Innovative methods of didactics

On the track of Modern Physics: from real-objects exhibition to internet galaxy

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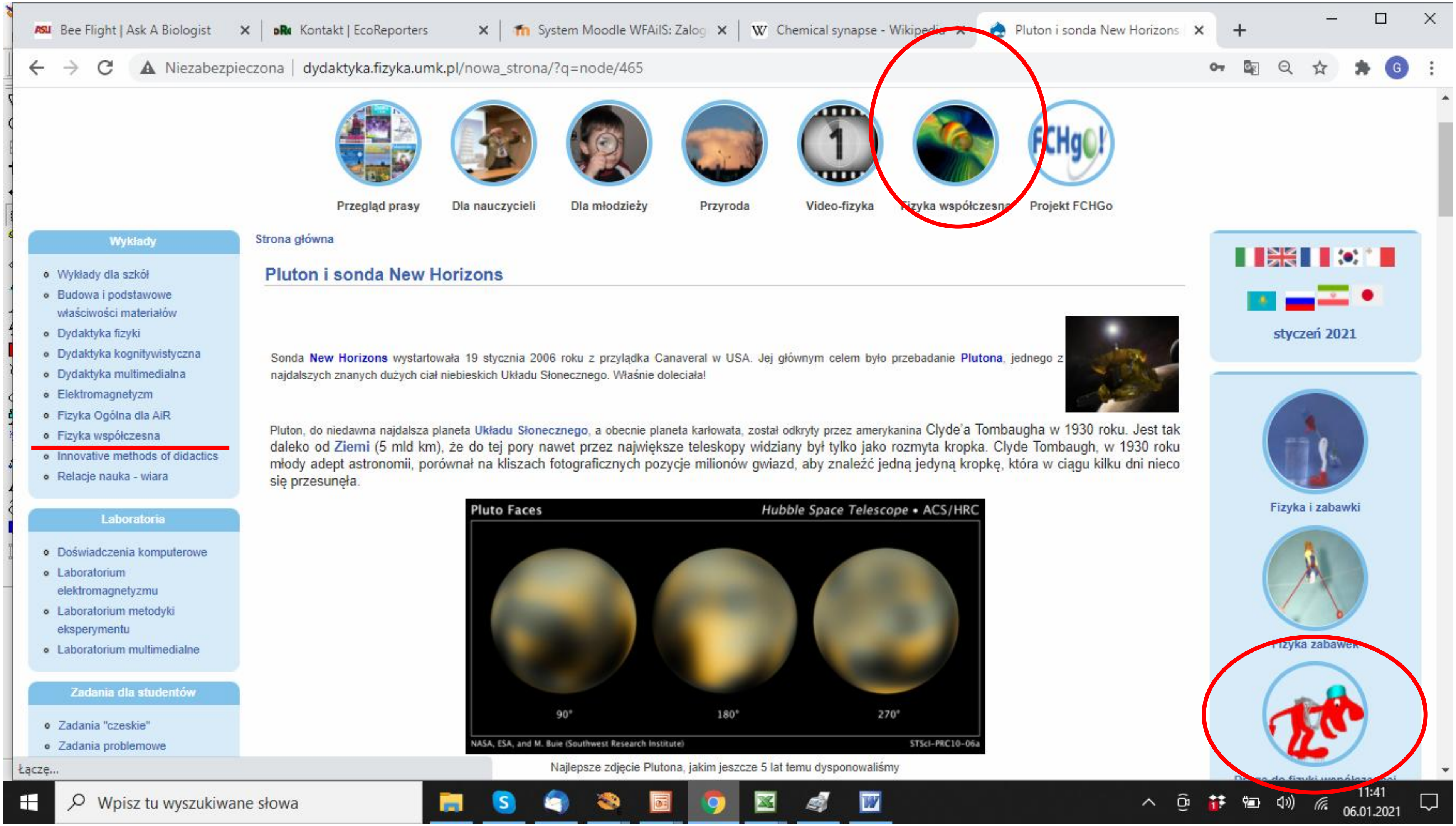
a/a 2020/2021

Where should we search it?

dydaktyka.fizyka.umk.pl



Rationale

Towards a successful scientific divulgation

Scientific divulgation, in particular in Physics, seems to be in troubles, say in Poland, to less extent in Italy, maybe even less in some other places. However, it became, compared to Faraday's times, quite a difficult task.

On the bottom of the pyramid, we have numerous journals, in particular so called „scientific divulgation", usually monthly journal, full of colourful photos (and publicity), but explaining that the physical world is made of 11 dimensions, out-of which six are hidden and one is turned-around; that the vacuum is populated by ghosts of Higgs bosons; that other, mirror worlds exist in parallel and who is unhappy here, could by lucky there...

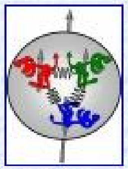
On a higher level are nice divulgation books, on the elementary level, we quote one:
Moderne Physik, by E. Üebelacker, Tessloff Verlag, Nürnberg, 2000

These books, and good TV programmes, explain that there was a Big Bang and that some quarks exists.
(What in German means „cheese", probably coming from East-Germany Slavian language, captured by J.Joyce during his visit in Berlin ?).

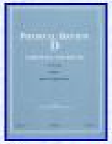
Rationale

But when we ask even a PhD student in Physics, how many quarks exist, which are their „colours”, and what are their masses, almost everybody, apart specialists, is in trouble. Seems that the knowledges stops at the elementary level.

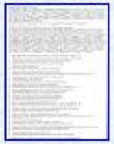
The point is that:
1) the colours are not determinable, as they change in continuation
2) masses are known with almost 50% error bar, for the lightest quarks
3) these masses are only a small part of the total mass of a proton or neutron (which comes from relativistic effects)
4) pictures like this above do not say anything on the electric charge, spin, mass of quarks.



On the other hand, hundreds of scientists, contribute every year to precise reviews of quark properties.



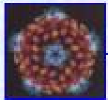
Several orders of magnitude more expensive are the very experimental studies of these quarks.



So a question arises, even by Nobel prices winner like L. Ledermann „do we really need to know Higgs boson mass?”. Is a „man in the street” really bothered by this question, hardly able to distinguish between real objects, experimentally verified like quarks

Rationale

So a question arises, even by Nobel prices winner like L. Ledermann „do we really need to know Higgs boson mass?”. Is a „man in the street” really bothered by this question, hardly able to distinguish between real objects, experimentally verified like quarks and anti-super-quarks of anti-parallel worlds?

So we find useful to construct some **TRACKS of MODERN PHYSICS** – for example starting form 5 weeks W. Röntgen passed in the laboratory more than one hundreds years ago, through photos of first X-ray machines , through the discovery of DNA structure  thanks to X-rays, to modern their applications, like protein studies  or visualisation of *d*-electron orbitals  in copper oxides .

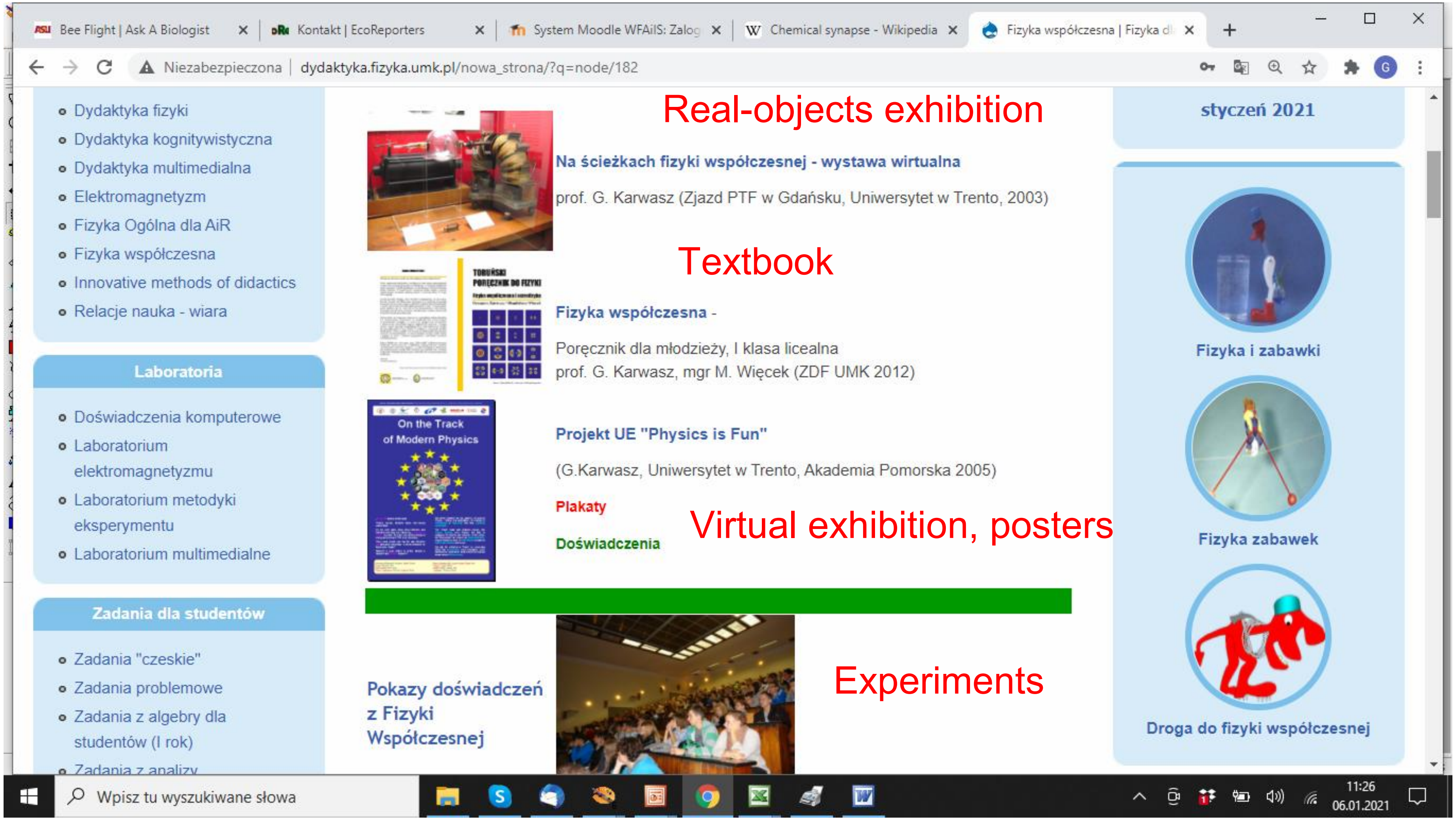
The material available is simply enormous, the difficulty stays in choosing „key” points, enough simple to be understood but enough scientifically „rigid” not to offend specialists.

The present page is a result of a real exhibition, held during XXXVIII National Congress of Polish Physical Society in Gdansk in September 2003, where short texts served as introduction to piles of scientific reprints and simple objects, like spinning tips were used to illustrate complex machine, like Paul magnetic traps for Bose-Einstein condensation.

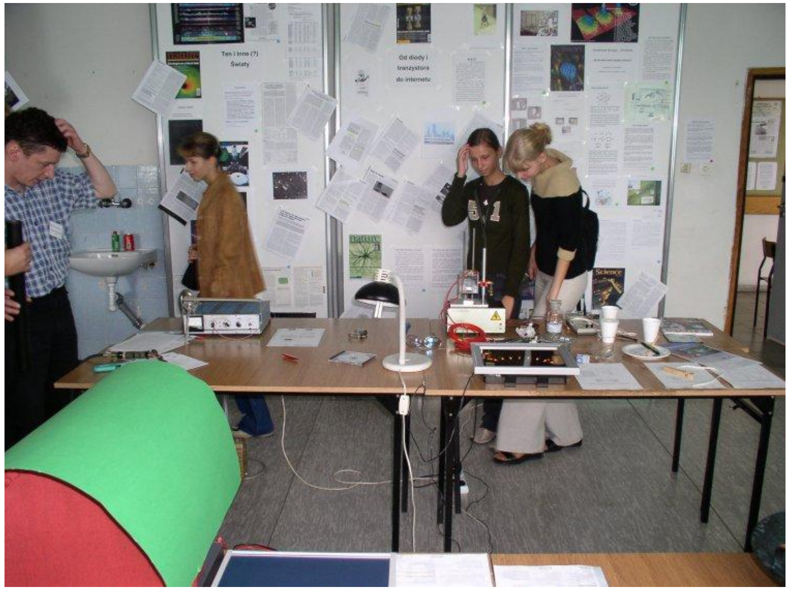
The present pages are to be considered as „demo” version – an invitation for other contributions

Grzegorz Karwasz, Trento, 30.12.2003

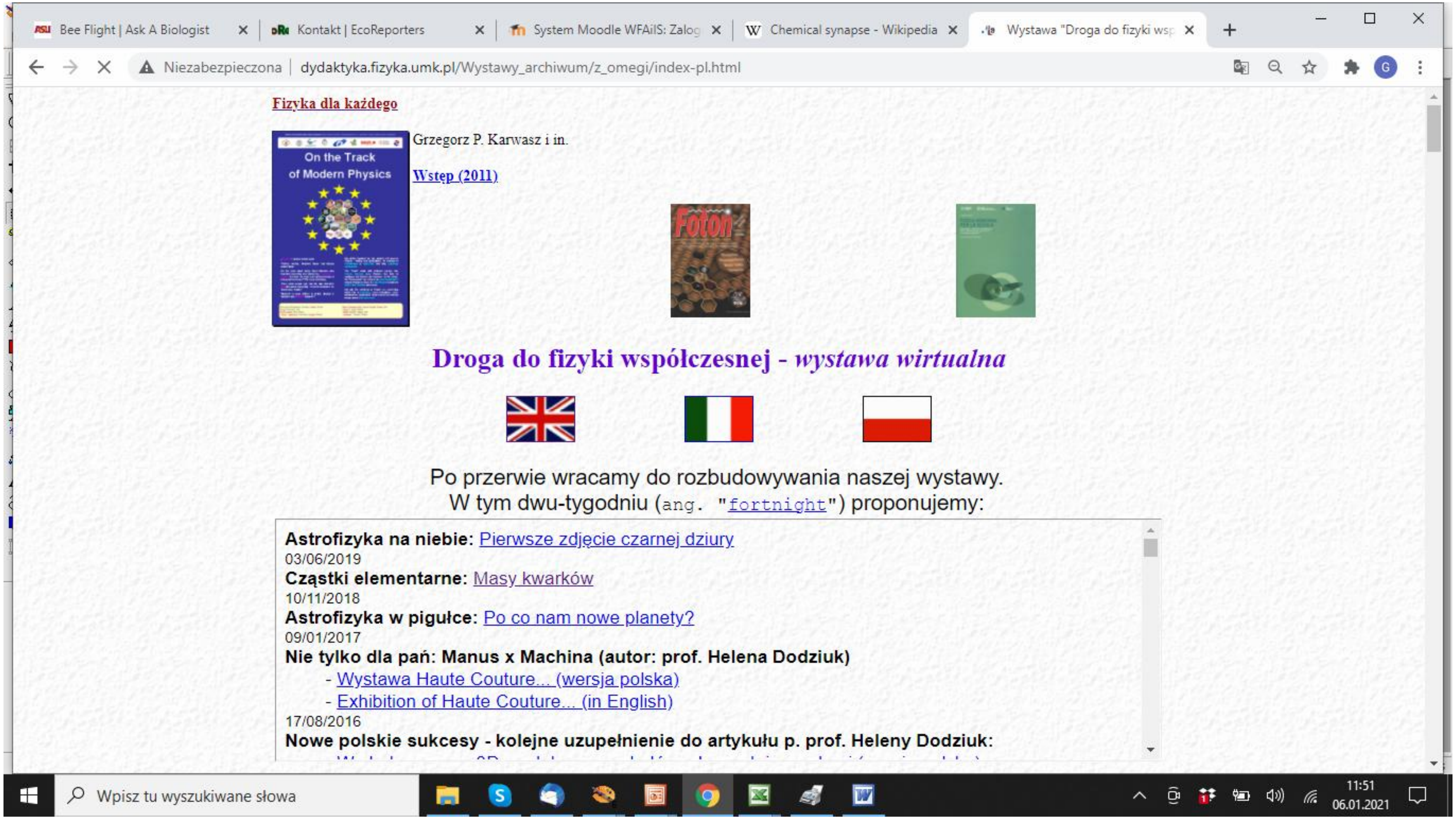
Four-fold approach



Real exhibition – PTF Gdańsk 2003



Real exhibition ↔ Virtual exhibition



http://dydaktyka.fizyka.umk.pl/Wystawy_archiwum/z_omegi/index-pl.html

„Branches” of Modern Physics

Spis plakatów

- A-Tomos
- Spektroskopia czyli nauka o duchach
- Niewidzialny bursztyn
- Przenikliwe promienie
- Mechanika kwantowa
- Mechanika falowa
- Wodór – historia bez końca
- Wiek XX = wiek Einsteina
- Podzielić niepodzielny
- Kwarki i skwarki
- Ten i inne (?) światy
- Od diody i tranzystora do Internetu
- Osoba, czy wojsko?

List of posters

- A-Tomos
- Spectroscopy or ghost science
- Invisible amber
- Penetrating radiation
- Quantum mechanics
- Wave mechanic
- Hydrogen - never ending story
- XX century = Einstein's century
- Divide undivisible
- Quarks and cheese
- This and another (?) worlds
- From diode and transistor to Internet
- Person or army?

Działy fizyki

- Fizyka atomowa
- Fizyka molekularna
- Fizyka jądrowa
- Fizyka cząstek elementarnych
- Fizyka ciała stałego
- Astrofizyka
- Geofizyka
- Biofizyka

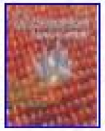
G. Karwasz, PAP Słupsk, 2004

„A-tomos”

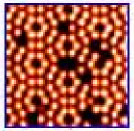
A-Tomos

a-tom, or by Democritos in-divisible. Really? When "yes", when "no"?

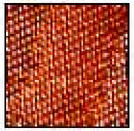
A-tom, or in-dividual 

How to count atoms? 

Atomic Force Microscopy

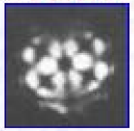


AFM - these are atoms on silicon surface [Omicron NanoTechnology]



AFM - these are atoms on gold surface [Omicron NanoTechnology]

The smalles inscription in the world (atom by atom) [Omicron NanoTechnology]



Picture of tungsten needle in field emission microscope [H. Haken i H.C. Wolf, Atomy i kwanty, PWN, 2002]

Avogadro and Maciej *(by Adam Mickeiwicz)*

Avogadro's number determination

How to measure atoms?

links, sources, photo, more

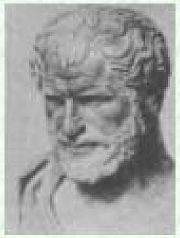
A-tom, i.e. in-dividual

A-tom, or in-dividual

„Tria àtoma" is shouting the ski-lift operator in Tajget, snowy mountains across the Pelopones, near Sparta, when the next sit is approaching.

Tajget, view from Sparta (foto GK, 27/12/2001).

The word „a-tomos" has, todays, in Greek, the same meaning as in **Democrit** times (Abdera, ca. 470-370 BC).



Atoms due to Democrit have two properties: **size** and **shape**. Atoms connecting each other in different orders (stoichometry and structural formula?) create different substances. Atoms are in permanent motion and collide each other (like in Boltzmann's perfect gas model?), their motion decides about their mass (gluons $m=E/c^2$?). Fluids emmited by atoms (photons?) are seen by our senses.

Without any doubt, **atom in physics** is not undividible: electrons, nucleus, and protons and neutrons inside of them, and quarks and gluons inside, and W and Z bosons, etc.

But „a-tomos" means in English „in-dividual" = un-divisible – a *thing in itself* – a person [1].

How can we count atoms?

How to count atoms?

The best way is on your fingers. But you need a very small finger!

Quite precisely atoms can be „counted" by X-rays: they are diffracted on crystal planes, like the light on a CD disk. Thighter are placed the atoms – more distant are light spots on the screen.There are others ways of counting atoms (i.e. calculation of the Avogadro or Loschmidt number). For example as dependence of slime sedimentation in a liquid* (J. Perrin) or as dependence of their brewery** motion (A. Einstein).Today is possible to count on „fingers" leading it on the crystal surface. But... the finger must be quite small and precise. This finger can be a sharp tip of the tungsten needle – when it touches an atom (or better: approaching it, then needle gets slightly bent. Ask at the University - they will show you how it works***.

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* Elements distribution of the slime with mass m in function of height h is defined by formula $e^{-mgh/kT}$,where $k=R/N_A$ is Boltzmann constant

** or better: Brown motions

*** Gdansk Technical University, for example (and mamy, many other) are equipped with atomic force microscope.

More serious: experimental determinations of Avogadro number

Metodi per determinare il numero di Avogadro

Metody wyznaczania liczby Avogadro

Secondo la prima legge dell'elettrolisi di Faraday quando una corrente scorre attraverso una soluzione la quantità di sale emessa dalla soluzione è proporzionale alla carica che è passata per l'elettrolita. Per emettere una mole di una sostanza monovalente serve una carica elettrica di 96485 Q. Questa carica è chiamata costante di Faraday F. Poiché ogni ione ha carica elementare e, il numero di Avogadro sarà:

$$N_A = \frac{F}{e}$$

Dalla dipendenza della costante dei gas R e dalla costante di Boltzmann *k*:

$$k = \frac{R}{N_A}$$

E' possibile calcolare il numero di Avogadro utilizzando la legge dei gas perfetti $pV=RT$ per calcolare la costante dei gas ed utilizzando p.es. il fenomeno del deposito di particelle colloidali il una soluzione per calcolare la costante di Boltzmann.

Un ulteriore metodo per calcolare la costante di Avogadro è di utilizzare la dipendenza tra massa atomica e molare

$$NAV_{atom}=V_{mol}$$

Poiché nel caso di una sostanza cristallina il numero di particelle per unità di volume dipende dal reticolo cristallino che è fisso, evidenziando quest'ultimo p.es. col metodo della diffrazione dei raggi X, è possibile calcolare con grande precisione il numero di Avogadro.

How to measure an atom?

Did you ever played with a drop of oil on the surface of the broth? Trying to stretch it to a bigger pond?
A certain Jean Perrin got a Nobel prize for this in 1926 – he measured atom dimensions.

„Dimensions" of the atoms can be obtained in many ways, but every answer is different. In gases, the atomic "dimension" is the distance, at which they start to push each other in a rather brutal way – their diameters are estimated with deviations from the perfect-gas equations, when it is impossible to pressurise more the gas* .

Similarly, in liquids, dimensions of the particles influence the "neighbourhood" effects, like the viscosity.

In crystals, atom diameters are defined as dimensions of elemantary cells, visible by the X-rays diffraction * *.

Atom diameters could be also evaluated from the density – if we knew how many atoms were contained in one portion, i.e. in 1 mole of the substance. But we need to know the advocate's Avogadro number, what is also difficult.

Finally, a drop of oil can be spread in the water and its and the diameter of the blot measured. In this way , if the blot is really big, say a mono-layer, knowing the volume of the oil drop one can simply calculate the "height" of the blot, i.e. the heigth of the molecules***. And the guy who did it first got the Nobel prize.

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* it means with coefficients of the Van der Waals imperfect gas equation

** dimensions of atoms determined from crystal lattice constants are usually slightly bigger than those obtained using Van der Walls or viscosity equations

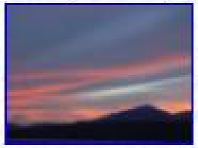
***The "height" of the particles obtained in present experiment, with oleic acid is about 8-10 Å

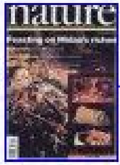
Spectroscopy or ghost science

It begun from Sun spectrum, and today we can say what was eaten and drunk on the funeral feast of King Midas

 -  - 

These are "spectra", i.e. ghosts... (more)
captions

 -  - 

At the funeral feast of King Midas 

How to weight an atom?

`Mass spectroscopy`

Mass spectrometer with magnetic deviation of Aston (1930)
. [Science Museum, Londyn]

First observation of neon isotopes [Aston 1920]

Mass spectrometers in Slupsk (more pictures)

How does the laser work? 

`CO`$_2$` molecular laser`  *[Science Museum, Londyn]*

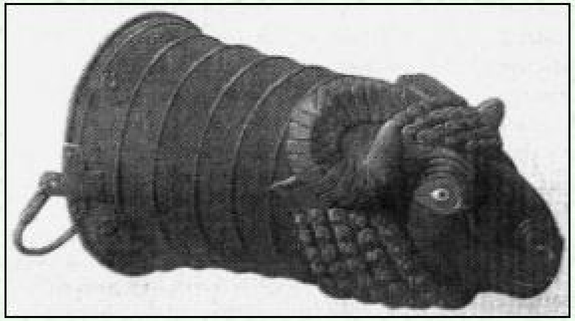
`Laser ablation`

How do the strawberies smell? 

Midas' funeral fest

Can we know what was eaten at a feast 3000 years ago? Yes, we can!

In 1999 archeologists discovered in Minor Asia, in land of ancient Frigia, a tomb full of precious objects of any kind, pearls, noble stones, expensive materials and subtle bronze dishes. The richness of the funeral indicated at high rank of the dead man, and place and age of the tomb pointed at similarity with ancient Greek cultures. Almost, almost king Midas' tomb.



On the bottom of bronze cups, in shape of sheep's head, there were some remains, almost unvisible with naked eye. The rests from the funeral feast? However, there was too little (and slightly out of date!) to taste it. But the appetite grows!

Luckily there is a contemporary science. It will tell you (and to the Police), not only how much you have drink but also what kind of alcohol! Different techniques used to find out what was eaten during the king's Midas funeral feast are common called **spectroscopy** (from Greek word *spectrum* it means a ghost).

It was a rich feast, that of Midas at his fineral: at the bottoms of the over 100 cups and plates the scientists found 16 different kinds of alcohols: a good quality wine, barley beer and fermented bee's honey. At the bottom of the dishes there were found at least 14 kinds of meat mainly sheep and goat. Meat first was grilled, and then detached from the bones, next mixed with Mediterranean herbs and spieces. Wines and beer were mixed in different proportions and served in elegant cups. Remains was loaded for king's Midas road through Styx river.

Well, well, such a funeral feast is enough to take a place in **mythology** forever!

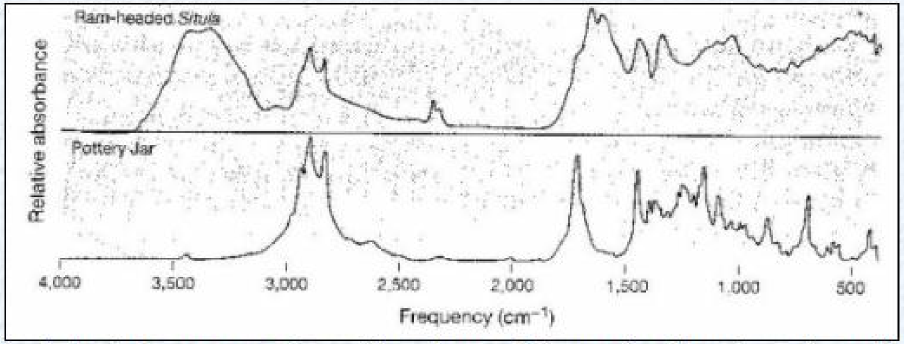
Quite serious: spectroscopic methods

Spectroscopic methodes used to examine remains of the king's Midas funeral feast:

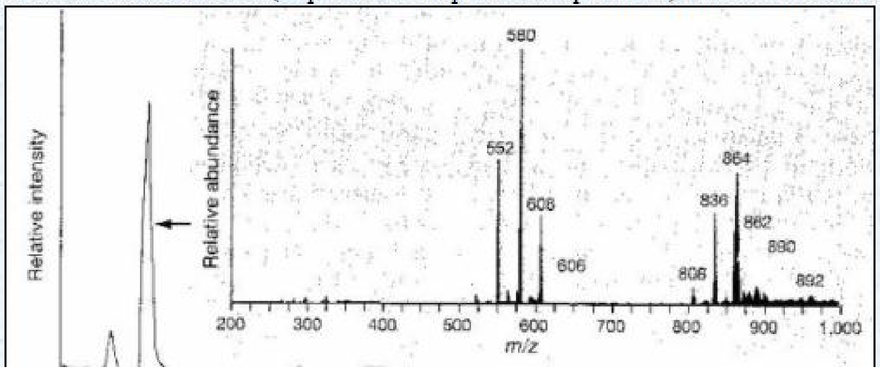
1. Infrared absorption spectroscopy allows to identificate particular function groups in chemical substances - vibrational frequencies of certains atom groups depends on their mass and kind of the chemical bond, similar to vibrational frequencies of the mechanic oscillator dependence on the spring elasticity constant

2. Mass spectroscopy - allows to determine ratio of charge to mass of chemical substances or their fragments (after previous ionisation); in order to avoid significant fragmentation during the ionisation, for complicated substances the proton transfer or electrospray ionisation techniques are used.

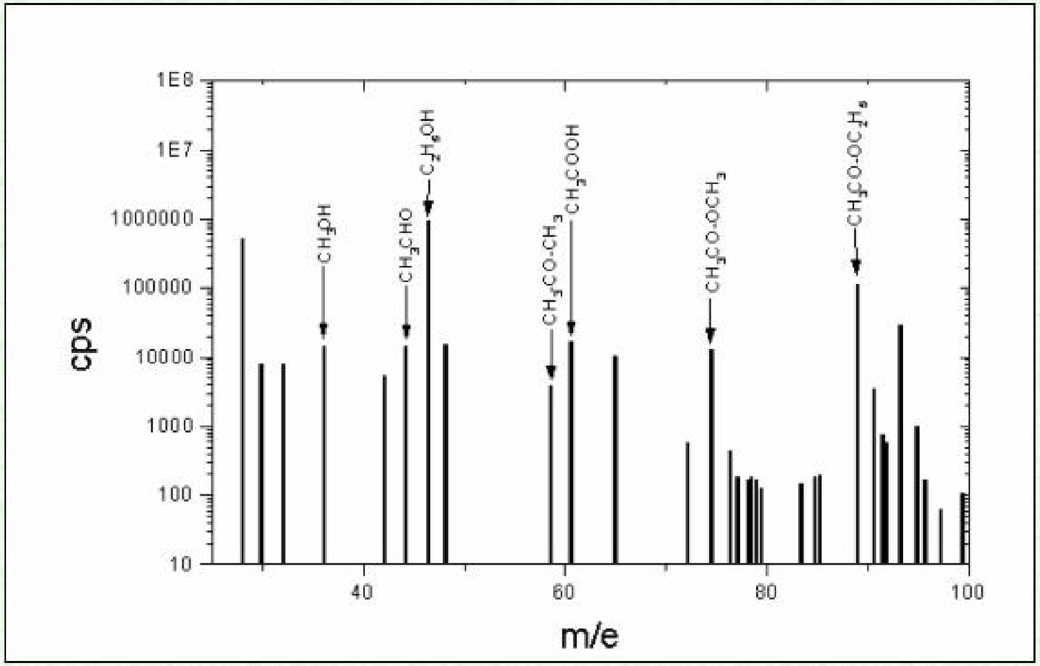
3. Liqud chromatography - it is a segregation of the substance due to different diffusion speed in liquid column (or gas - gas chromatography).



Infrared spectra analysis of the situla contents (cup with a shape of sheep's head) and remains of food from ceramic plate.



How do strawberries smell?



Well, this is exactly strawberries flavour! Are dissapointed?

Luckily, from time to time, in summer, you can find real strawberries...

And what you see, is so called mass spectrum - saying how much different molecules, forming the flavour of strawberries do weight!.

This spectrum has been obtained in the lab of prof. Davide Bassi from Trento University by so-called proton-transfer mass spectroscopy

Proton transfer spectroscopy

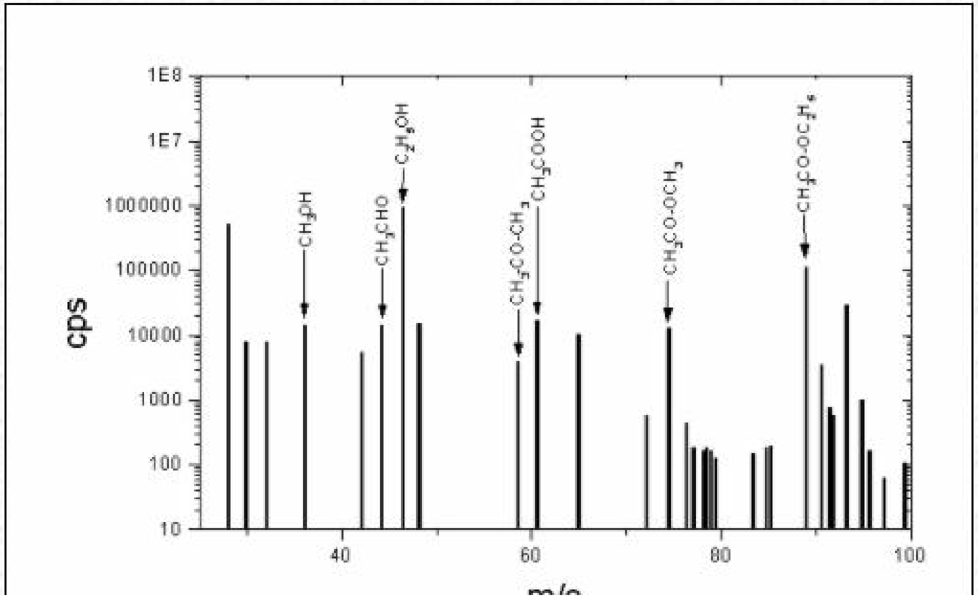
One of the problems in mass spectroscopy is the way in which molecules are ionized. Ionization can be done by eletrical discharge, laser light, electrons or another charged particles, but it usually leads to fragmentation of the molecules. In that case, finding out the original chemical composition of the sample from its fragments mass spectra is very difficult.

However, some ionization methods are "soft". One of them is a chemical ionization - by proton transfer. In that case the charge is transferred from previousl ionized particles of the buffer gas, like methane, ammonia or isobuthan, to the studied molecules.

From recently, first in Innsbruck, **hydronium H_3O^+** is being used for proton transfer ionizaion. These hydronium ions are created, for example during dissotiation of the protonated water clusters $H^+(H_2O)_n$. Ionization process rely on transfer of the proton from hydronium to the neutral molecule M according to equation:

$$H_3O^+ + M = MH^+ + H_2O$$

As a result, the peaks in mass spectra appear shifted right by 1 atomic mass unit.



„Einstein and Relativity Theory"

XX Century = Einstein's Century

*Four manuscripts - from March 12th to September 1st. A miracle? An explosion? Plagiarism? Or **happy marriage**?*

Albert and Mileva 

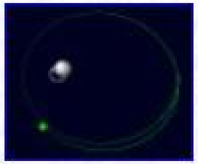
Four manuscripts that changed the world

A cow-boy from Strzelno

`Ether wind`

Postulates of relativity

 Quicker but tighter 

Einstein: "A pur si muove" 

links, sources, photo, more

„was born, …

Albert and Mileva

Albert, as said two years younger sister Maia, **learned to speak late**. He used to „drawl" sentences like conteplating them. Mother, Paulina teached him to play cello, uncle Jacob teached algebra and an older friend, a medicine student, used to borrow him popular-science books. In age 15, he studied by himself differential calculus.

When Albert was one year old, his father's company was to close, so the family moved from Ulm to München. Bismarck's scholastic system, closed-minded teachers and studying as the must, changed the school into a nightmare. In Italy, where the father moved just before Albert's (matura) graduation, **he revived**.

His parents wanted Albert to study at Polytechnic in Zurich – the best high school outside Germany. Without matura he **had to pass** entrance exams. He fell in German and philosophy. Following Rector's advice, Albert stayed one year in Switzerland, where he finally got matura. But against his father's will, Albert decided to become a scientist, not an engineer.

One more time Albert will not follow his father: when he got in love with Mileva Maric, a student of mathematics from Serbia (under Austria at thas time). In 1901 they had a daugther which died soon. Mileva failed her graduation exam and stayed without job. Only after his father death, Alberts married to Mileva. The university research position, promised to him, goes to another person: Albert also stays **without a job**. His friend find him to take a position as a patent adviser in Bern. In a short time, before 1906, he published 6 works

„elementary particles”

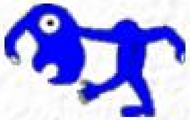
Quarks and cheese

6 quarks in 3 colors, and anty-quarks, and gluons, and leptons: poor God is

"Tree quarks for Muster Mark"

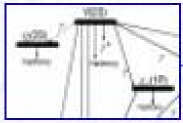
Proton & Co. [*note*]

Super-multiplets



Quarks almost the same, but the smells different ! [*note*

Mésalliance

What mesons are?  Charmionium chart D-charmed mesons NEW

Hadrons in strong interactions [Gesselshaft fur Schwerionenforschung mbH, Darmstadt]

See quarks

A model of proton and neutron (metal cubes) show another feature of q
there are inside, like two pictures on opposite walls,
but no one can get them out of the cubes .

1. Etymology

Enigmatic quarks

In fact it is not clear what James Joyce had in mind writing in "Finnegans Wake":

- *Three quarks for Muster Mark!*

Sure he hasn't got much of a bark

And sure any he has it's all beside the mark.

If that was "quarts", then Mark had to drink beer, a quite big amount, that's six pints! Anyway the rest of the text is also unclear. Is it a tree? A dog somewhere? A scar or a lesson?

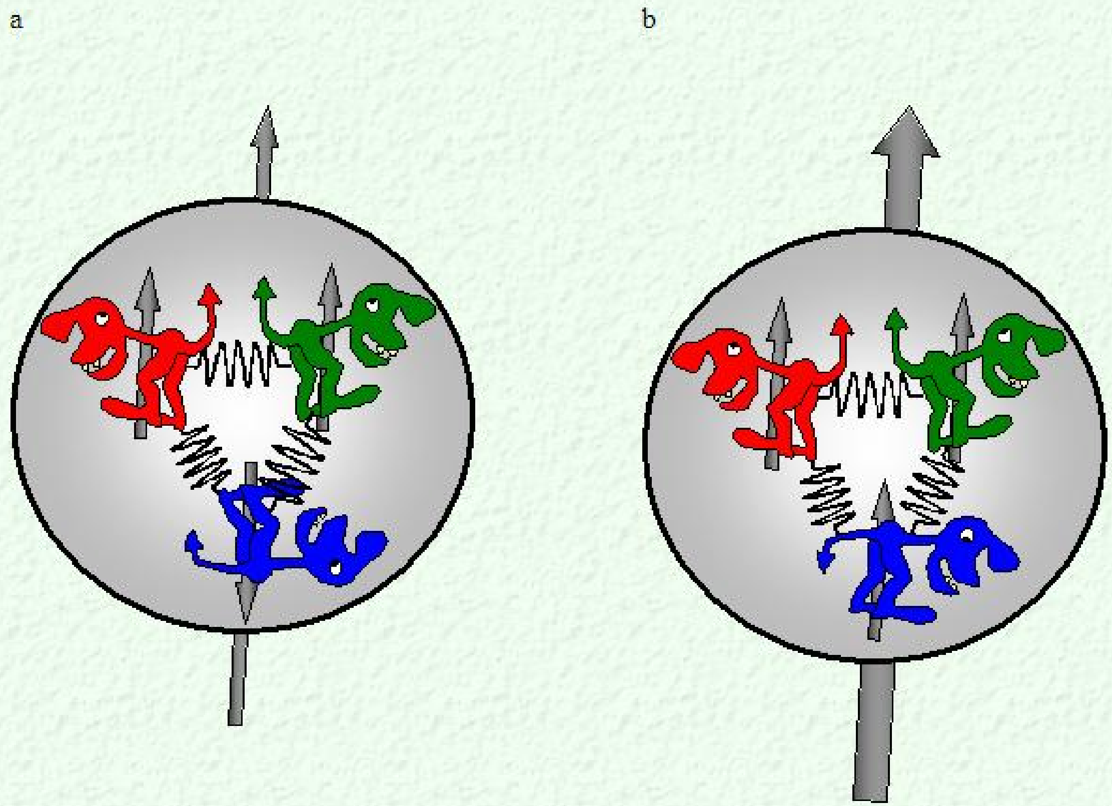
Now, a similar situation is with the quarks: there were only **three** when they were named by Gell-Mann in 1964. Now they are **six** quarks, but in three colors, and, additionally some negative ones, in pink, cyan and yellow. And no one ever catched them by hands, like Mark.

Explanations:
Quart =1/4 gallon
Gallon =3,785 dm^3
bark - 1) sound emmited by a dog; 2) hard, external covering of the tree
mark - 1) sign on face; 2) letter or digit to valuation
quark - 1) assigment for Mark Muster in "Finnegan's Wake", 2) basic, beside the leptons, elements of matter: components of mesons (=2 quarks) and barions (=3 quarks), unable to be isolated, but observable during in high energy colisions of

2. Proton, neutron, hyperion Δ

Proton & Co.

Proton (a) and Δ^+ particle are built in the same way - with two *up* quarks and one *bottom* quark. The only difference is in spin, what causes that Δ^+ particle is 30% heavier than proton.



2. Proton, neutron, hyperion Δ

Proton (uud)

Isospin=1/2
Mass m=938.27231 ±0.00028 MeV (=1836 electron masses*)
Electric momentum D= $(-3{,}7\pm6{,}3)\times10^{-23}$ e cm
Magnetic momentum μ= 2,792847386 ± 0,000000066 μ_B
Lifetime $\tau=1{,}6\times10^{25}$ yr (>>age of the Universe $=14{,}5\times10^{9}$ yr)

Neutron (udd)

Isospin=1/2
Mass m=939.56563 ±0.00028 MeV (a bit more than proton)
Electric momentum $D< 12\times10^{-26}$ $e$cm
Magnetic momentum μ= -1,91304275±0,000000456 μ_B
Electric charge $q=(-0{,}4\pm1{,}1)\times10^{-21}$ e (read: zero!)
Lifetime τ=888,65 ± 3,5 s (= academic quarter!)

Barion Δ^+(uud)

Isospin=3/2
Mass m=1230-1234 MeV (more or less)

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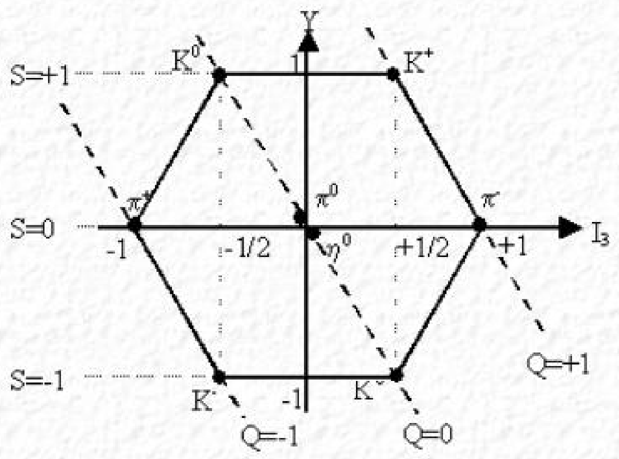
*1831 - beginning of the November Insurection in Poland

3. Discovery paths

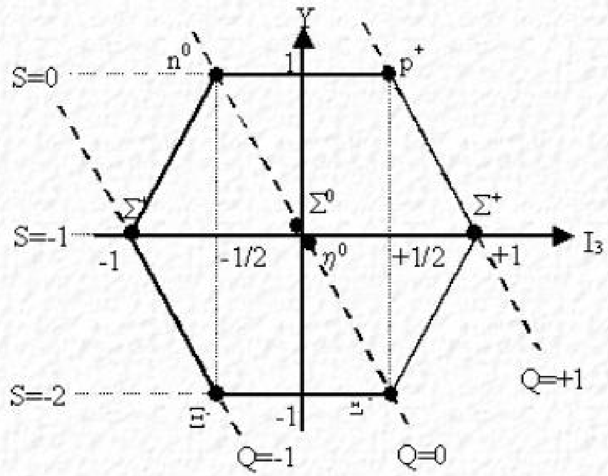
Super-multiplets

In the beginning of '60 of last century, Gell-Mann and Neewman independently noticed, that due to the same *spin*, *parity* and *strangeness*, and due to similar masses, hadrons can be grouped into so called **multiplets**, which than are grouped into **supermultiplets** consisting of singlets, octets and decouplets. Introducing values descibing the multicity - like **isospin** I=(N-1)/2 and **hypercharge** (Y=B+S, where B - barion number, S - strangeness) and after plotting dependences of these values (to be exact - hypercharge vs. isospin's projection on "selected direction" I_3) characteristic geometrical figures can be obtained. That situation was similar to first trials of classification of chemical elements into Mendelejew's table.

Supermultiplets allowed to predict existence of new particles. **Quark's** hypothesis was "on the way".

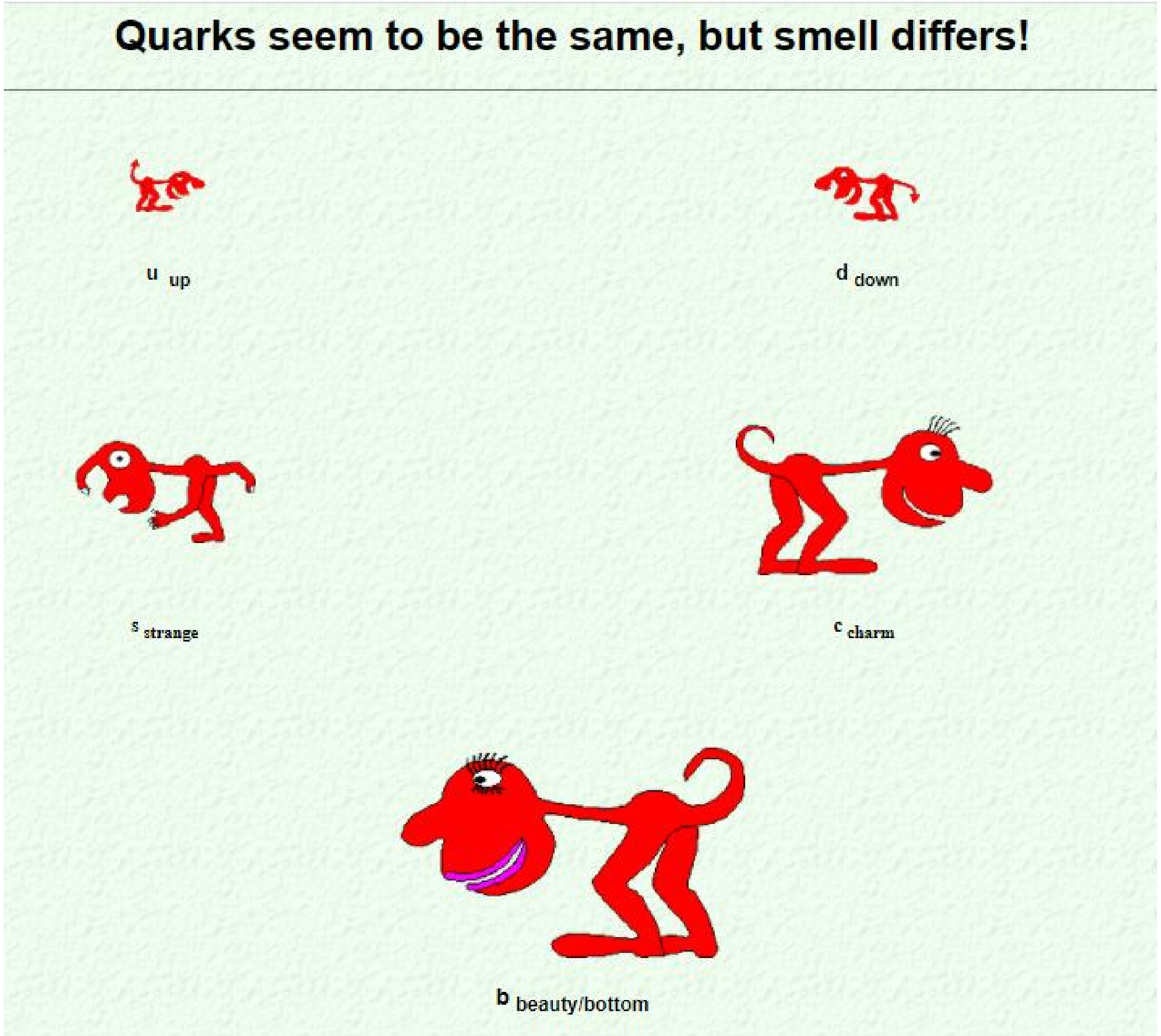


Mesons octet with spin s=0



Barions octet with spin s=(1/2)

4. Quark's physiognomy



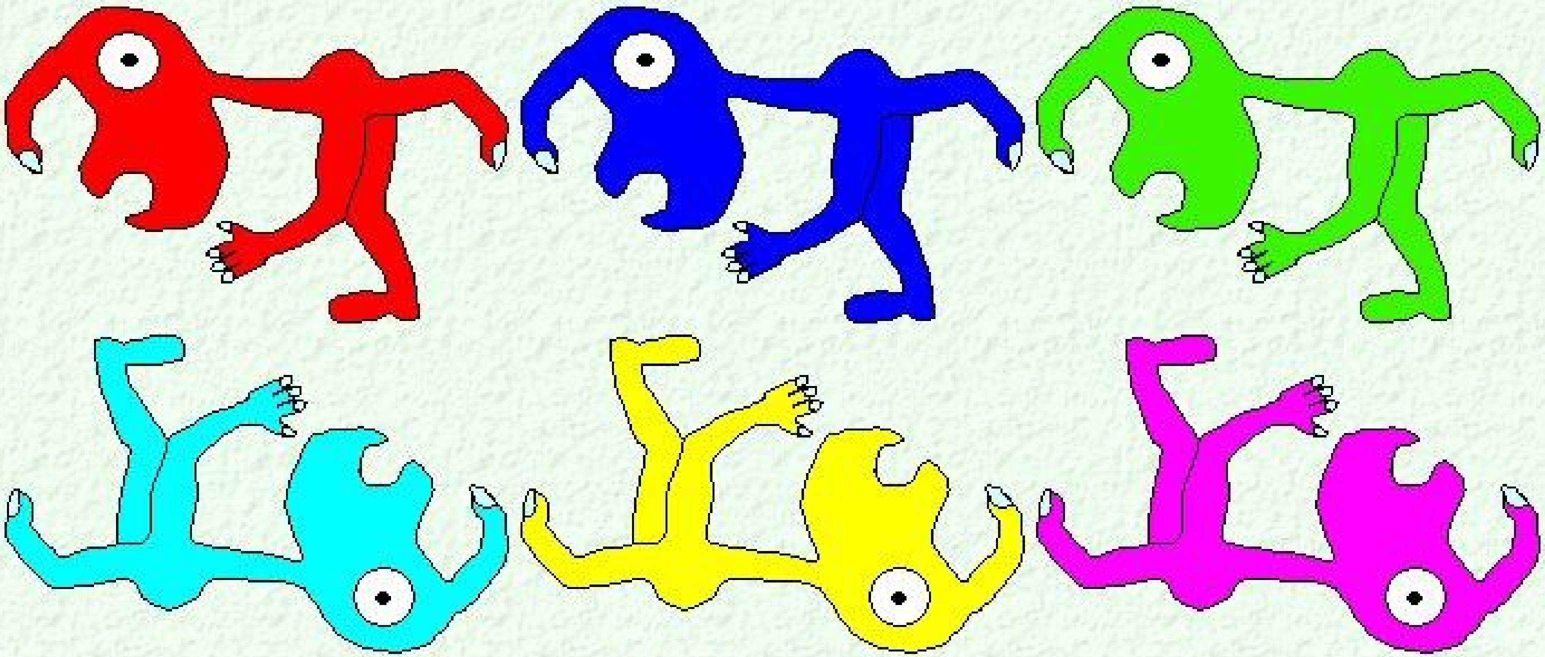
smell,
i.e. flavour

Now we call it
„generation”
No. 1, 2, 3

5. Adding quarks: mesons

Kwarki i kolory

Dwie połowy jednej z rodzin kwarków idą na spotkanie



Jak się kwark zwiąże ze swym antykwarkiem, to powstaje **mezon**
(nie mylić z mezaliansem)

6. Again, now serio

Hadrony

***+ Strange** quarks*

uds Λ(lambda)
1115,683+/-0,006

uds Σ^0 (sigma zero)
1192.642+/-0,024

uus Σ^+ (sigma plus)
1189,37+/-0,07

dds Σ^- (sigma minus)
1197,449+/-0,030

$d\underline{s}$ K^0 (neutralny kaon)
497,672+/-0,031

$\underline{d}s$ $\underline{K}^0$ (neutralny antykaon)
497,672+/-0,031

$u\underline{s}$ K^+ (dodatni kaon)
493,677+/-0,013

$s\underline{u}$ K^- (ujemny kaon)
493,677+/-0,013

- -

uss Ξ^0 (ksi zero)
1314.83+/-0,20

dss Ξ^- (ksi minus)
1321,31+/-0,13

- -

sss Ω^-
1672,45+/-0,29

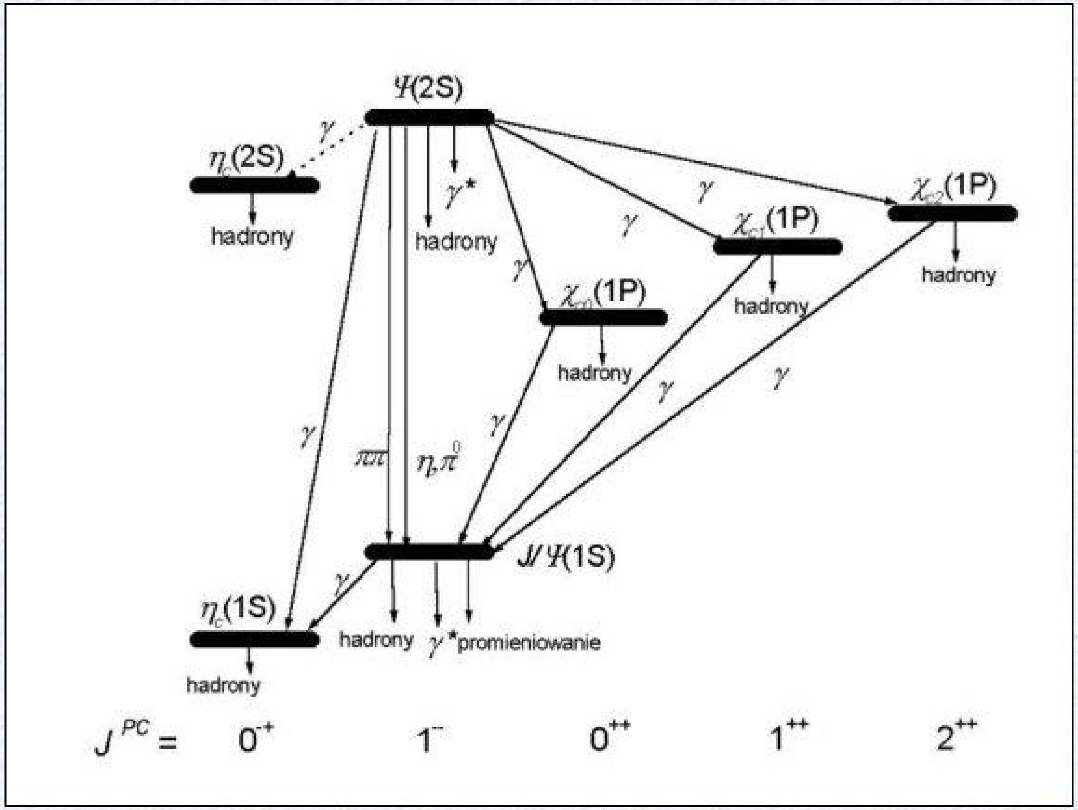
***+ Charm** quarks*

ddc Σ_c^0 (sigma-c)
2452,6+/-0,6

$c\underline{c}$ J/Ψ(charmionium 1974 r.) zwany tez η_c
3096,87+/-0,04

7. Example: czarmionium

Charmion chart



Obecny stan wiedzy o układzie stanów **charmionium,** tj. mezonu będącego stanem związanym kwarku *c* i antykwarku *c̲*) oraz przejsciach między tymi stanami. Odległości między poziomami odpowiadają różnicom mas - przykładowo masa mezonu J/ψ w stanie (1*S*) wynosi *m*=3097 MeV a w stanie (2*S*) *m*=3686 MeV.

Oznaczenie γ^* oznacza rozpady, w których uczestniczą wirtualne fotony, włączajac rozpady do e^+e^- i $\mu^+\mu^-$.
Niepewne stany i przejścia zaznaczono przerywanymi liniami.

Źródło: Particles and fields, *Phys. Rev. D.*, Vol. 66, No 1-I, 2002, str. 719

8. Appendix: other quarks *charm*

D - charmed mesons

After charmionium, another class of interesting charmed mesons are those mixed with "ligher", like ***u*** or ***s*** quarks
An experiment run in Fermilab aims to validate or not the Standard Model of elementary particles, and also check other phenomena, like CP parity violation.

D_s^+ and D^o have unique non-spectator decays

The experiment is called FOCUS and run at Fermilab
High energy photon beam (~300 GeV) impinges on beryllium oxide target, producing the charm quarks by "fusing" with a gluon in the target

---

Theory predicts: the lifetime ratio (D_S^+) /(Do) =1.07-1.20

The preliminary experimental result is: (D_S^+) /(Do) = **1.214 ± 0.017**

i.e. within the error bar in agreement with the Standard Model Theory !

8. Appendix: other quarks *charm*

Introduction to the FOCUS Experiment

FOCUS is a collaboration of about 70 physicists from the US, Italy, Korea, Mexico, Brazil studying charm particle production and decay at the Fermilab Tevatron (Batavia, Illinois).
The acronym stands for FOtoproduction of Charm with an Upgraded Spectrometer (the spelling is half Italian).
It utilizes the worlds highest energy photon beam to produce charm quarks which can be detected using a magnetic spectrometer consisting of wire chambers, silicon detectors, gaseous Cherenkov counters, etc.
The raw data sample was about 25 TB (data taking finished in late '97).

The Physics of the Charm Quark

The c-quark was discovered in 1974, simultaneously at Brookhaven Lab (Long Island) and at SLAC (Stanford Linear Accelerator Center)

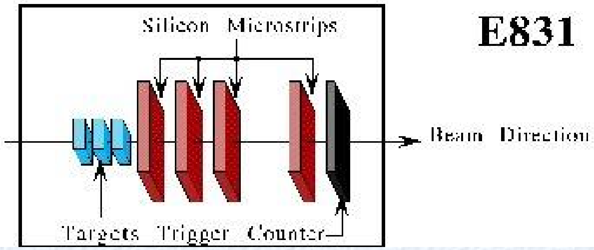
It is a "heavy" quark, which makes it difficult to produce (because of the way cross sections scale). Therefore, data for this object has been slow in coming, making all of the particle physics involving the charm quark difficult to study.

The charm quark is well-behaved in the so-called Standard Model of particle physics. That is to say, SM predictions for weird behavior are tiny. This opens a window for observing physics beyond the SM… "New Physics". If we can find SM forbidden charm quark decays, we will be onto something really hot in the world of particle physics. (The world at large may also be interested, from a philosophical point of view.)

FOCUS has the worlds largest sample of fully reconstructed charm particle decays and will for the near term future.

Detectors

Located in the Fixed-Target area (Wide Band Photon Lab) at Fermilab
High energy photon beam (~300 GeV) impinges on beryllium oxide target, producing the charm quarks by "fusing" with a gluon in the target



E831 Spectrometer Layout

9. „Leptons”

Lighters and heaviers

After the discovery of *meson* (μ) i.e. "intermedier" , heavier 207* times than electron, but much more lighter than proton, it was decided to name light particles as *leptons* or lighters.

Leptons can be found in Greece - ~~you can take one of them as a souvenir**~~.

Lepto(n)

It's a bit unlucky but third lighter - tau (τ), is twice heavier than proton, neutron and many others *heaviers* or hadrons.

Do not try to lift up τ lepton, you will squeeze your fingers!

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* **Lepton's masses** (1990)

- m_e=0,51099906±0.000000015 MeV, lifetime > $2 \cdot 10^{22}$ years
- m_μ=105,658387±0.000034 MeV, lifetime $(2,19703 \pm 0,00004) \cdot 10^{-6}$ s
- $m_\tau = 1784,1^{+2.7}_{-3.6}$ MeV, lifetime (0,303±0.008)·10-12 s

** Organizers appology, but Bank of Greece retracts 1 lepto coins from currency and it was not possible to deliver a sufficient amount of **leptons**.

Masses of presented here μ lepton, proton and neutron corresponds exactly to the proportions to 1 cent lepton e (2.29g). τ "Lepton" in the present shape is slighty heavier than it should be from comparison to *e* lepton .

10. „God's" particle (?)

Lecieć, jak higgsy na LEP

Powodem asymetrii między oddziaływaniami elektromagnetycznymi a słabymi jest (hi
Foton nie posiada masy, dlatego oddziaływanie elektromagnetyczne, podobnie jak gr
słabe, o zasięgu rzędu rozmiarów kwarków (o ile o rozmiarach można mówić), czyli m
bozony: dwa naładowane (W^+ i W^-) o masie 81 GeV/c^2 i jeden neutralny Z^0 (m=93 Ge

Masa bozonów W i Z jest, według najbardziej prawdopodobnych teorii, wynikiem ich o
"dostarcza" też masy kwarkom i leptonom (różnej, dla różnych rodzin leptonów i kwar
dziura, zwana duchem cząstki Higgsa.

"Boska cząstka" Leona Ledermana (laureata nagrody Nobla, za odkrycie neutrina m
dodaje sam Lederman, "jest tylko jeden".

Doświadczenia przeprowadzone w CERN w 2001 roku, na krótko przed zamknięciem
sugerują, że być może higgs (a właściwie dwa z nich) się pojawił, około energii 114 G
potwierdza. Na Higgsa, w CERN-ie już się buduje **lep jeszcze większy**, hadronowy. L

"Aby zdefiniować w sposób kompletny model standardowy jest niezbędnych dwadzieścia albo i więcej parametrów i stałych, nie wyznaczonych przez teorię: między innymi siła sprzężenia między oddziaływaniami silnymi, słabymi i elektromagnetycznymi, masy kwarków i leptonów i inne parametry, które definiują oddziaływania z bozonem Higgsa. Poza tym, istnieje co najmniej 34 składników materii, które wydają się cząstkami elementarnymi lub pośrednikami oddziaływań: 15 kwarków [18 dziś, 2003] (pięć [sześć] smaków z którego każdy w trzech kolorach), sześć leptonów, foton, osiem gluonów, trzy bozony oddziaływań słabych i hipotetyczny bozon Higgsa.

W kwestii prostoty, model standardowy wydaje się nie przedstawiać żadnego postępu w stosunku do starożytnej wizji materii składającej się z **ziemi, wody, powietrza i ognia**, oddziaływujących przez **przyjaźń i konflikt**."

Chris Quigg, Scientific American, czerwiec 1985.

Summary (2003)

Instead of summary

Recent centuries, strarting from Galileo, Newton to Einstein are the triumph of the Science. Science is a moving force of progress!

Both number of works and adepts are increasing. While on Solvay's congresses we can still count all participating scientists, today (15.09.2003) “Philadelphia's (ISI) list)” shows::

51 of 12957015 documents matched the query

It is difficult even for scientists to read 13 million of manuscripts.

So imagine how much more difficult this task is for journalists! That's way, popular magazines are full of bacterias from Mars, intelligent beings in the Space and 11 dimensions of space-time, with 7 of them hidden or folded around like a carpet.

But if we asked of the visitors, why *tetanus* is so much dangerous, why *invar* does not changes its dimensions and which are the modes of the *Wilberforce pendulum* - most of them would try to avoid the subjects.

So, the task of this exhibition is to show, that Physics is a **still written book**, *in statu nascendi*, and **not a closed Science**. Therefore, the more simplifications and omissions are in these texts - better it is. Important is to fill the gap between the "big Science" and the "man on the street", which otherwise is populated by green (or gray?) beings from Mars.

Authors *do not* pretend to be a specialists in *all* topics here presented. Moreover, they hope that numerous simplifications and errors will invite true *specialists* to organize NEXT exhibitions of this type.

Grzegorz Karwasz, Tomasz Wróblewski

Thank you!