are their own antiparticles.

Figures

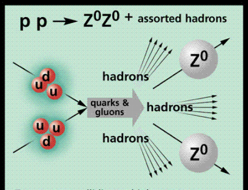
These diagrams are an artist's conception of physical processes. They are *not* exact and have *no* meaningful scale. Green shaded areas represent the cloud of gluons or the gluon field, and red lines the quark paths.



A neutron decays to a proton, an electron, and an antineutrino via a virtual (mediating) W boson. This is neutron β decay.



An electron and positron (antielectron) colliding at high energy can annihilate to produce B^0 and $\bar{B}^0$ mesons via a virtual Z boson or a virtual photon.



Two protons colliding at high energy can produce various hadrons plus very high mass particles such as Z bosons. Events such as this one are rare but can yield vital clues to the structure of matter.

The Particle Adventure

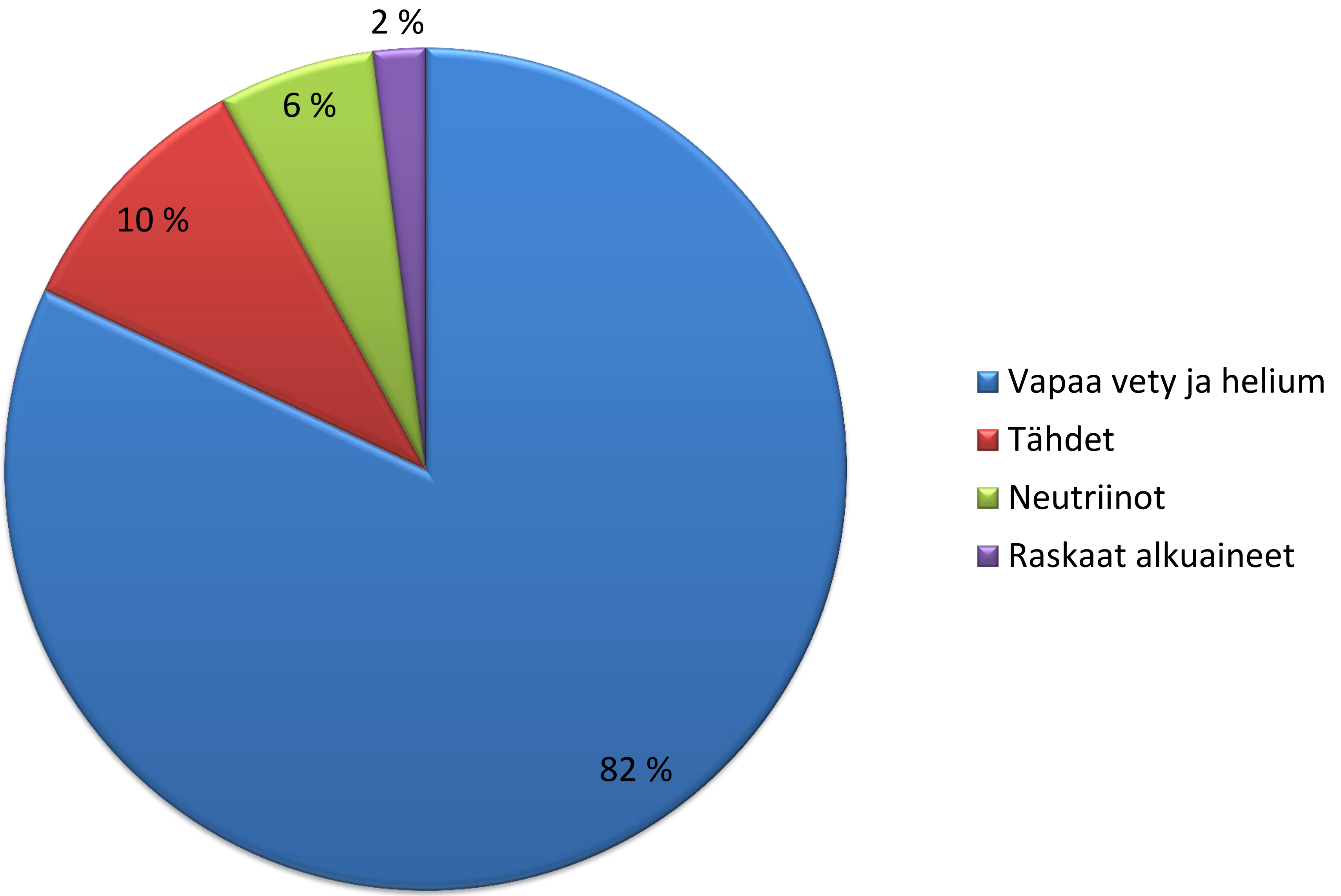
Visit the award-winning web feature *The Particle Adventure* at
http://ParticleAdventure.org

This chart has been made possible by the generous support of:
U.S. Department of Energy
U.S. National Science Foundation
Lawrence Berkeley National Laboratory
Stanford Linear Accelerator Center
American Physical Society, Division of Particles and Fields
BURLE INDUSTRIES, INC.

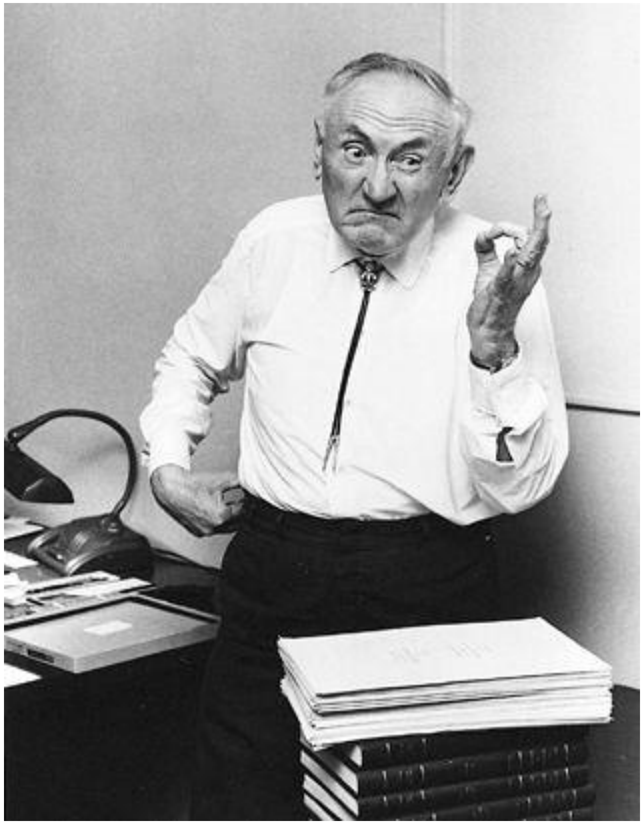
http://CPEPweb.org

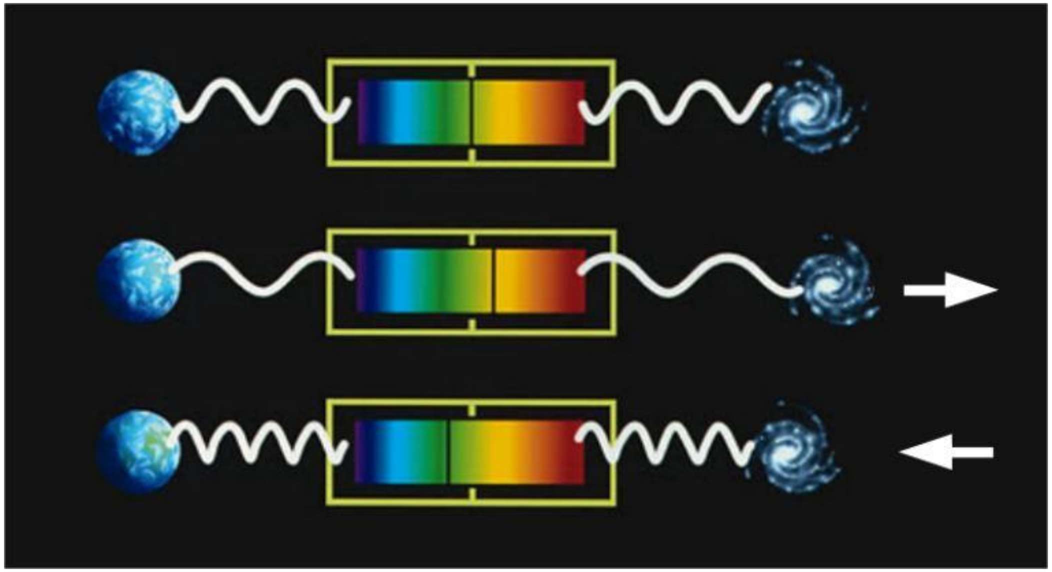
http://www.pha.jhu.edu/~dfehling/particle.gif

NÄKYVÄ “NORMAALI” AINE UNIVERSUMISSA



FRITZ ZWICKY





Mittasi vuonna 1933 kahdeksan galaksin punasiirtymät ja totesi galaksien liikkuvan toistensa suhteen odottamattoman suurella vauhdilla.
Hän laski, että niiden esittämä piirileikki onnistuu vain, jos ainetta on 50-kertainen määrä valoisan aineen määrään verrattuna.

1) http://scienceblogs.com/startswithabang/files/2009/06/zwickysb.jpg
2) http://deskarati.com/wp-content/uploads/2012/11/red-shift.jpg

Vetypilven nopeus v kiertoradallaan (säde r) riippuu vaikuttavan painovoiman suuruudesta.

Dynamiikan peruslain eli Newtonin II lain mukaan vetypilven liikeyhtälö galaksia kiertävällä radalla on $\sum \vec{F} = m_{pilvi}\vec{a}_n$. Gravitaatiovoima pakottaa siis vetypilven ympyräradalle galaksin ympäri, joten gravitaatiovoima toimii keskeisvoimana:

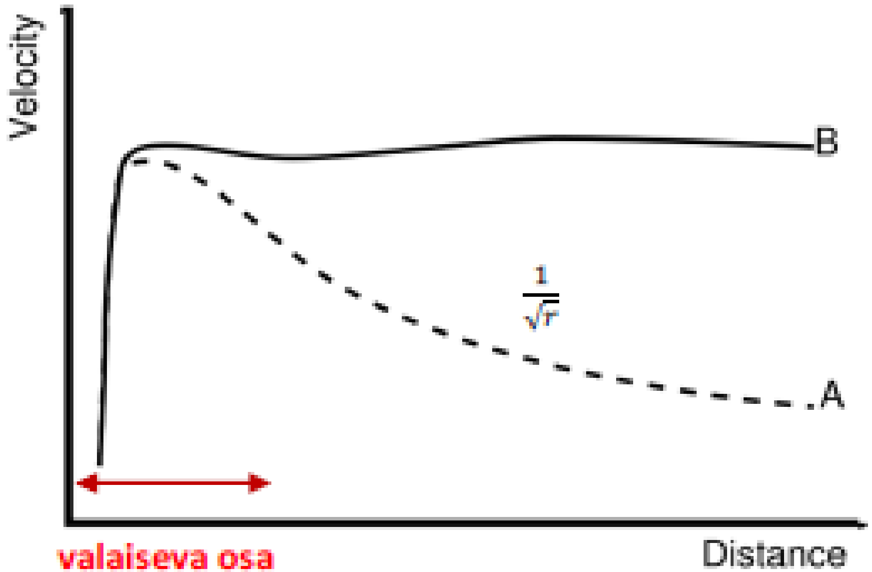
$$G\frac{m_{pilvi}M_{galaksi}}{r^2} = m_{pilvi}\frac{v^2}{r} \quad \rightarrow \quad v^2 = \frac{GM_{galaksi}}{r}$$

$$\rightarrow \quad v = \sqrt{\frac{GM_{galaksi}}{r}}.$$

Tästä seuraa, että vetypilven nopeus riippuu kiertoradan säteestä seuraavasti:

$$v \sim \frac{1}{\sqrt{r}}.$$

Mittaustulokset osoittavat kuitenkin, että nopeus säilyy monien galaksien tapauksessa muuttumattomana, vaikka etäisyys galaksista kasvaa. Tämä merkitsee, että näkyvän aineen lisäksi galaksissa ja sen ympärillä on runsaasti näkymätöntä eli pimeää ainetta, jonka keskellä vetypilvi liikkuu. Painovoiman takia pimeä aine on keskittynyt galaksien ja galaksiryhmien läheisyyteen.



Kuva.
Galaksin teoreettinen (A) ja mitattu (B) rotaatiokäyrä.
Galaksin rotaatiokäyrän tulisi laskea, kun liikutaan galaksin keskustasta poispäin (A), mutta havaintojen mukaan näin ei tapahdu (B). Eron selittämisen katsotaan vaativan pimeää ainetta.

Yllä olevassa kuvassa on tyypillinen mitattu galaksin nopeuskäyrä (rotaatiokäyrä B) galaksin keskustasta mitatun etäisyyden r funktiona. Jos galaksissa ei olisi muuta kuin säteilevää ainetta, pitäisi käyrällä olla kuvassa hahmoteltu $\frac{1}{\sqrt{r}}$ muoto (A) galaksin valaisevan osan ulkopuolella. Kuvaajien erilaisuus osoittaa selvästi pimeän aineen olemassaolon.

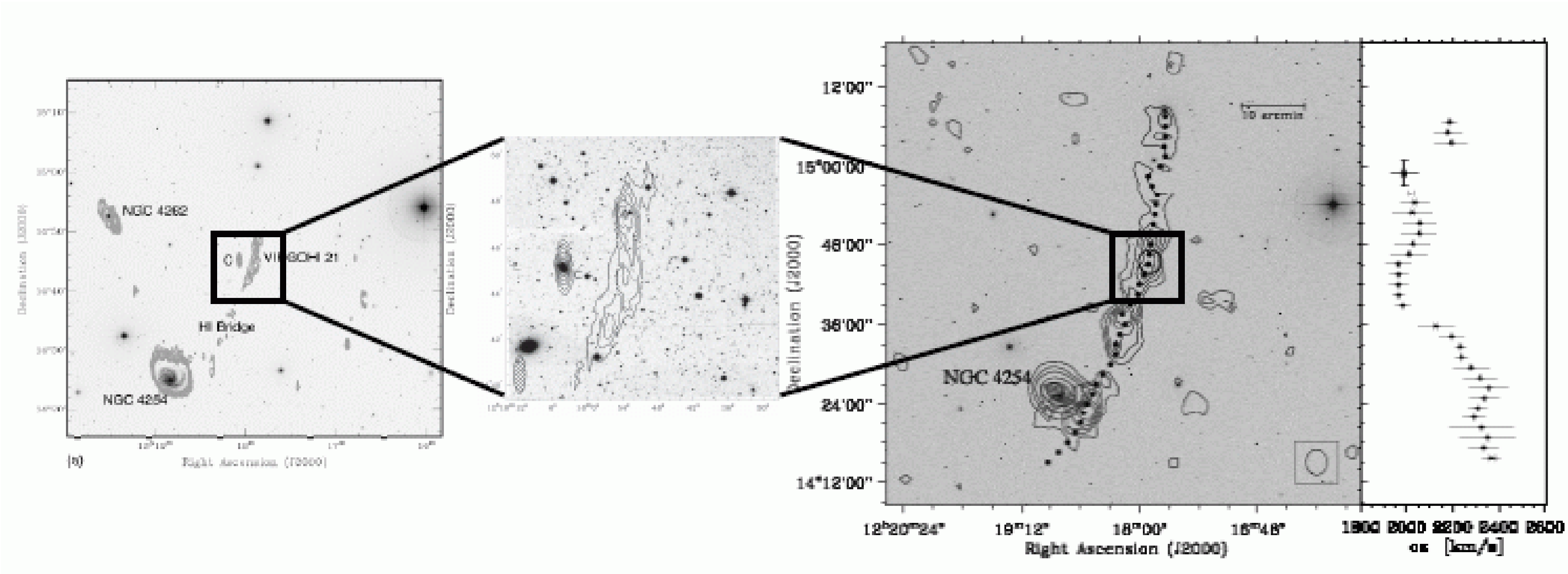
http://sivut.koti.tpo.fi/ajnieminen/pae.pdf

Galakseilla liian vähän
näkyvää massaa,
että pysyisivät koossa

→ oltava näkymätöntä massaa

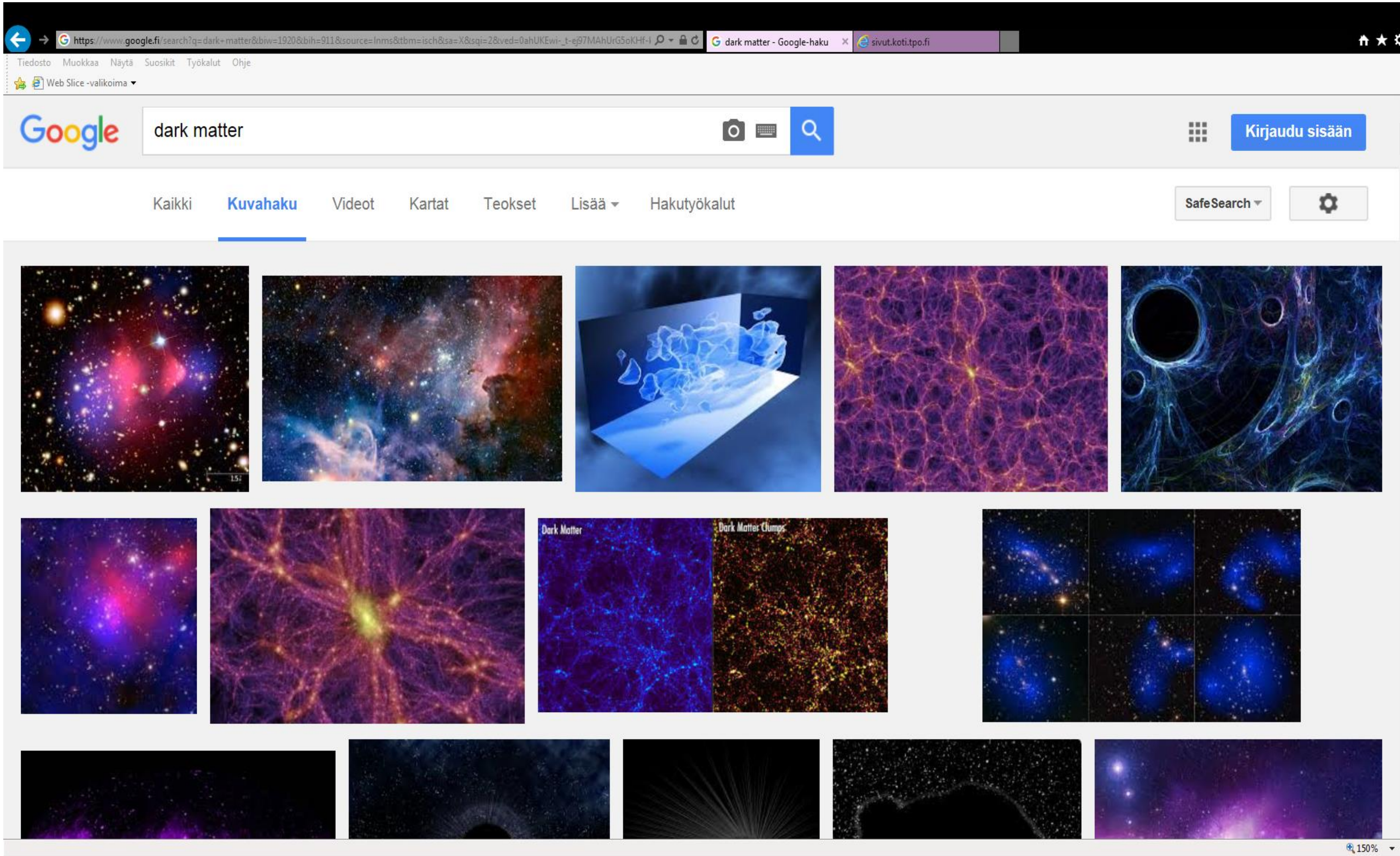
→ ***PIMEÄ AINE***

VIRGOHI21

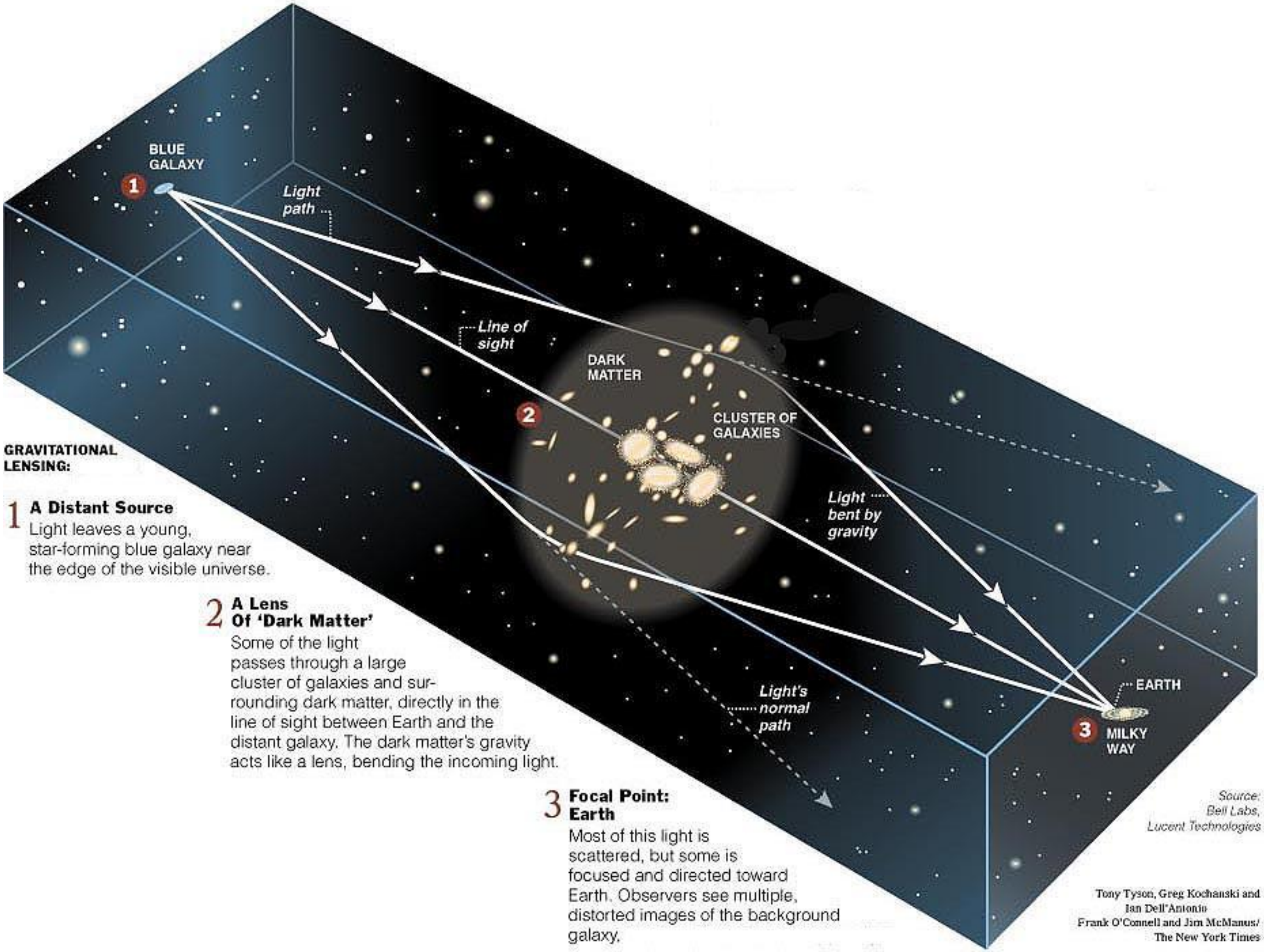


havaittua neutraalia vetyä on 100 miljoonan Auringon massan verran,
mutta galaksin kokonaismassa on 100 miljardia Auringon massaa.

http://egg.astro.cornell.edu/index.php/images/n4254figcrop.gif


https://www.google.fi/search?q=dark+matter&biw=1920&bih=911&source=lnms&tbm=isch&sa=X&sqi=2&ved=0ahUKEwi-_t-ej97MAhUrG5oKHf-
dark matter - Google-haku
sivut.koti.tpo.fi
Tiedosto Muokkaa Näytä Suosikit Työkalut Ohje
Web Slice -valikoima
Google
dark matter
Kirjaudu sisään
Kaikki
Kuvahaku
Videot
Kartat
Teokset
Lisää
Hakutyökalut
SafeSearch
Dark Matter
Dark Matter Clumps
150%

Pimeää ainetta on noin 25 %
koko maailmankaikkeuden aineesta.
Se on näkymätöntä,
ei emittoi eikä heijasta
riittävästi sähkömagneettista säteilyä,
jotta sen voisi havaita suoraan.
Voidaan havaita ainoastaan
painovoiman kautta.



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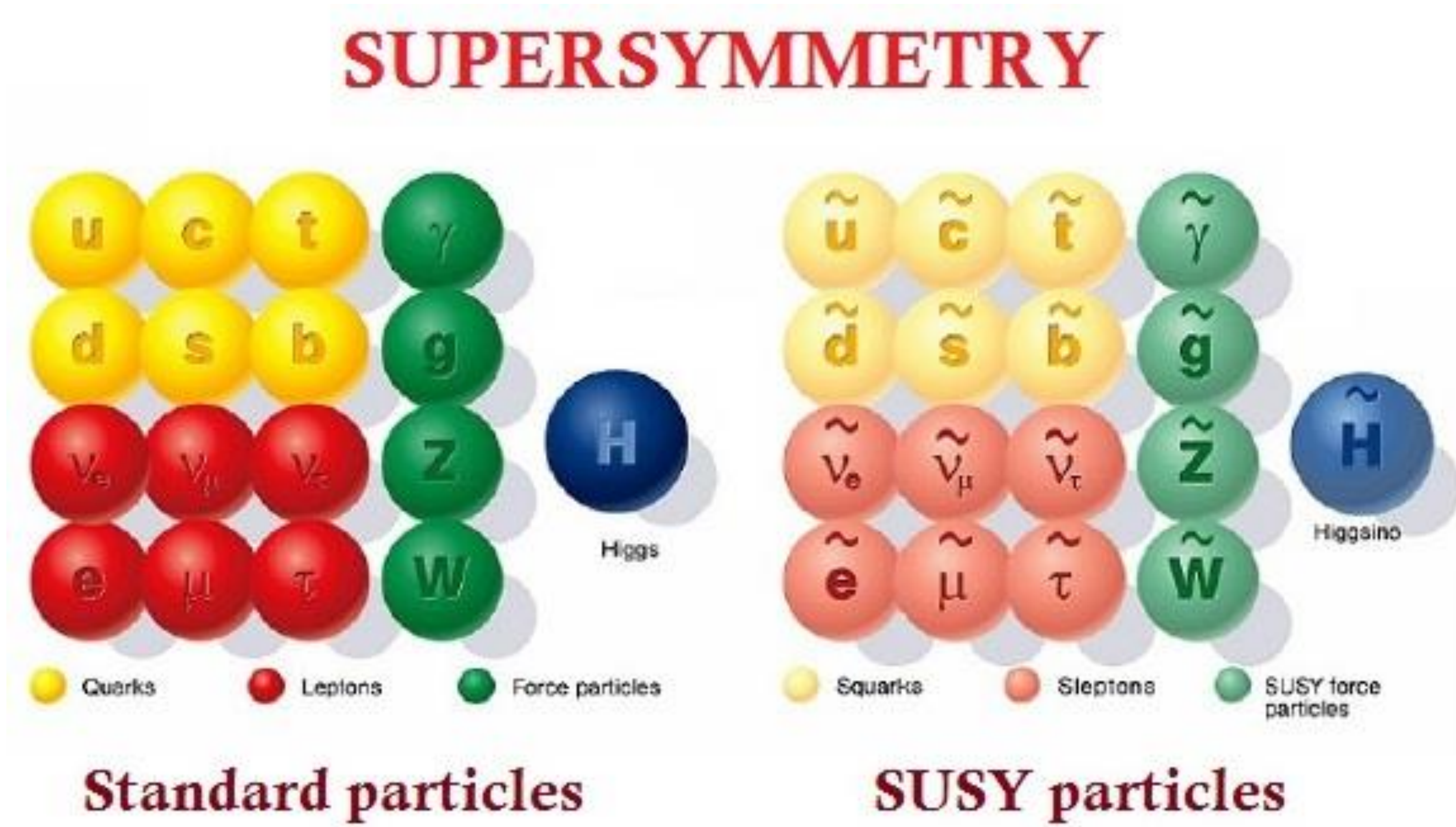
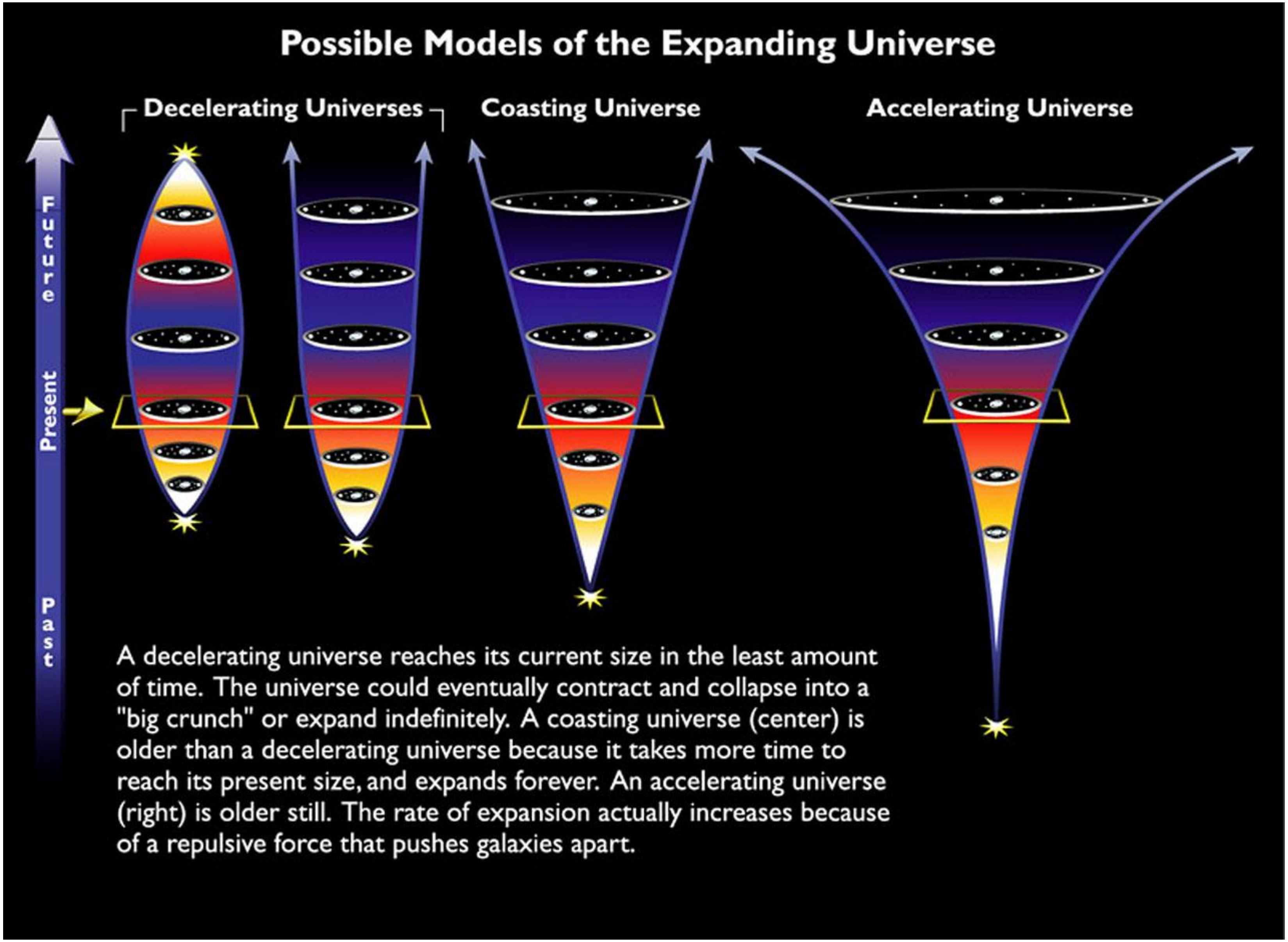


Hiukkasfysiikan Standardimalli on onnistunut ennustamaan oikein kaiken, mitä hiukkaskiihdyttimissä on mitattu vuosikymmenien ajan.
Tiedetään kuitenkin, että Standardimalli ei toimi mielivaltaisen suurilla energioilla, joten jossain vaiheessa jotain uutta löytyy

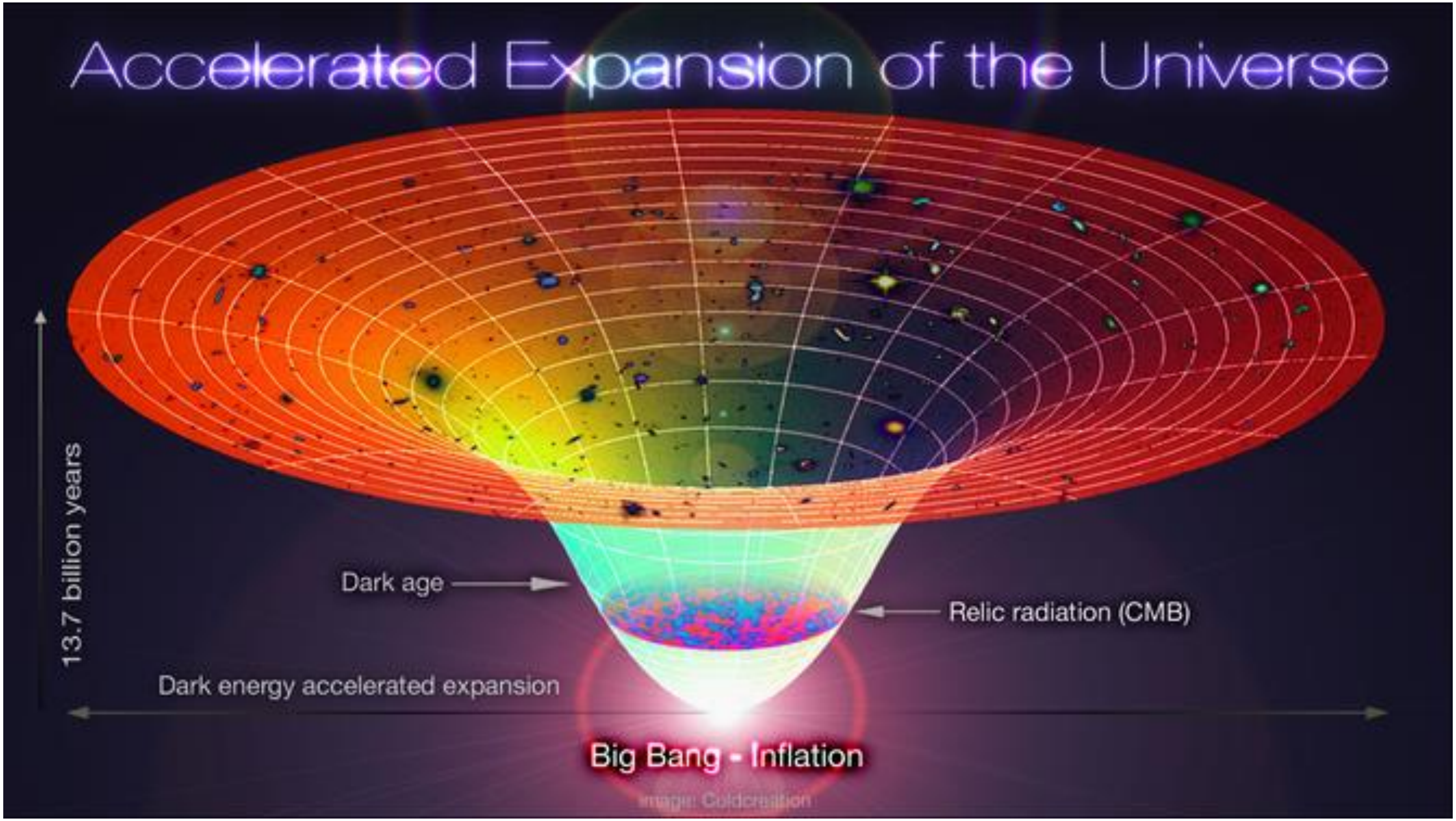
https://www.quantamagazine.org/wp-content/uploads/2012/11/Susy-particles.jpg

LHC etsii viitteitä supersymmetriasta ja pimeästä aineesta.

http://www.ee.washington.edu/faculty/hauck/LargeHadronCollider/lhc.jpg



http://cdn.spacetelescope.org/archives/images/screen/opo9919k.jpg



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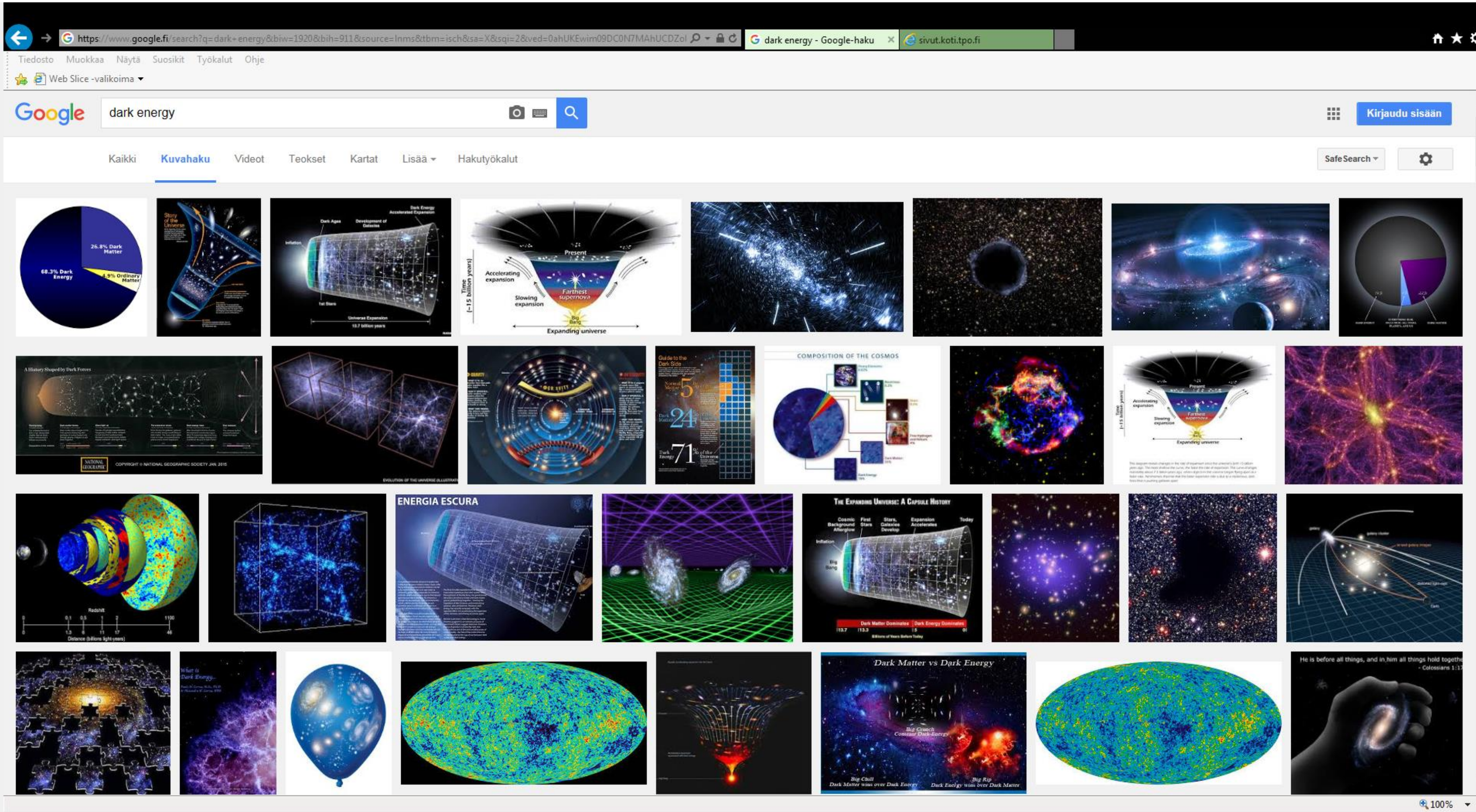
Universumimme
laajenee kiihtyvästi

→ Tarvitaan suunnaton määrä uutta energiaa vastustamaan painovoimaa

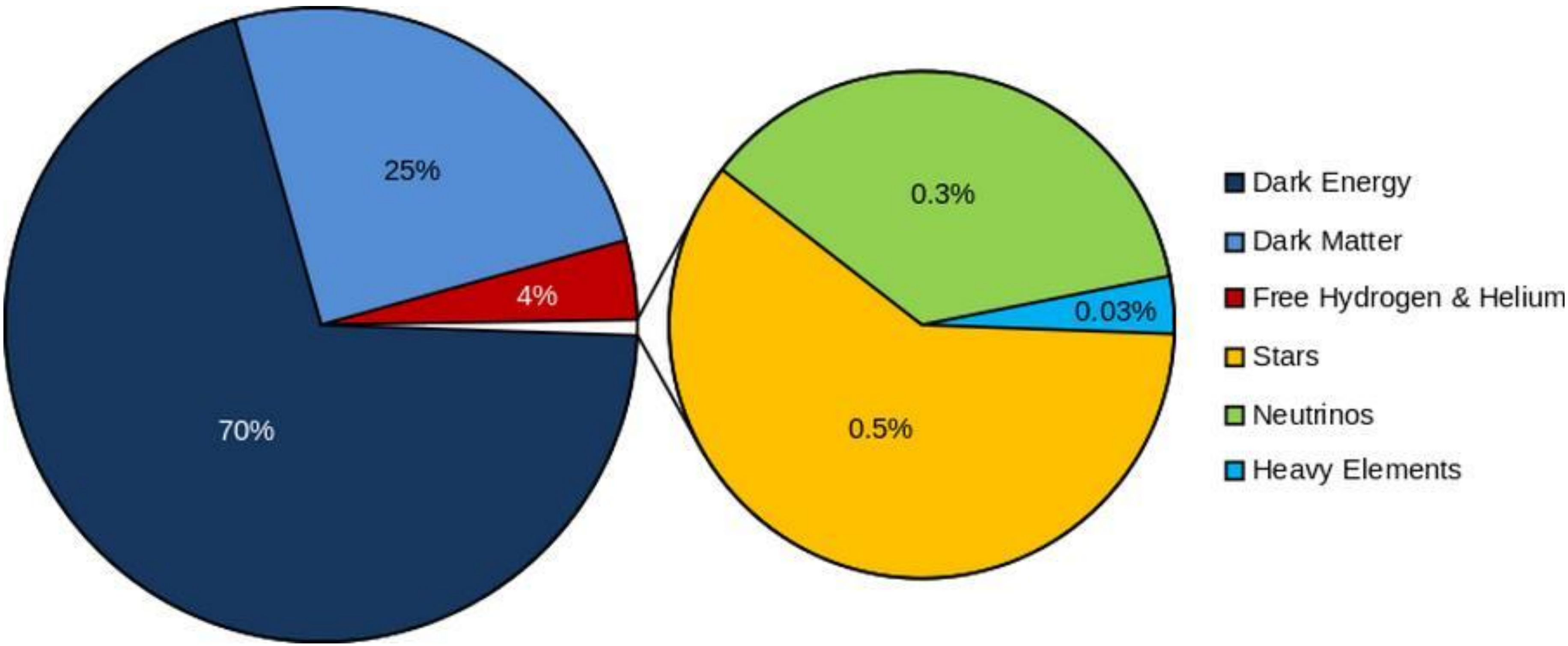
→ ***PIMEÄ ENERGIA***


https://www.google.fi/search?q=dark+energy&biw=1920&bih=911&source=lnms&tbm=isch&sa=X&sqi=2&ved=0ahUKEwim09DC0N7MAhUCDZol
dark energy - Google-haku
sivut.koti.tpo.fi
Tiedosto Muokkaa Näytä Suosikit Työkalut Ohje
Web Slice -valikoima
Google
dark energy
Kirjaudu sisään
Kaikki Kuvahaku Videot Teokset Kartat Lisää Hakutyökalut
SafeSearch
68.3% Dark Energy
26.8% Dark Matter
4.9% Ordinary Matter
Accelerating expansion
Slowing expansion
Present
Farthest supernova
Big Bang
Expanding universe
A History Shaped by Dark Forces
COMPOSITION OF THE COSMOS
ENERGIA ESCURA
The Expanding Universe: A Capsule History
Dark Matter vs Dark Energy
Big Chill
Dark Matter wins over Dark Energy
Big Rip
Dark Energy wins over Dark Matter
He is before all things, and in him all things hold togethe
100%

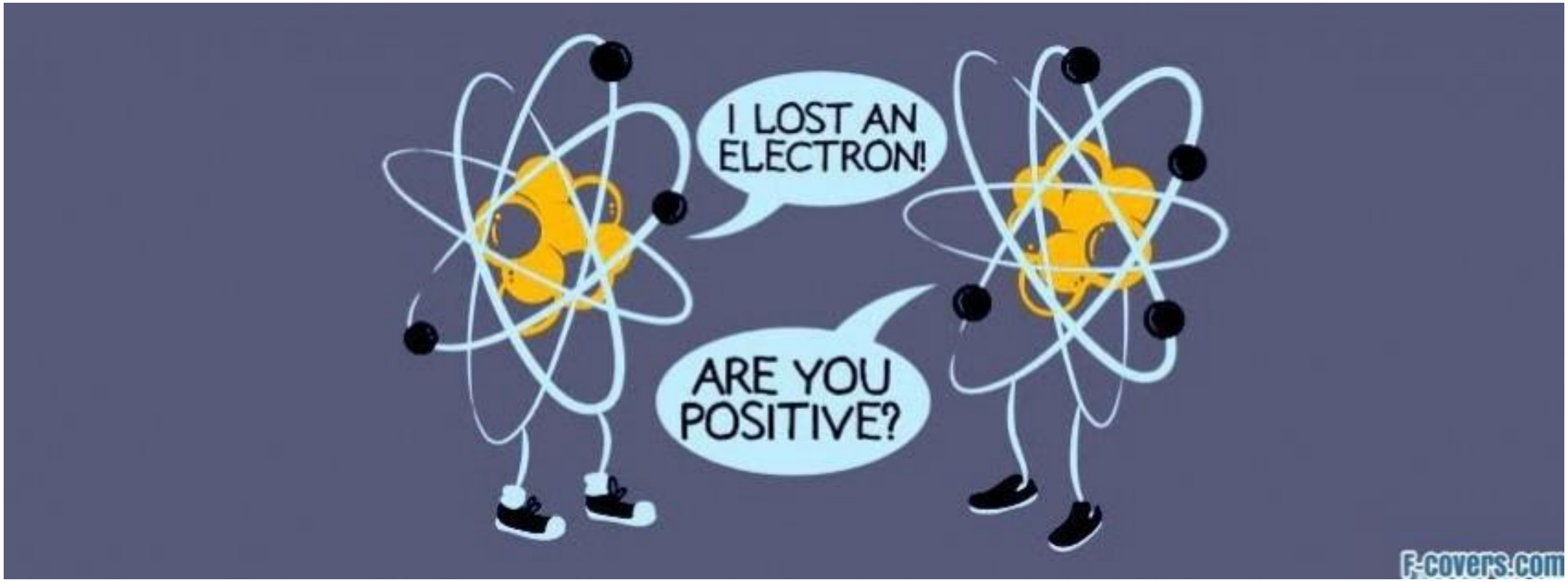
Kukaan ei tiedä
mitä se on!

Noin 70 %
universumin aineesta
pimeää energiaa.

UNIVERSUMIN ”RESEPTI”



http://wordlesstech.com/wp-content/uploads/2013/04/The-beginning-of-the-universe-for-beginners-2.jpg



http://www.f-covers.com/cover/funny-science-physics-facebook-cover-timeline-banner-for-fb.jpg