

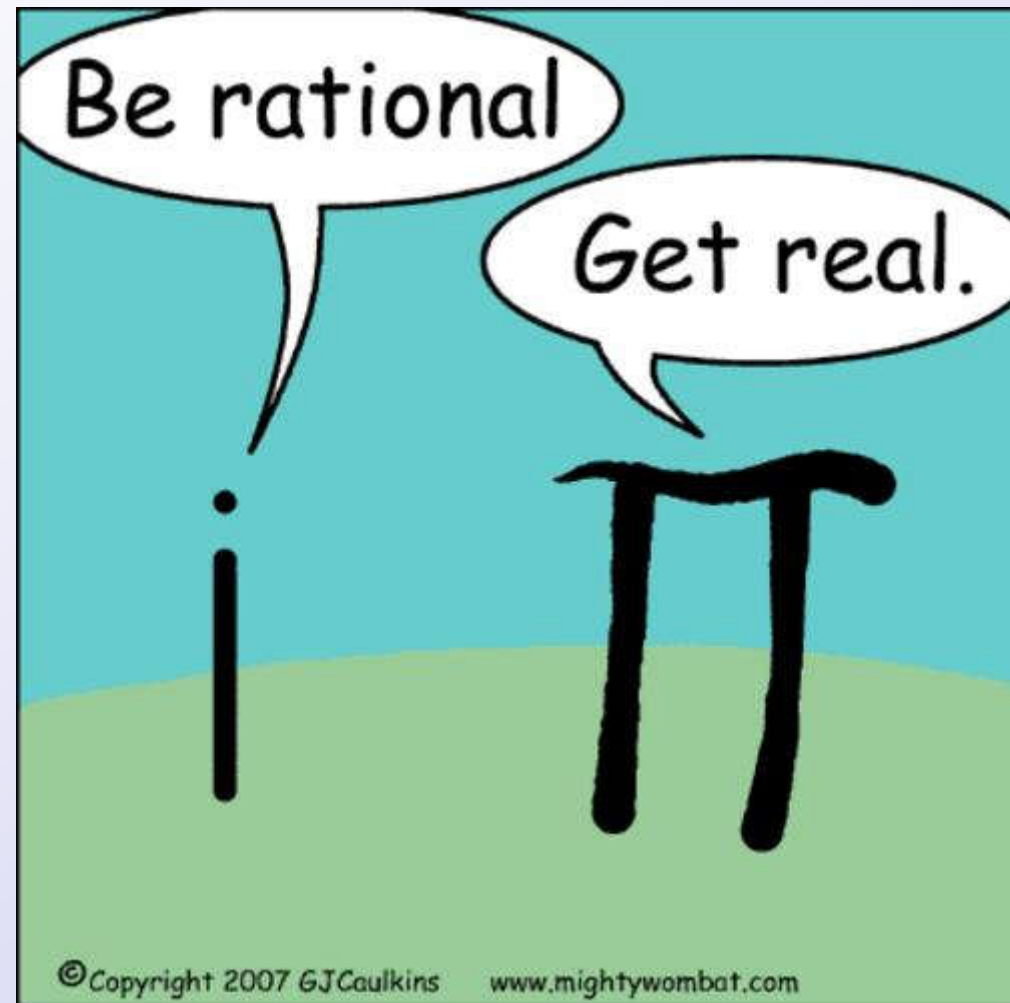


Analogies

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... what is an analogy ... ?

- ... lots of very 'academic' stuff ... !
- ... using something that is understood (analog) to explain something that is not understood (target) ...
- ... an analogy fails when the analog is ...
- ... *not understood, or is too complex* ...
- ... **wrong** (*embeds a misconception*) ...
- ... *taken too far (analog ceases to be true)* ...



... using analogies ...

- ... they can be abused and misused ...**
- ... analogies are about student/teacher interaction ...**
- ... and I firmly believe that they do serve a purpose, but need to be used carefully and with explanations that point out where they fail ...**
- ... prior knowledge is important ...**
- ... what does snake taste like ... ?**
- ... like crocodile ... !**
- ... pointless if you've never eaten crocodile ... !**



... OK some analogies ...

- ... but remember – none are perfect or ideal ...
- ... serve only to illustrate a particular point ...
- ... I'll try and point failures out occasionally ...



... measuring distances ...

- ... how far to ... ?
- ... time is a good way to do this ...
- ... our answer depends on whether the questioner is walking, cycling or going by car ...
- ... but so is money ... !!
- ... Hans Zinecker and friend



... other examples ...

| Place | Distance | Foot | Taxi/Car | Jet | Shuttle |
|------------|----------------|------|----------|------|---------|
| Muizenberg | 10 km | 2 h | 10 m | 1 m | 1 s |
| Sutherland | 400 km | 8d | 4 ½ h | 35 m | 40 s |
| JHB | 1 600 km | 1 mo | 20 h | 2 h | 160 s |
| Europe | 8 000 km | 8 mo | 20 d | 12 h | 13 m |
| Moon | 400 000 km | | 3 y | 21 d | 11 h |
| Sun | 150 million km | | 171 y | 21 y | 1.16 y |

... these are *ball park* numbers for the direct route ...
... to give a recognizable time ...



... light travel time distances ...

... distance is defined as the spatial separation at a common time ...

... if a distant cluster of galaxies is 9.1 billion light years away in a universe that is 13.7 billion years old, how did the cluster get so far away in only 4.6 billion years ... ?

... it makes no sense to talk about the difference in spatial positions of a distant galaxy seen 9.1 billion years ago and the Milky Way now when galaxies are moving ...

... redshift z is usually the only number in the whole story that is unambiguous and likely to be correct ...



... analogy ...

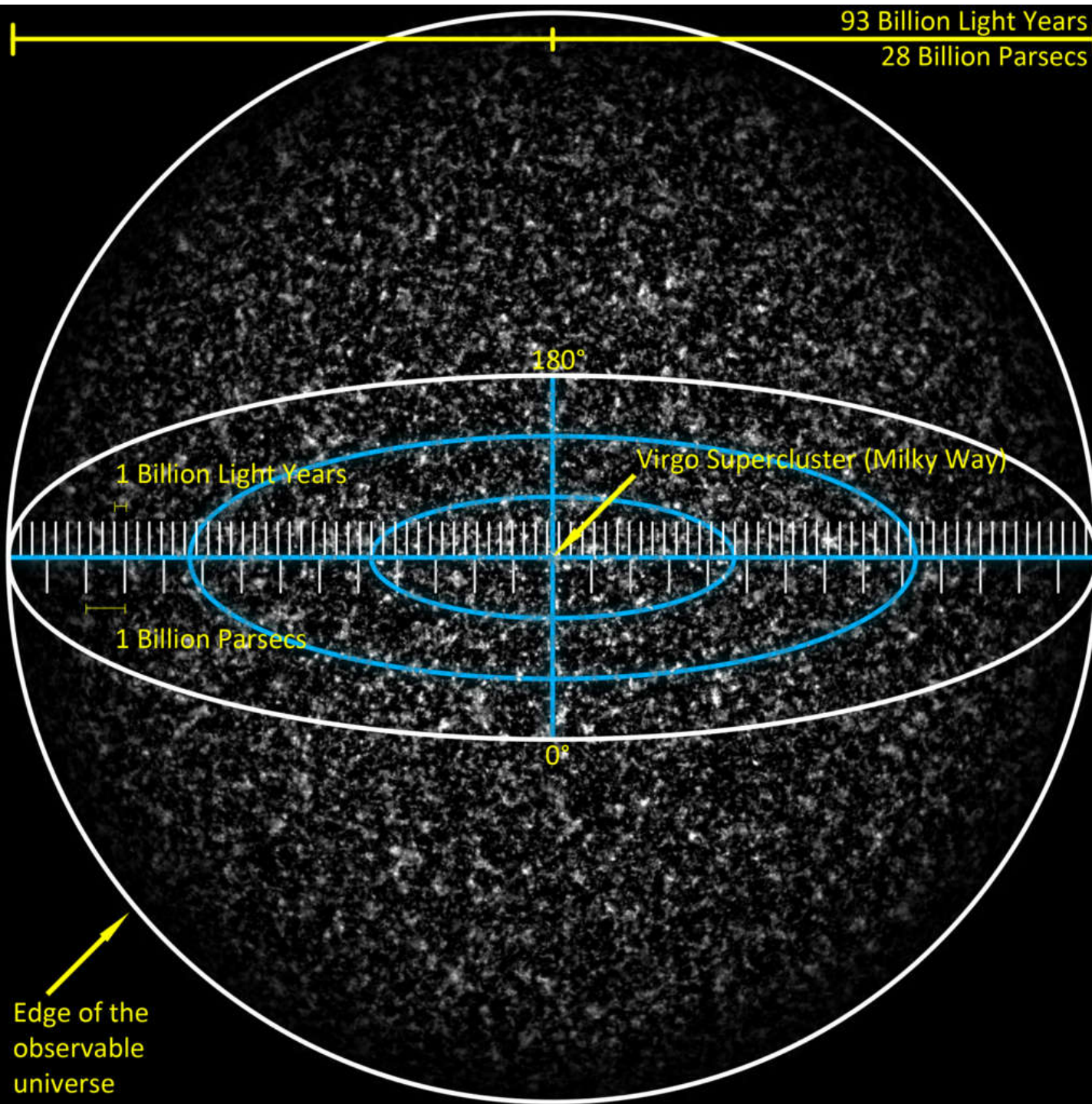
... if an SR-71 blackbird flies over at Mach 3 and you hear the sound 30 seconds later ...

... then answer to the question how far away is it ... ?

... is clearly not 30 *sound seconds* or 10 km ...

... good analogy, but prior knowledge ... ?

Courtesy Ned Wright.





... using intermediary standards ...

... when judging distances in the veld or wherever ...

... we use things we are familiar with ...

... cricket pitches, rugby fields, 100 m sprinter ...

... but how about numbers ... ?

... how 'big' is a million, or a billion ... ?

... how many R1 coins in a std. 2-l ice cream tub ... ?

... 4 000 ... !

... so 1 million = 250 tubs ($\sim 1\text{m}^3$) ...

... and 1 billion = 1 000 m^3 ...

... $(10 \times 10 \times 10)\text{m}^3 = \sim \text{vol of a house}$...

... one lifetime = 2.2 billion secs ... !!



... atmosphere ...

... how thick is the atmosphere ... ?





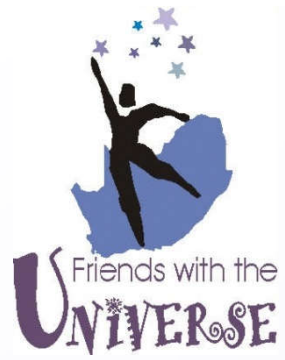
... analogy ...

... take a soccer ball ...

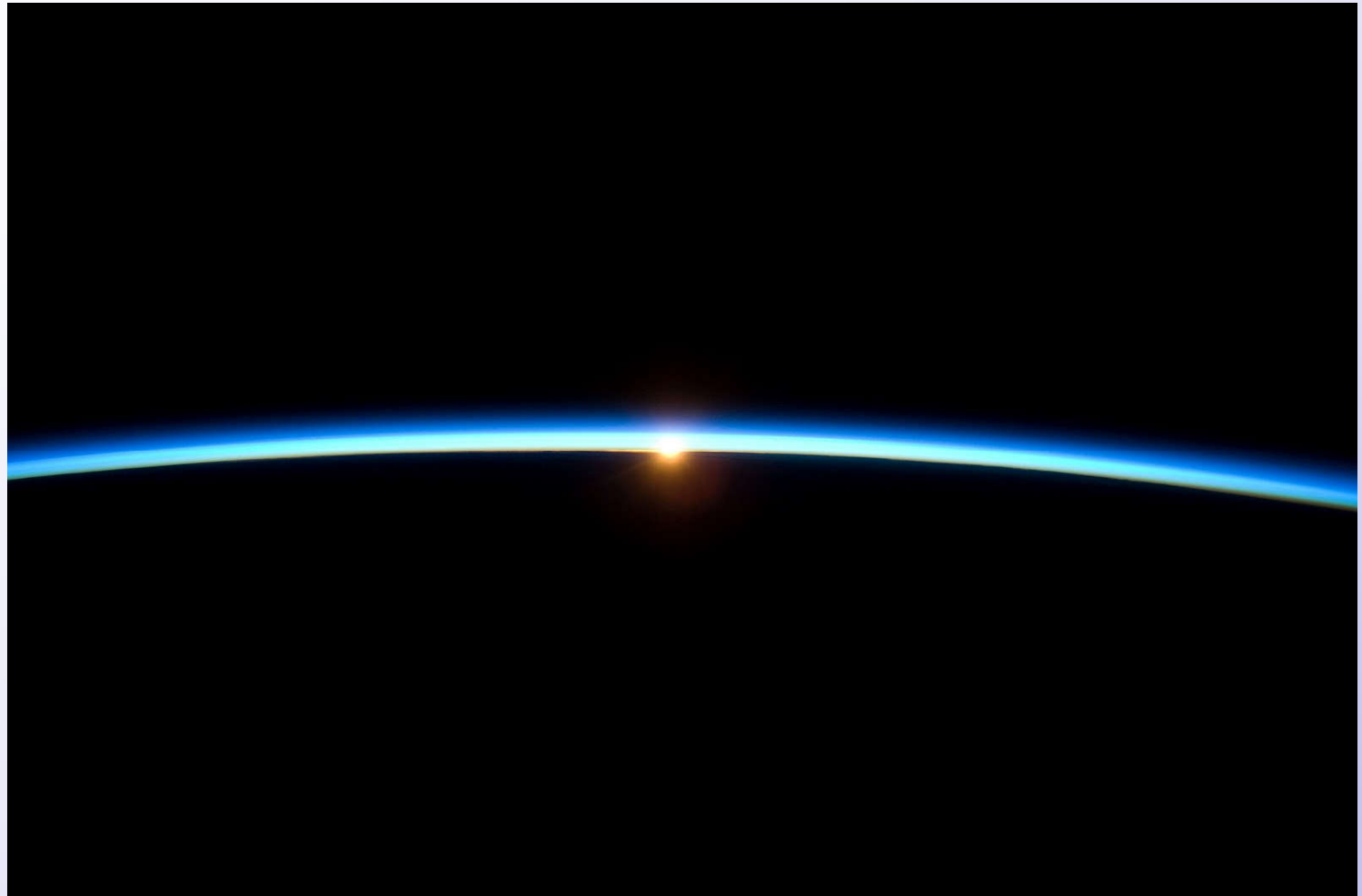
... imagine an Earth the size of a soccer ball ...

... add a sheet of paper ...





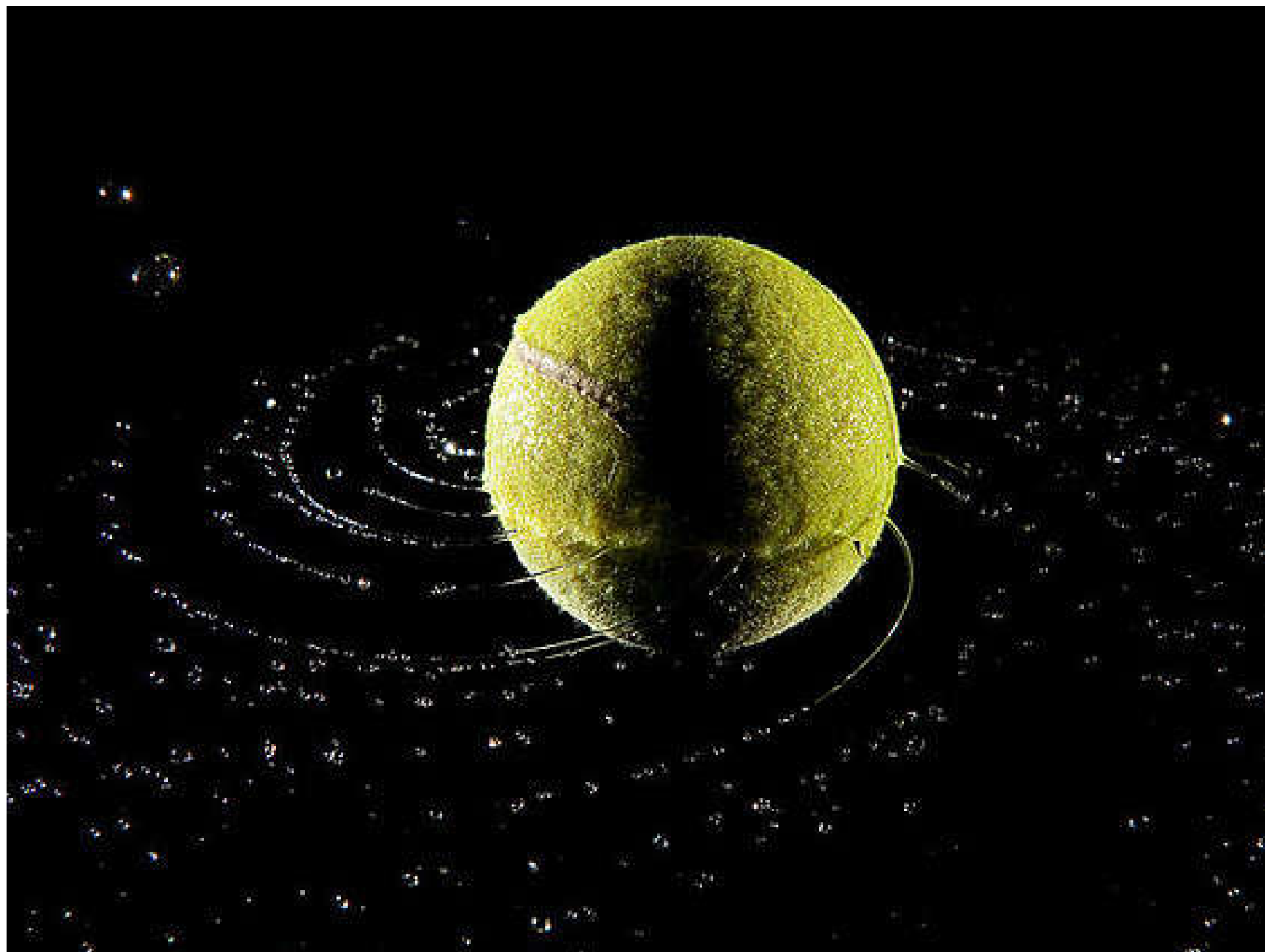
... evidence ...





... ecliptic ...

- ... why do all the planets orbit the Sun in a plane ... ?
- ... wet a tennis ball and spin it ...
- ... careful though ...
- ... the droplets lie in an equatorial plane ...
- ... here analogy ends ... !!
- ... because unlike the planets, droplets spiral outwards ...
- ... planets held in orbit by the centripetal force ...
- ... and then it gets really tough ... !!
- ... true for accretion disks around stars, BH, WD too ...





... core collapse SN ...

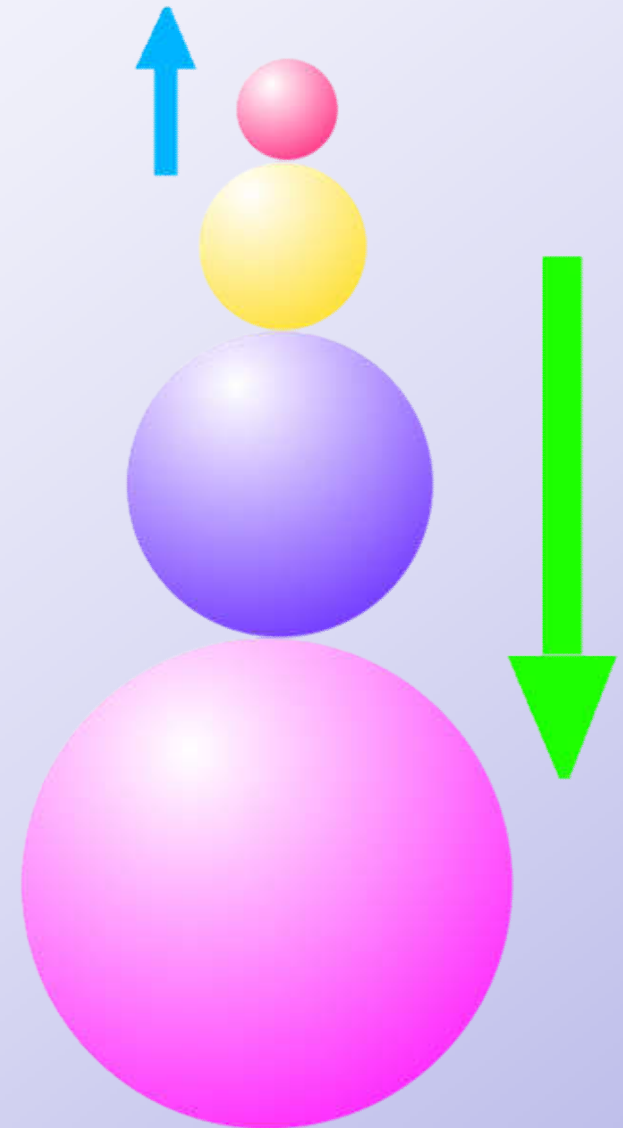
- ... stars mass $8 < M_{\text{star}} < 40 M_{\odot}$...
- ... type II SN occur when the core fusion reaction stops at iron ...
- ... $M_{\text{core}} > 1.4 M_{\odot}$...
- ... electron degeneracy can no longer counter gravity ...
- ... cataclysmic implosion occurs ...
- ... collapse is halted by neutron degeneracy, causing the implosion to bounce outward ...





... Galilean Cannon ...

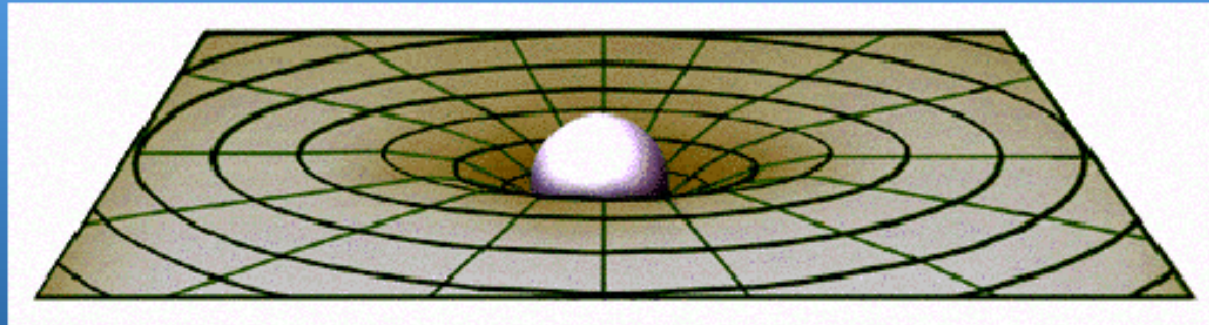
... the basket/tennis ball works well ...
... this works better ... !
... imagine when a few million particles
bounce off each other ...



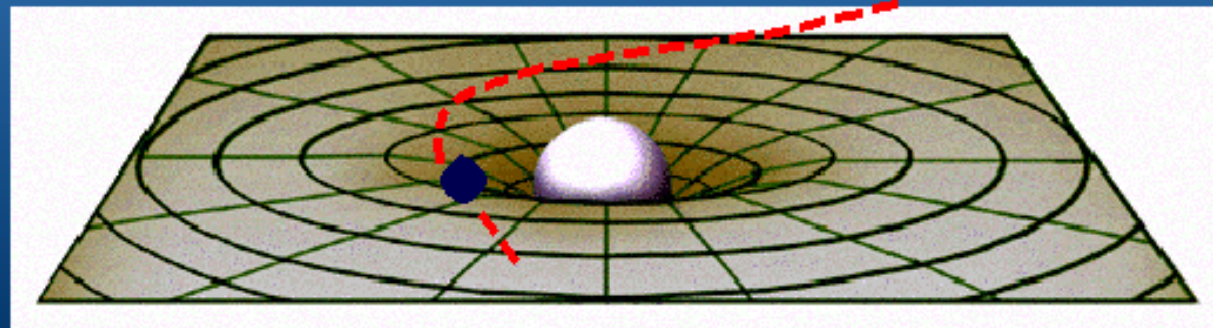
... effects of gravity ...

Gravity: Space as a Rubber Sheet

- Matter tells space how to curve



- Curved space tells matter how to move





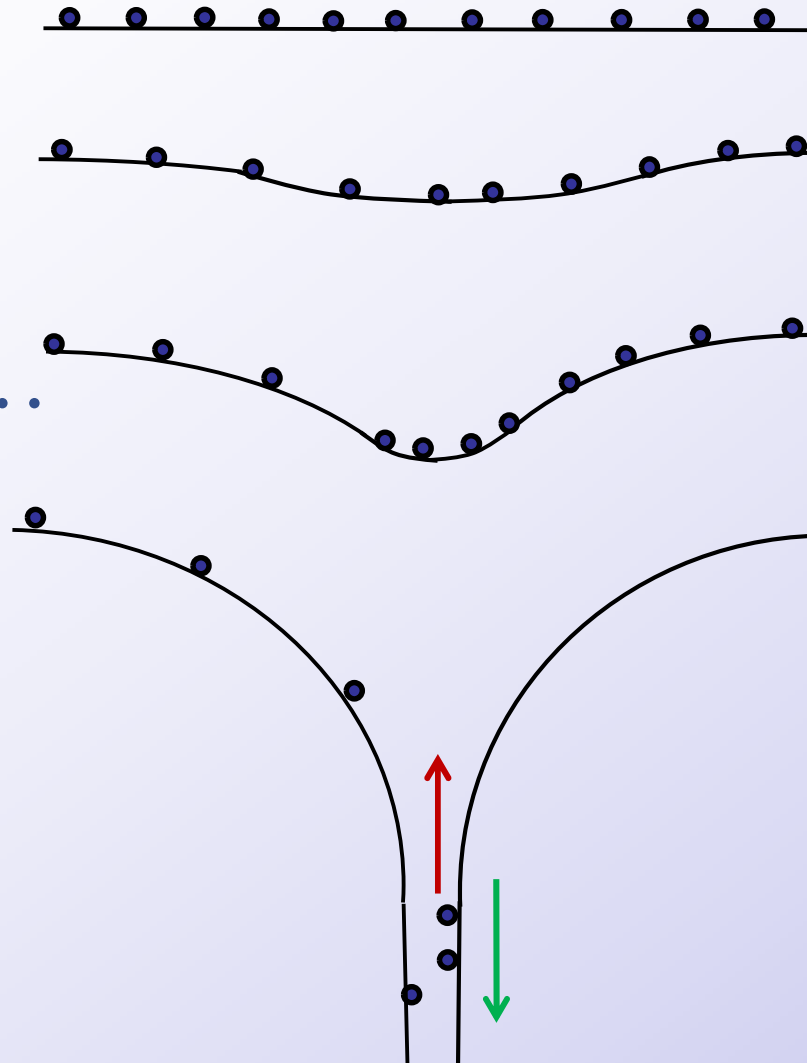
... gravity simulation ...





... black holes ...

... ants and BH ...





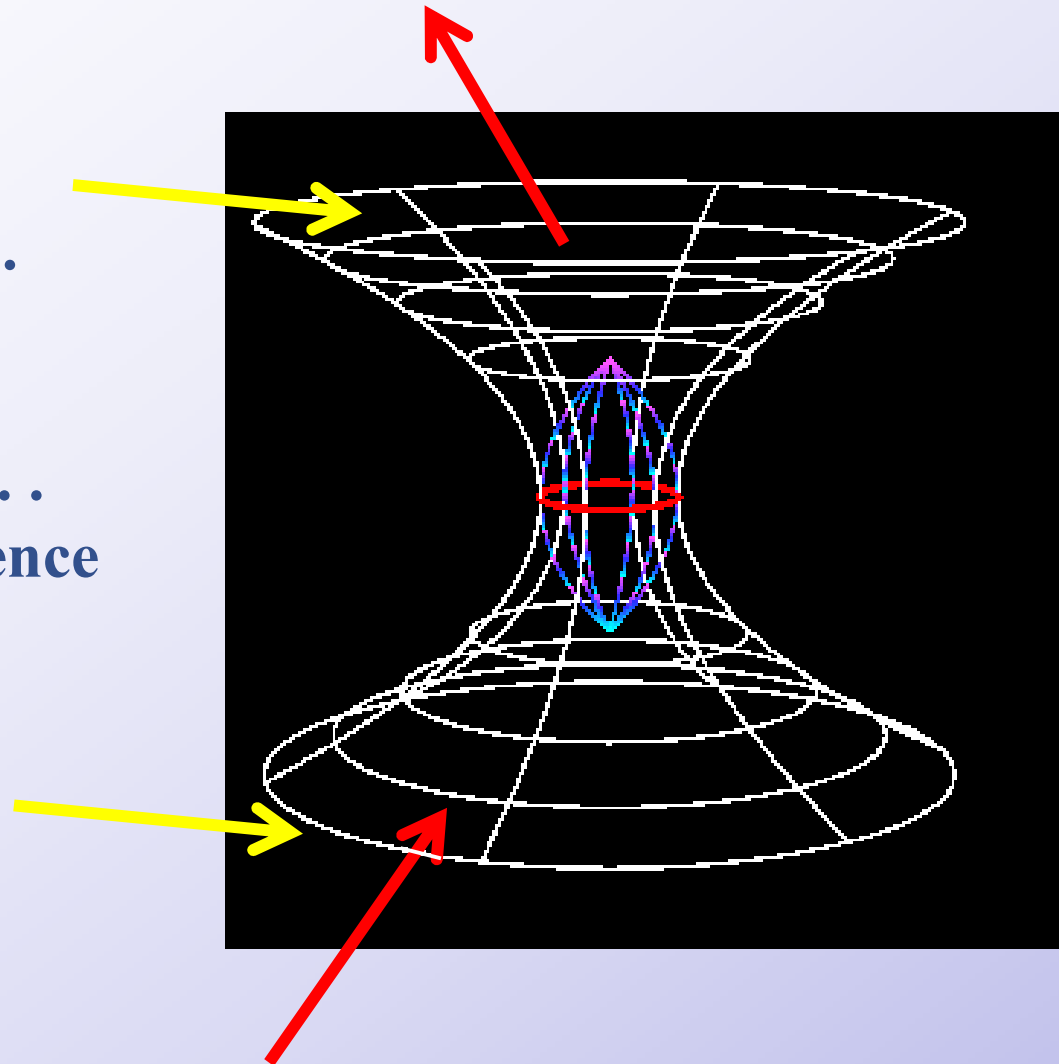


... wormholes ...

... black hole here ...
... nothing comes out ...

... great for Star Trek ...
... but not really for science
just yet ... !

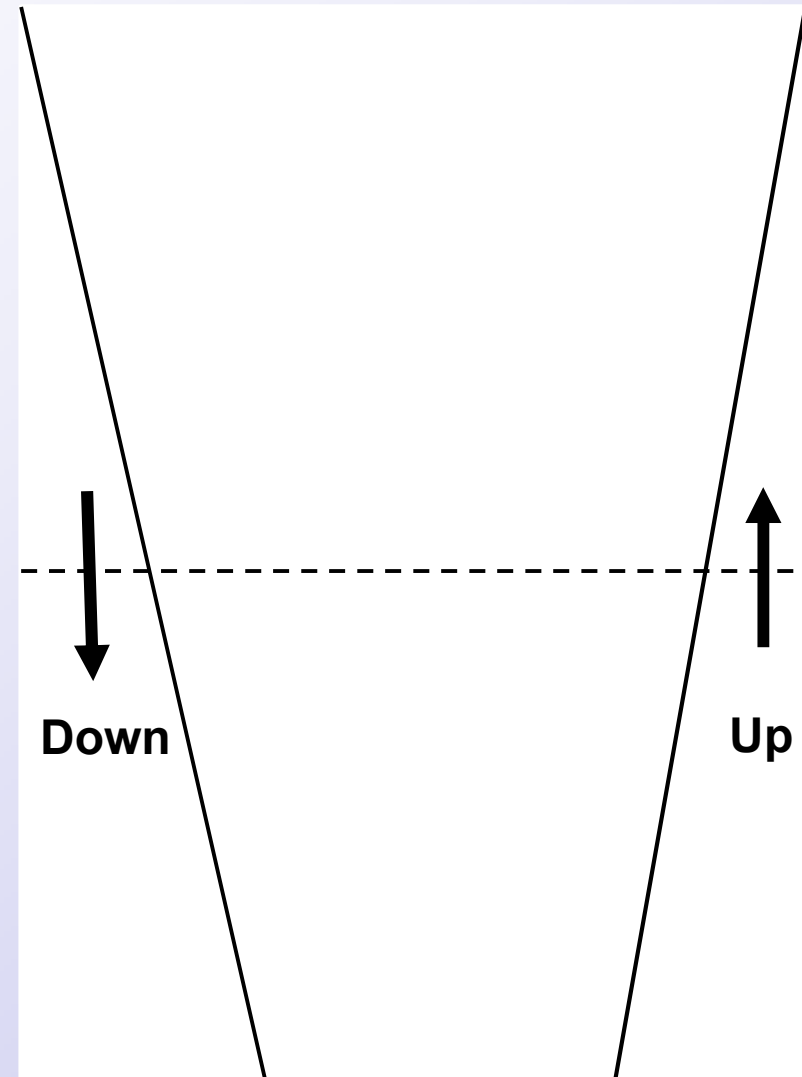
... white hole here ...
... nothing goes in ... !





... why ...

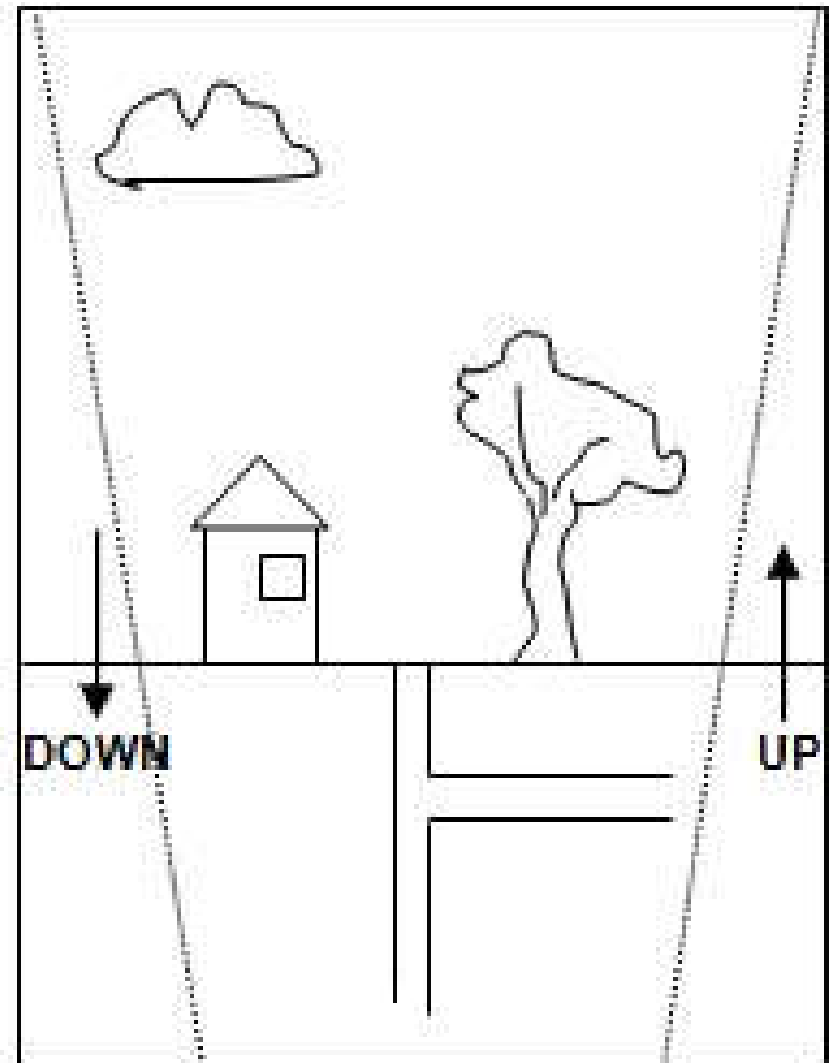
... don't I fall off the Earth ... ?
... you can understand gravity
by just knowing what's UP and
what's DOWN ...
... works really well with little
children ...
... and they will learn to do some
art as well !





... why don't I fall off the Earth ... ?

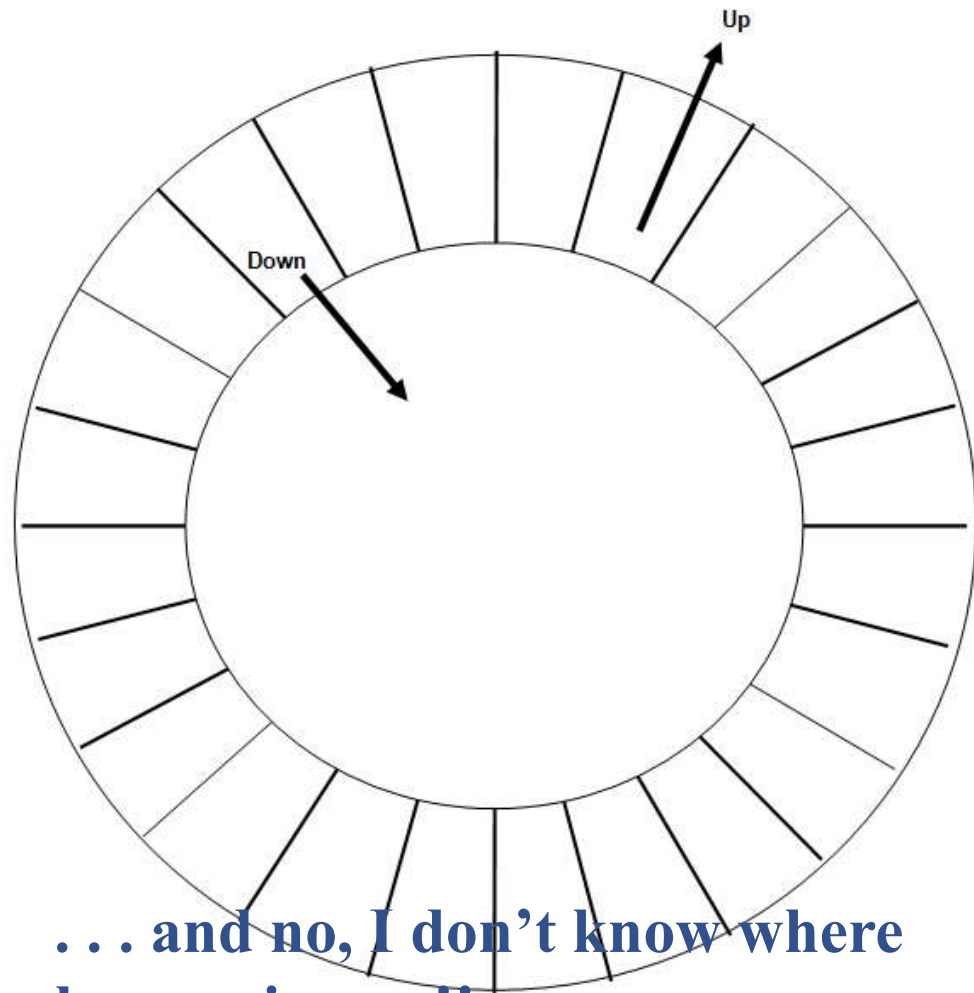
... young children draw
on the sheet what is UP
and what is DOWN and
make a picture ...
... cut along the dotted
line ...
... and ...





... making an Earth ...

... lay each segment on
the ground as shown ...
... and it becomes clear
that **DOWN** is always in
the same direction ...
... towards the centre ...
... and **UP** is always away
from the centre ...
... that's why I don't fall
off the Earth ...
... without mentioning
gravity at all ... !



... and no, I don't know where
heaven is ... !!



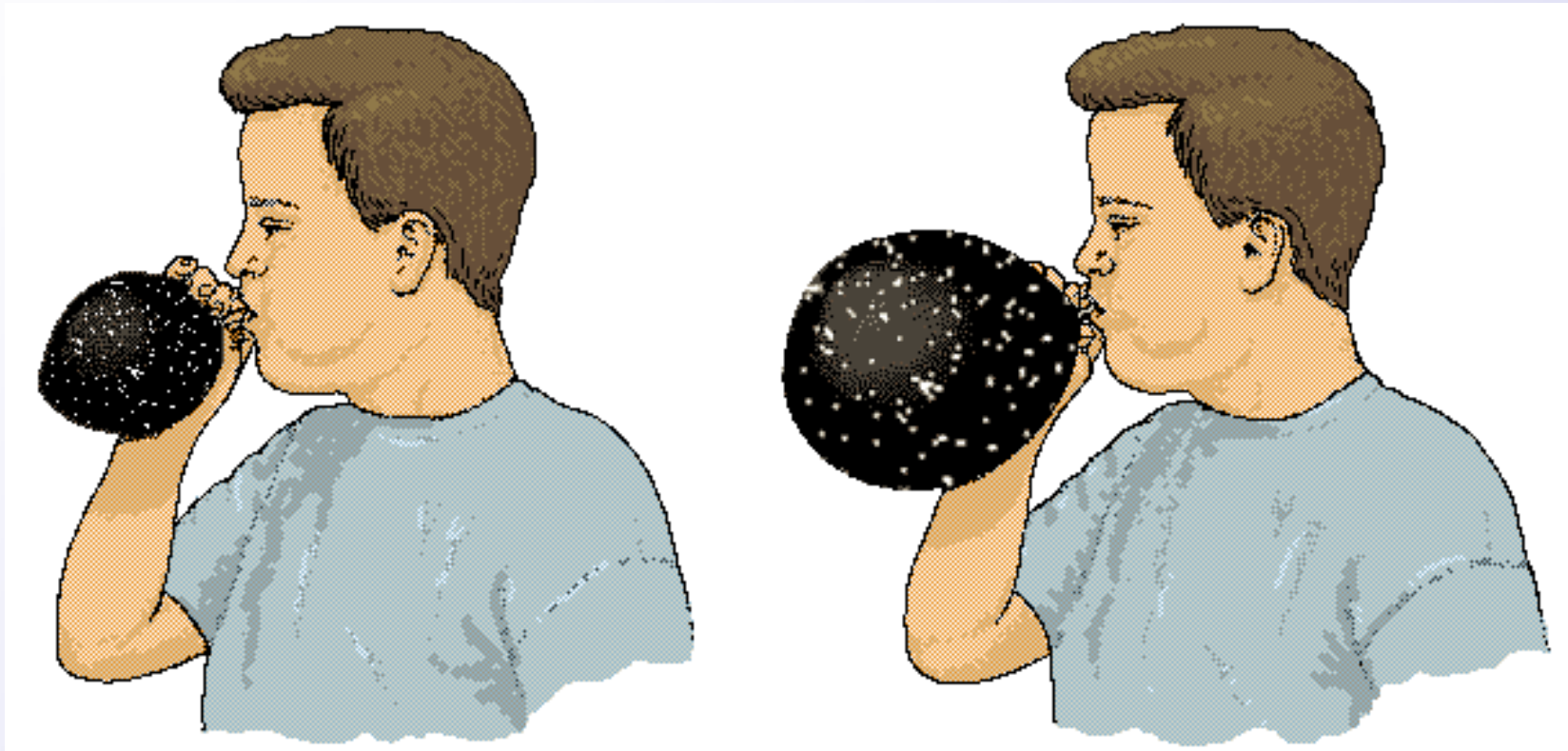
... expanding Universe ...

... well the balloon really only shows that no matter where you are everything moves away from you ...
... don't draw dots on the balloon ...
... the galaxies don't expand in proportion ...!
... stick on jolly dots ...



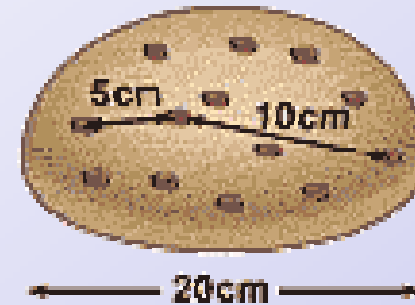


... expanding Universe ...



... NASA view ... !

... NASA uses bread dough
with currants in it ...
... but here the currants just
get further apart ... !
... they don't get bigger ...
... this all usually leads to
the BB theory ...
... and all these analogies'
accompanying problems ... !

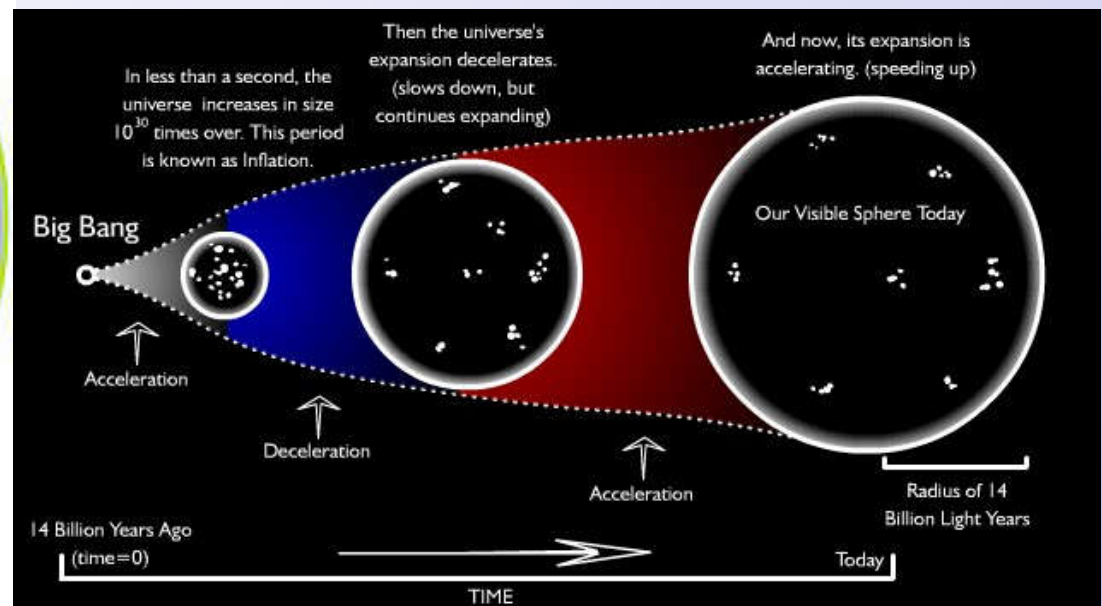
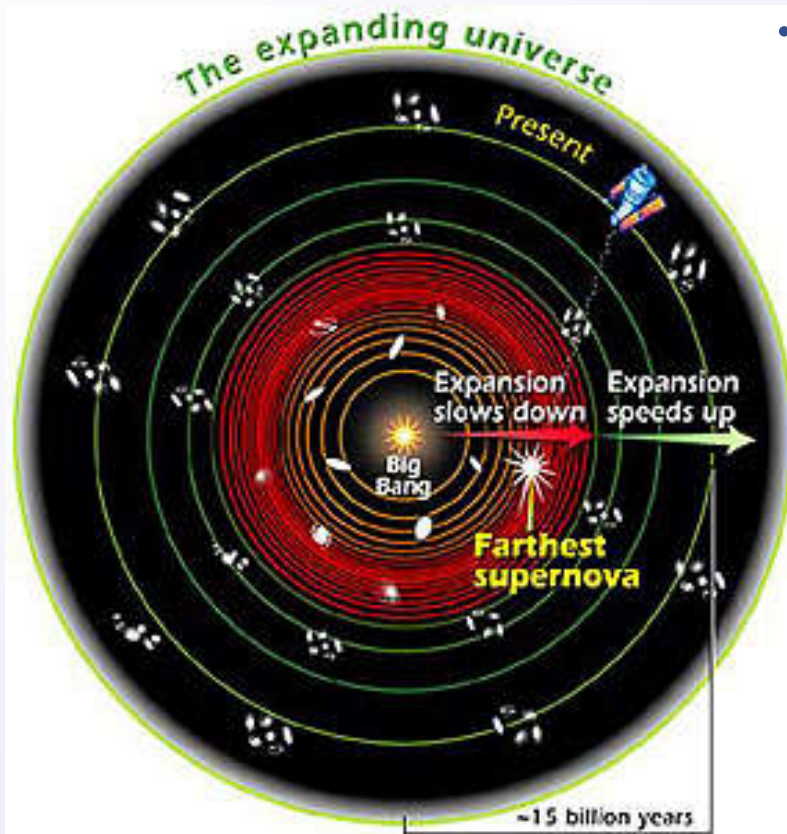


... big bang ...

... there are many illustrations ...

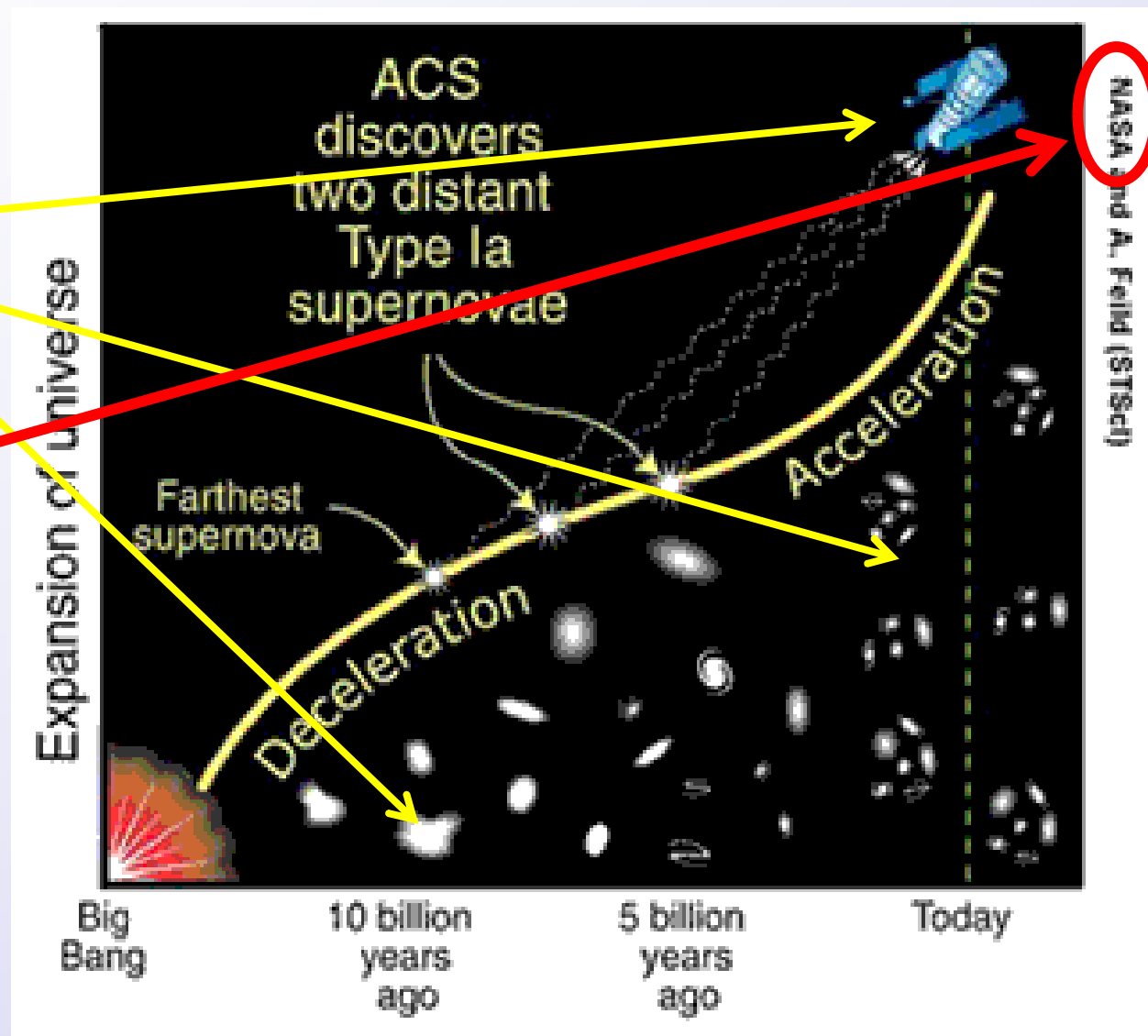
... most are poor ...

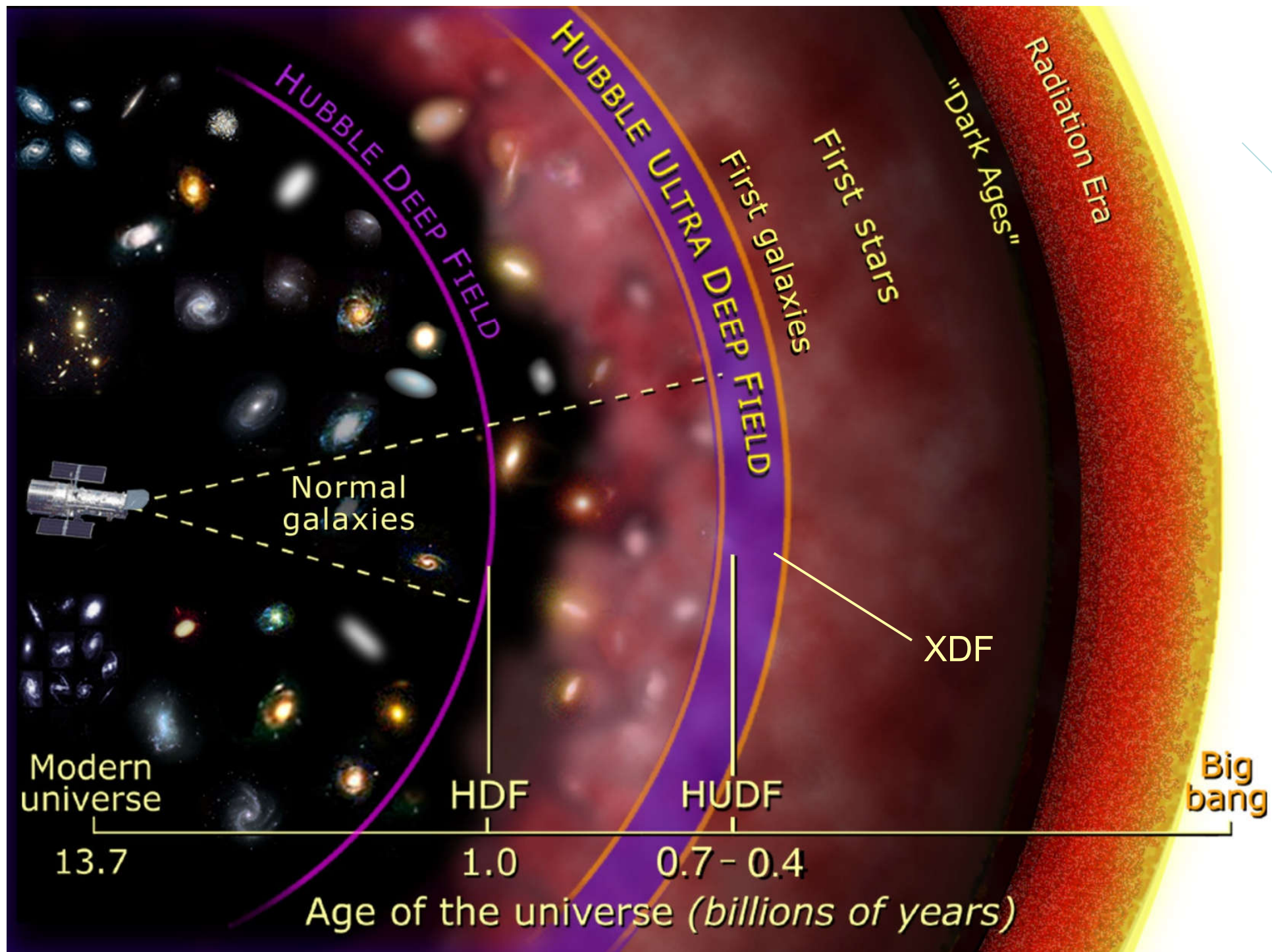
... some are really awful ...!



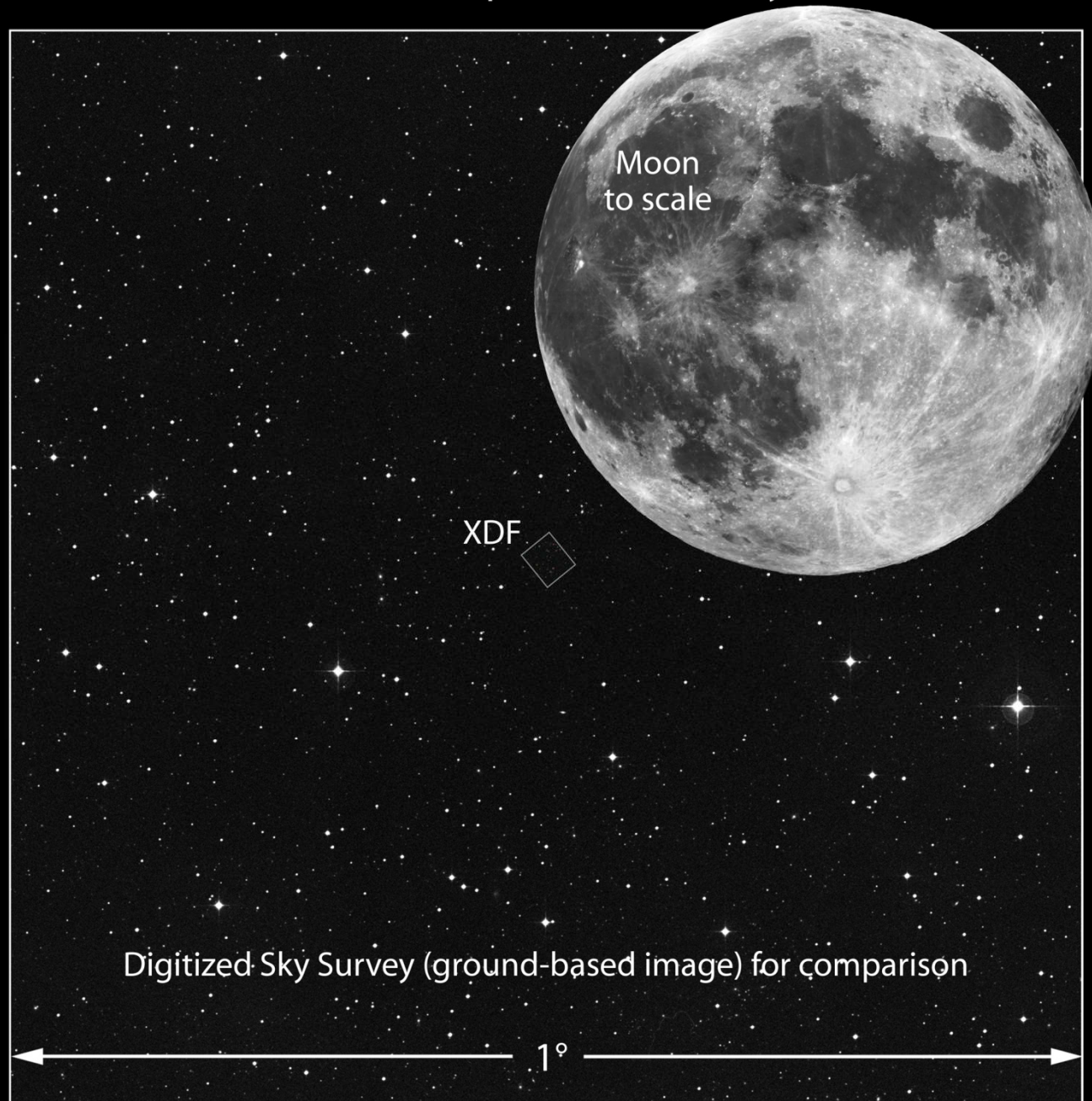
... even worse ... !

... ??????? ...
 ... ??????? ...
 ... ??????? ...
 ... !!!!!!!! ...

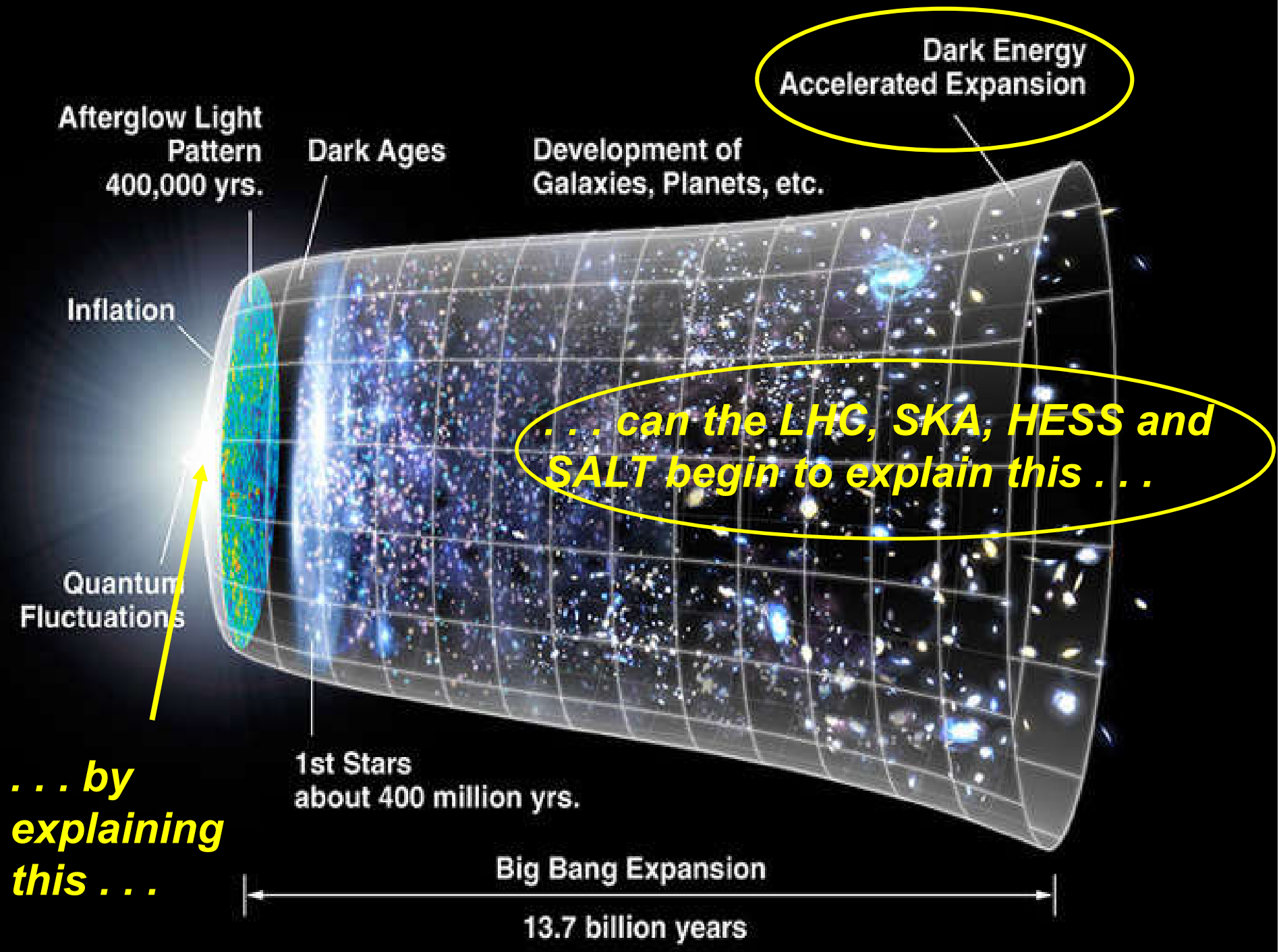




Size of Hubble eXtreme Deep Field on the Sky



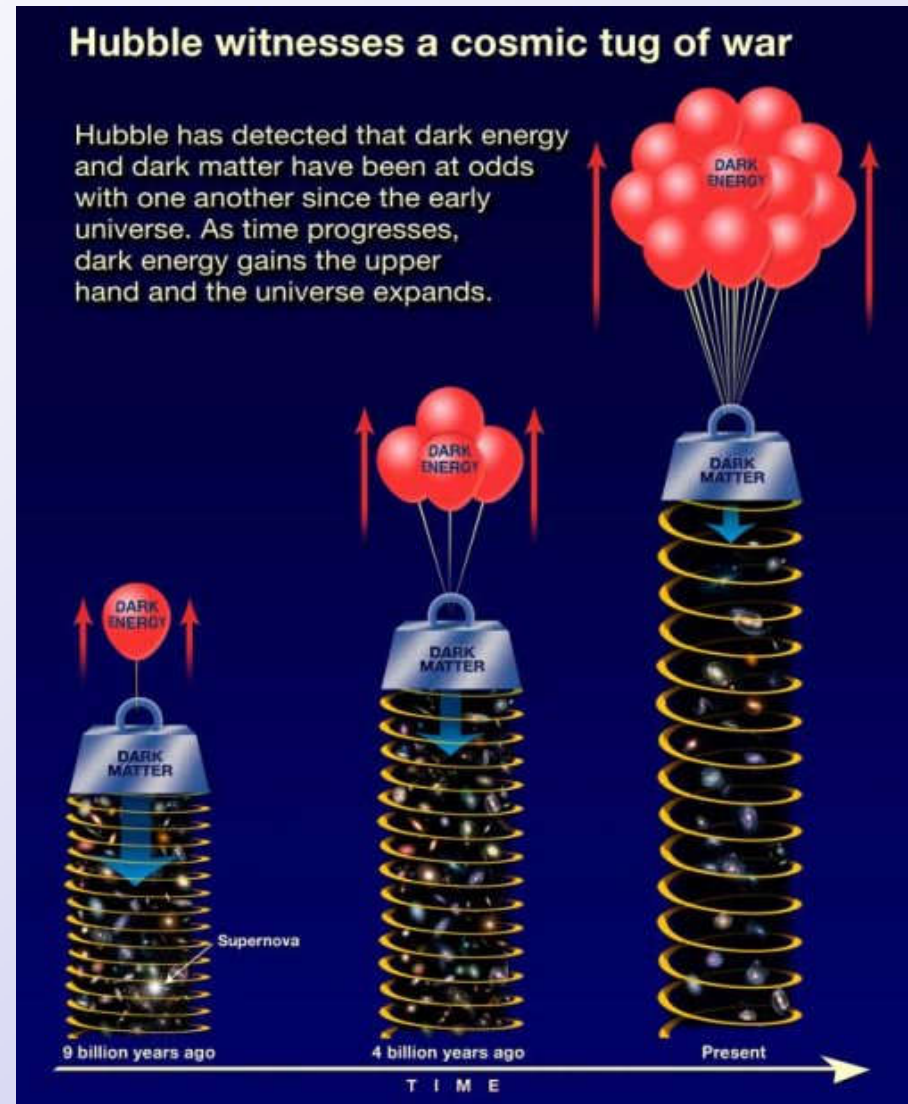






... DM vs DE ...

... not a good analogy ...
... but it sort works if you
just look at it by way of the
forces acting ...
... early U DM dominates ...
... about 4 GY ago there was
a sort of equilibrium ...
... after which DE dominates
the U ...





... higgsteria ...

... events at CERN on 4 July certainly created this ... !
... had the long sought for Higgs Boson really been
discovered ...
... but why hadn't it been found before ... ?
... not enough energy ...
... to reveal the detail needed a lot of energy is needed ...
... to really smash matter into the tiniest fragments ...
... maybe what follows will help explain this most
remarkable of achievements ...



... Oops – car crash ...



... debris at speed ...

... sometimes speeds are high
enough so that big pieces ...
... like engines and ...
... gearboxes ...
... are thrown onto the road ...



... more speed ...

... at even higher speeds ...
... even smaller pieces
are thrown out ...





... even higher speeds ...

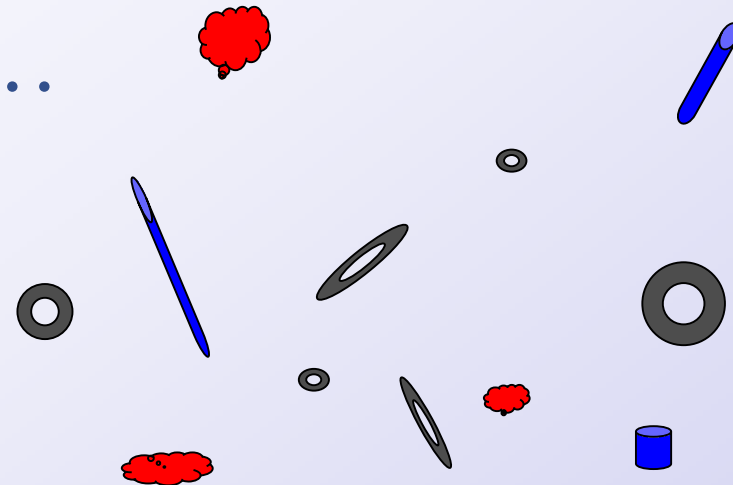
... we get even smaller pieces ...

... washers ...

... paint flakes ...

... pins ...

... and more ...

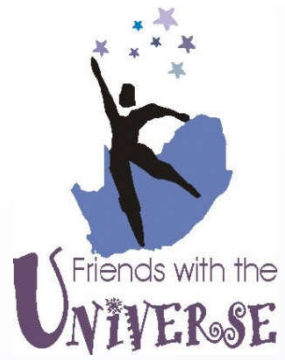


... but the main thing is that the higher the speed, the more the energy, and so ...

... the smaller the pieces ... more detail ...

... LHC doesn't use cars ... !!

... it uses protons travelling at $0.9999999991c$...



... fields ...





... fields in physics ...

... we talk of electric, magnetic, gravitational and other fields ...

... but what are they ... ?

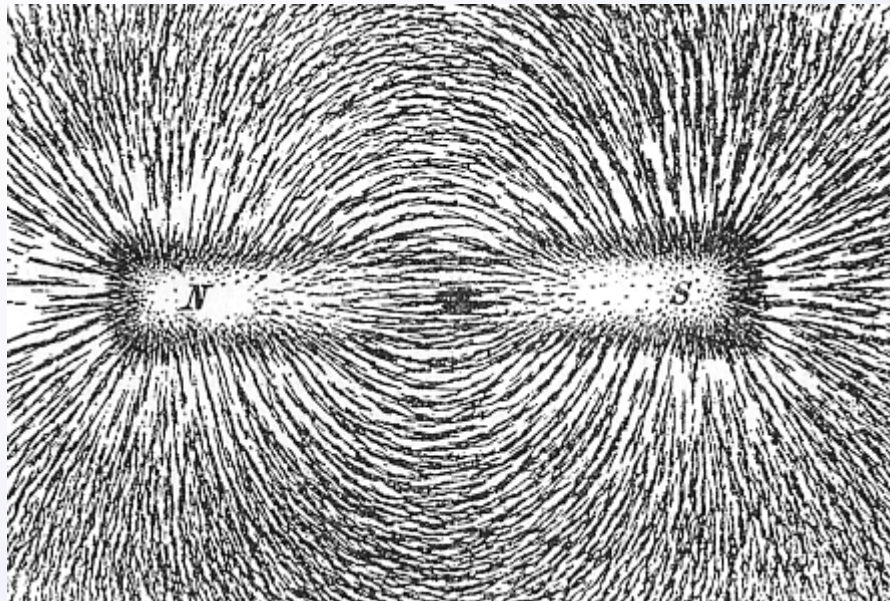
... how do scientists *see* fields ... ?

... they see many different types, but can all be put into a few *types* ...

... scalar, vector and tensor being the principle ones ...



... magnetic field ...



... this is arguably one of the most well known fields ...

... sprinkle iron filings on some paper covering a magnet and you get a visible representation of the magnetic field lines ...

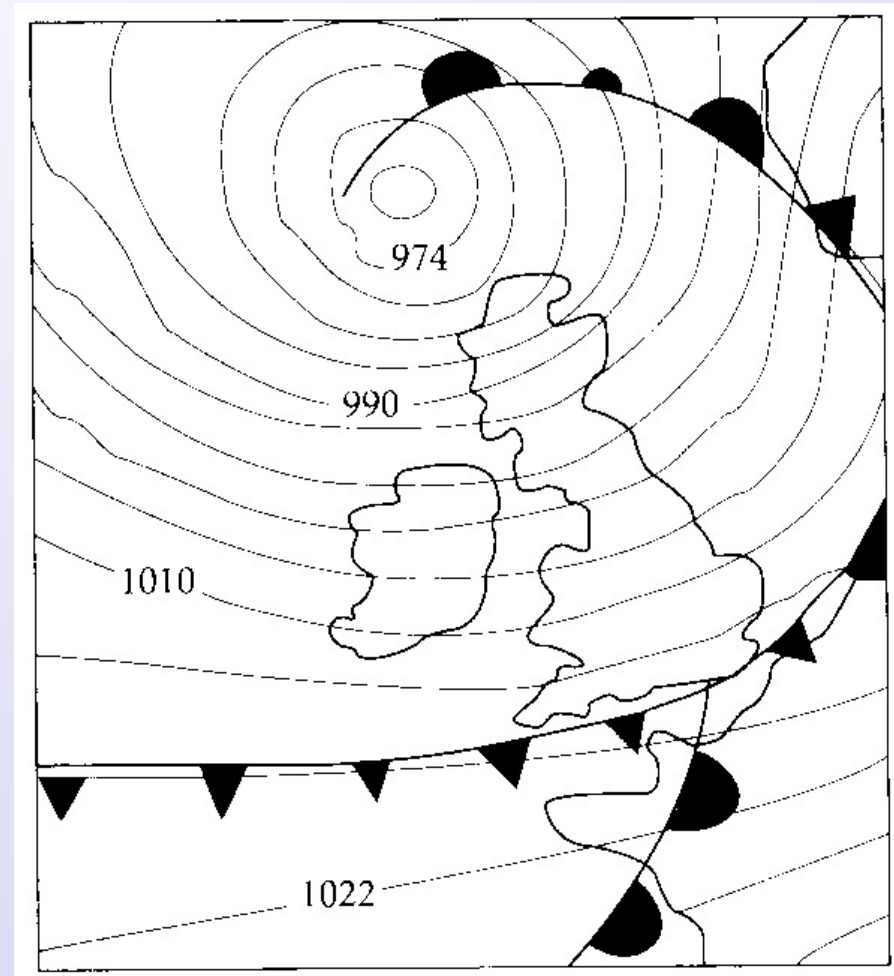
... each point on the piece of paper shows the strength and the direction of the field ...

... this is called a vector field, since each point requires two values to describe it ...



... scalar fields ...

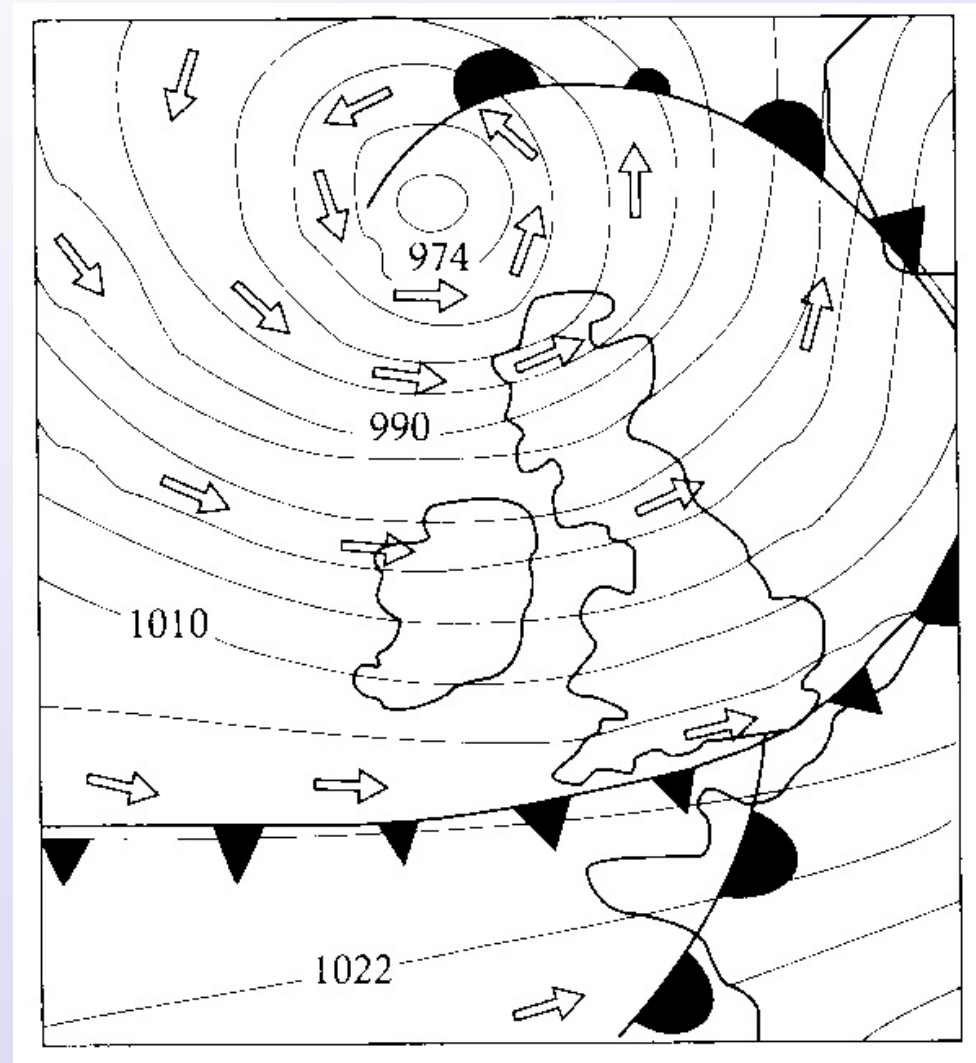
... a weather chart ...
... the lines are isobars ...
... lines of equal pressure ...
... pressure is a scalar quantity
as it requires only one value to
describe it ...
... the familiar weather chart
represents a scalar field ...





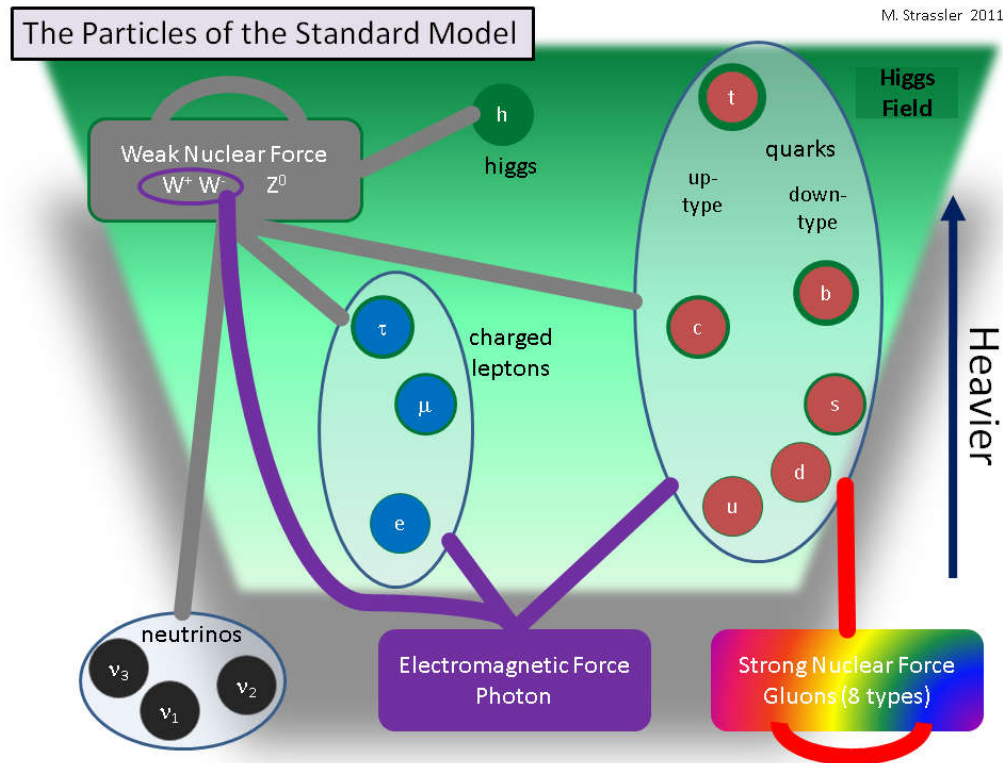
... vector fields ...

... but regions of differing pressures ...
... means wind ...
... wind needs two values to describe each point ...
... speed and direction ...
... so this, like the magnetic field, is a vector field ...
... arrows should be different lengths for different speeds ...



... Higgs field ...

... briefly ...!



... this is a scalar field that imparts mass to particles interacting with it ...

... particles that don't interact with the Higgs field remain massless and travel at the speed of light ...

... more interaction means more mass and less speed ...



... Higgs Field analogy ...

- ... there are many analogies to explain this, including ...
- ... one where particles travel through “treacle” ...
- ... the most popular one seems to be a room filled with people as the Higgs field ...
- ... John Ellis at CERN uses snow, skiers and T-shirt ...
- ... but I have one serious criticism or problem with all of these ...
- ... they confuse *mass gain* with *resistance to motion* ...
- ... I use iron filings on a plastic tray as mine ...



... honey and treacle ...

... the Higgs field has also been described as an all-pervading *cosmic treacle* ...

... a kind of sticky syrup spread throughout the universe ...

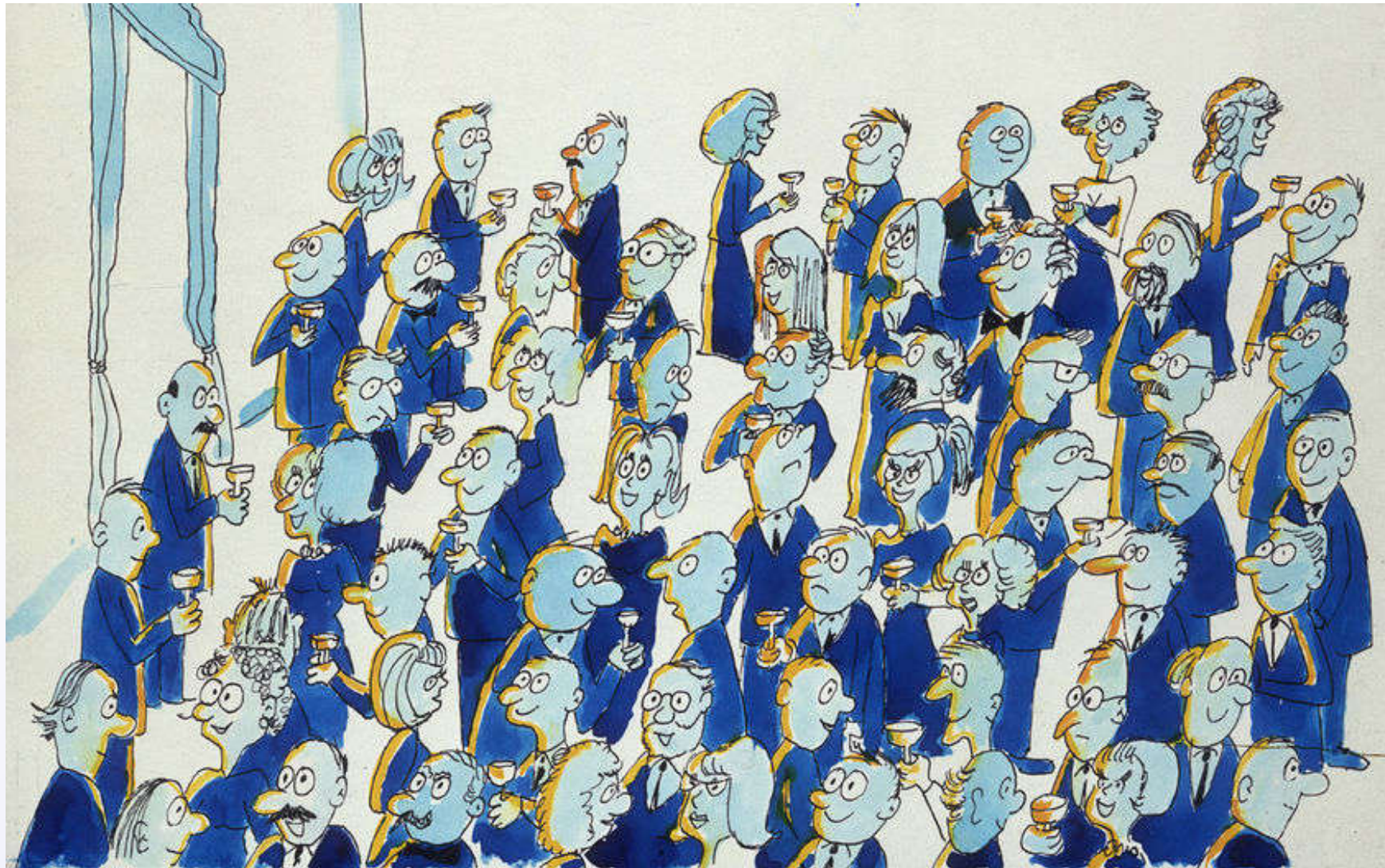
... particles moving through the treacle stick to it, slow down, lose energy, and become heavier ...

... heavier ... ?

... the particle doesn't gain mass ... !

... kills this one for me ...

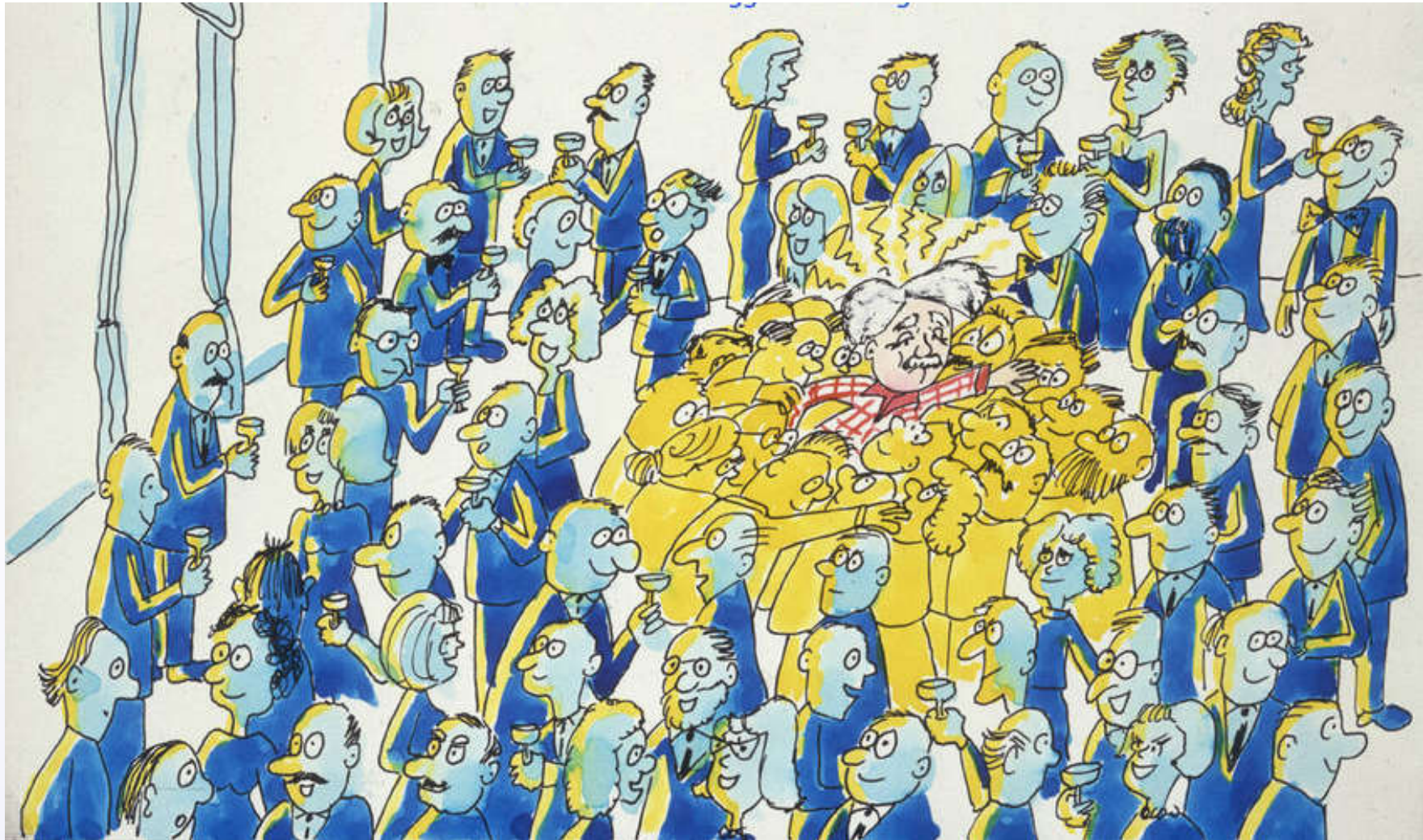




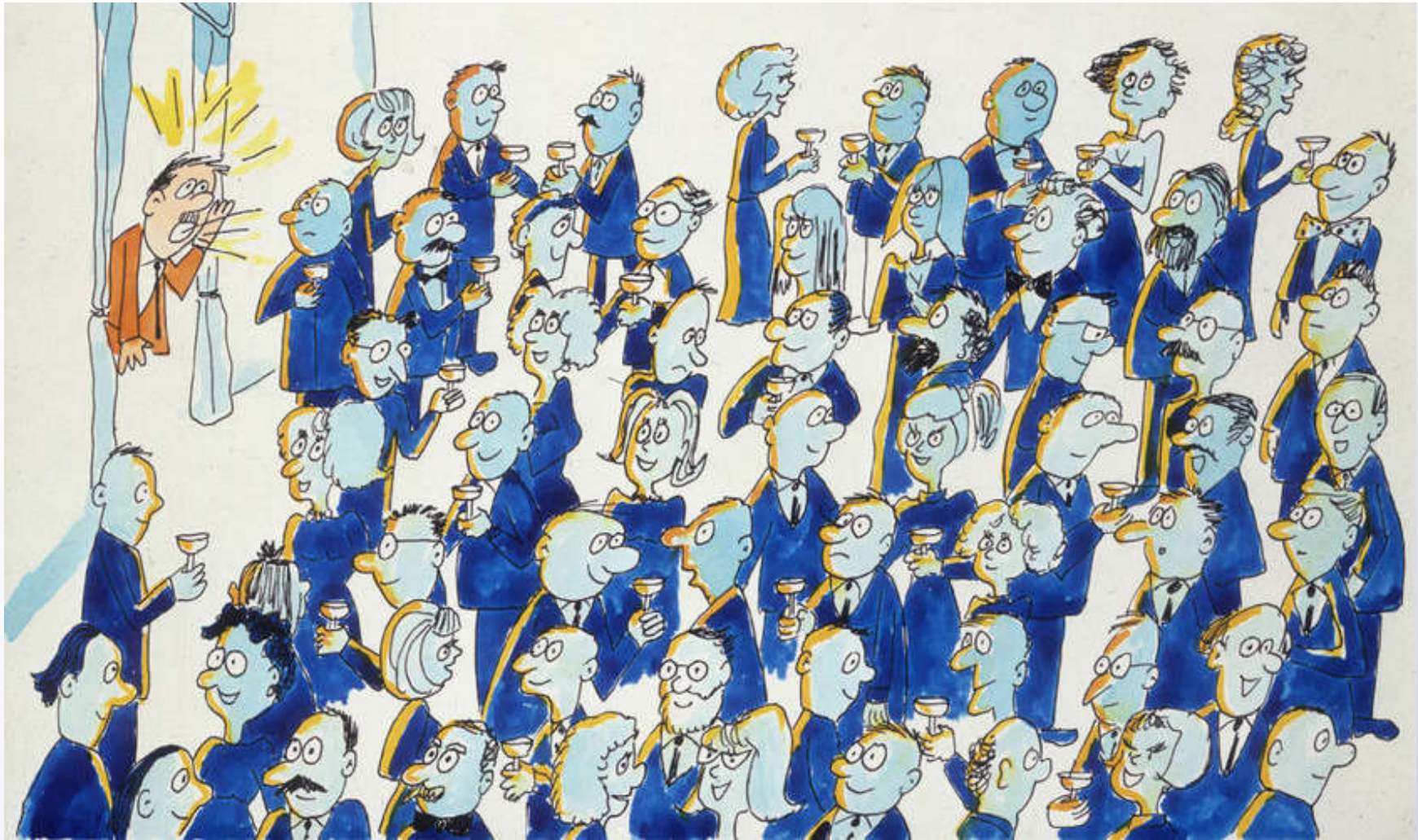
... the universe with its Higgs field corresponds to a room full of physicists ...



... now Albert Einstein enters the room (elementary particle) and attracts a couple of admirers as he crosses the room ...
... I've seen variations of this with Margaret Thatcher, Marilyn Monroe, Justin Bieber and a naked woman ... !



... thereby he experiences a resistance in his movement that can be interpreted as inertia - in other words, he acquires mass ...
... in a similar way an elementary particle acquires mass as it passes through the Higgs field ...
... does Einstein gain mass ... ?

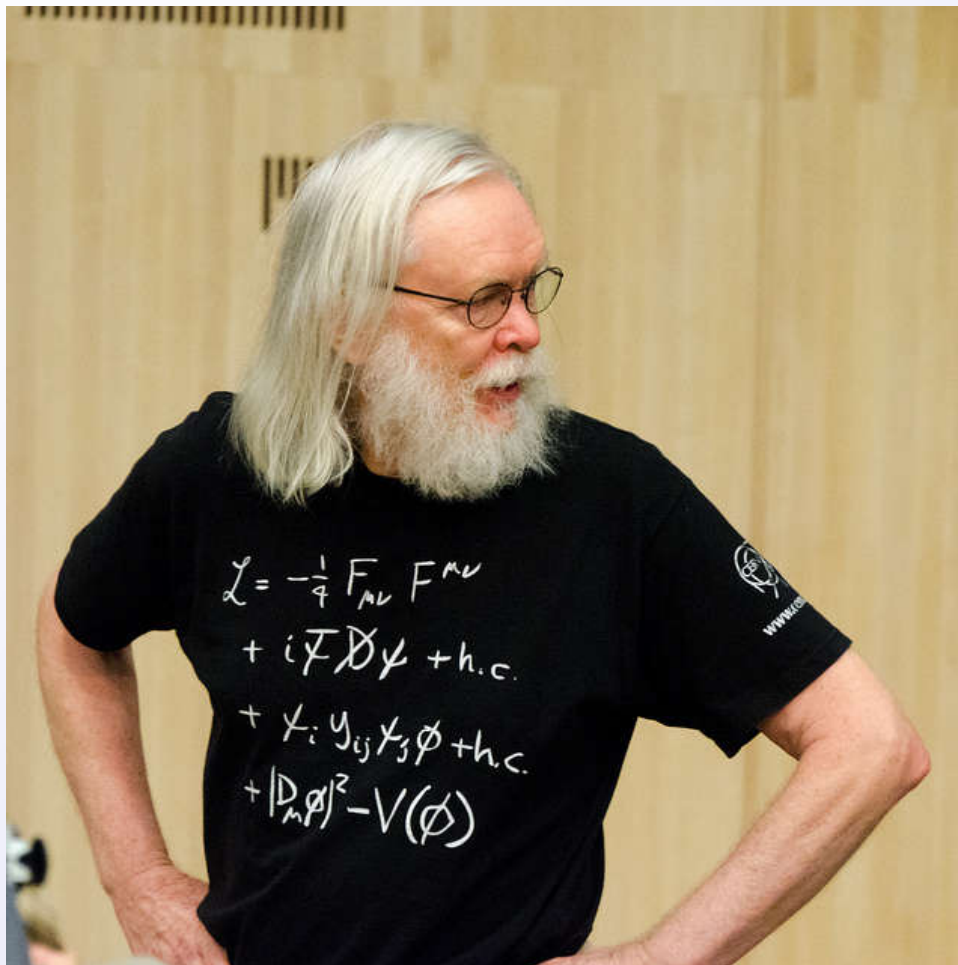


... but it could happen as well that a rumour is spread in the room ...



... as the rumour moves through the room, a group of physicists clumps together - this group corresponds to a Higgs particle ...

... John Ellis ...



... let me give you an analogy...

... imagine an infinite field of snow extending throughout all of space, flat, featureless, going in all directions ...

... ah, maybe the middle of Siberia ...

... now imagine that you are trying to cross this field of snow ...



... snow – skiing ...



... so maybe you are a skier, and you skim across the top ...

... that's like a particle that does not interact with the Higgs field ...

... it doesn't sink into the snow ...

... it goes very fast ...

... it's like a particle with no mass, traveling at the speed of light ...



... snowshoes ...



... but maybe you've only got snowshoes ...

... in that case, you sink into the Higgs "snowfield" ...

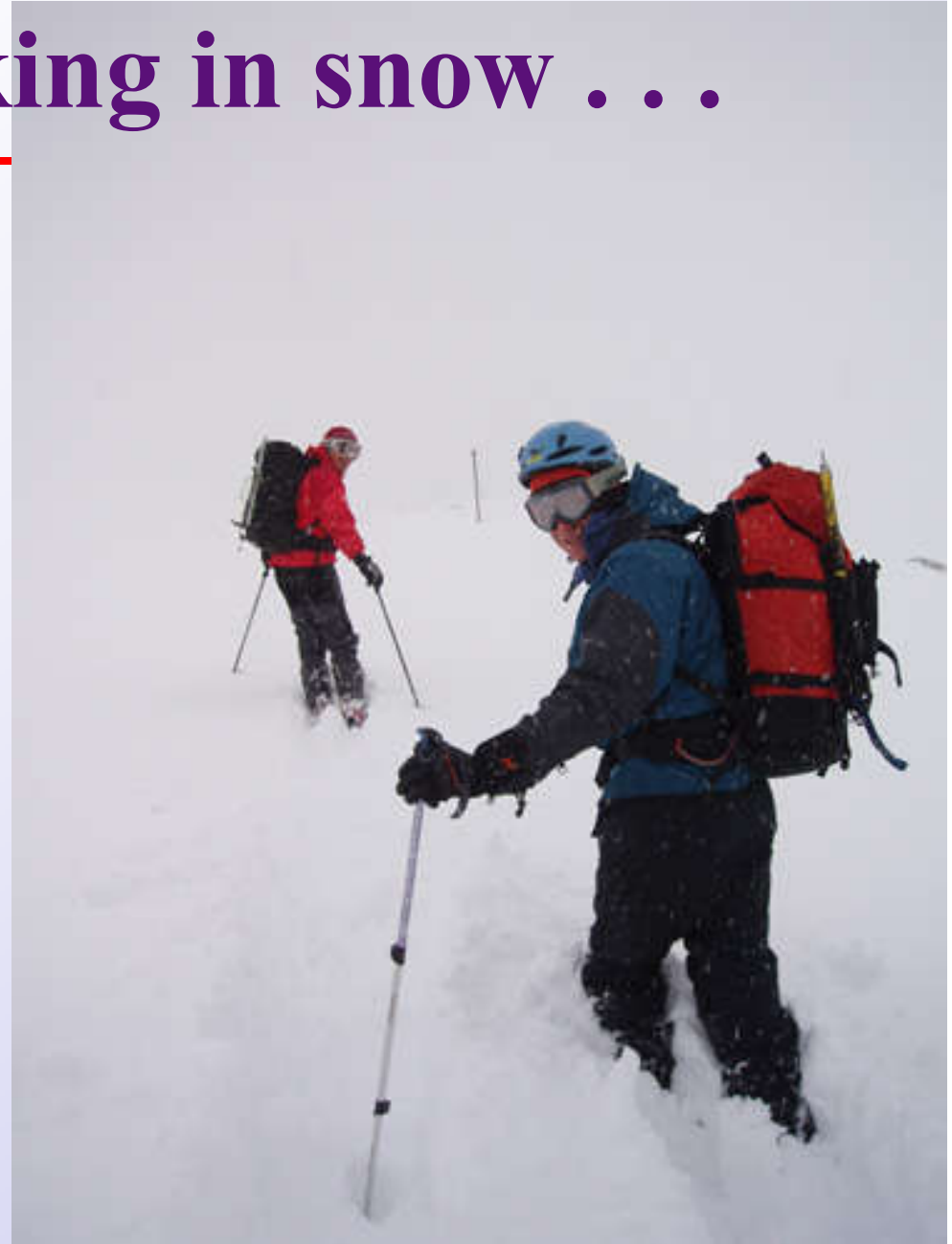
... you've got less speed than the skier, and so less than the speed of light ...

... that's like a particle with mass because you are connecting, interacting with that Higgs "snowfield" ...



... walking in snow ...

... and then finally...
... if you've just got boots
on, then you sink deeply
into the snow ...
... you go very slowly, and
that's like a particle with a
big mass ...
... OK, but the people
don't gain mass ... !





... Higgs Boson ...



... we all know what snow is made out of, right ... ?

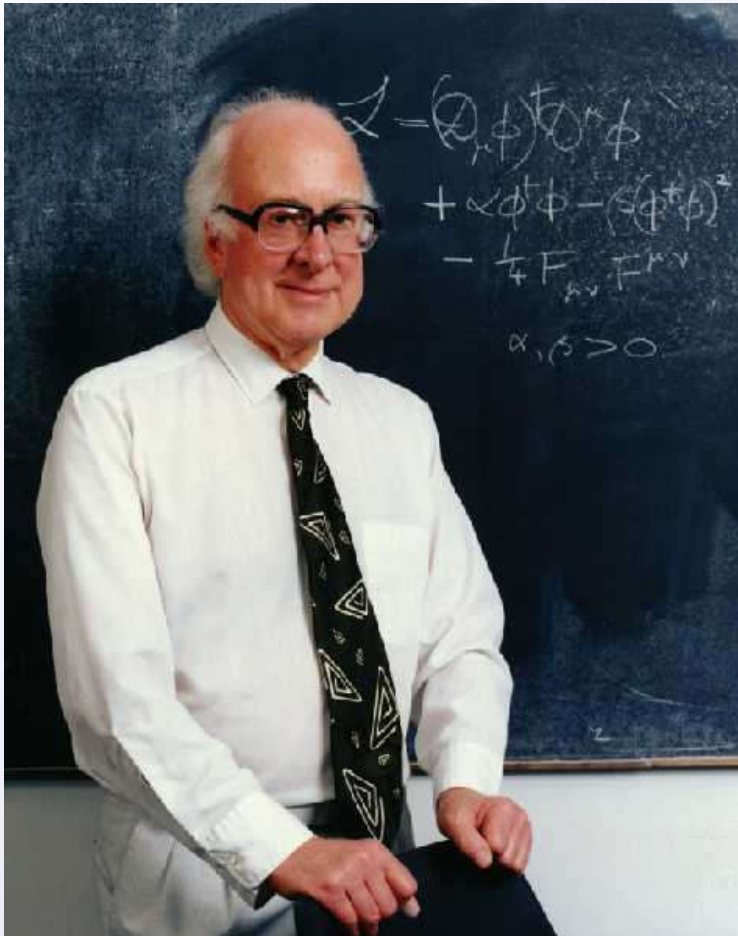
... it's made out of snowflakes ...

... in the same way, this universal Higgs snowfield is made up of little quanta ...

... those quanta are like snowflakes ...

... that's what we call the Higgs Boson ...

... comments ...



... but what Peter Higgs objected to is ...

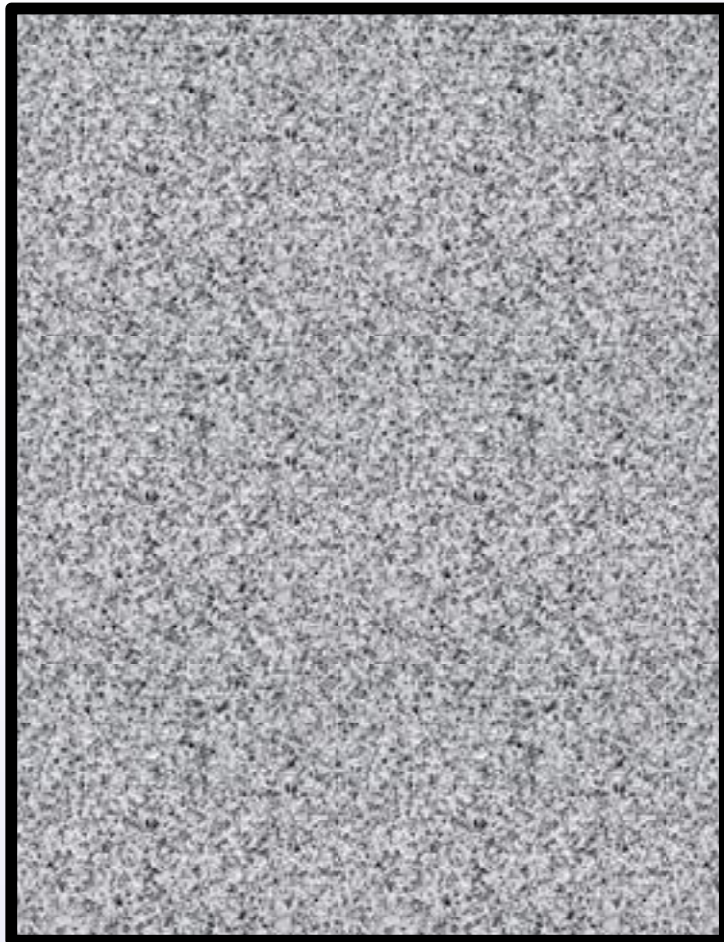
... “when people draw an analogy with dragging something through treacle as that’s a dissipative process” ...

... and he seems to agree with my sentiments ...

... and it applies to snow and crowds of people ...



... my Higgs analogy ...



no magnet



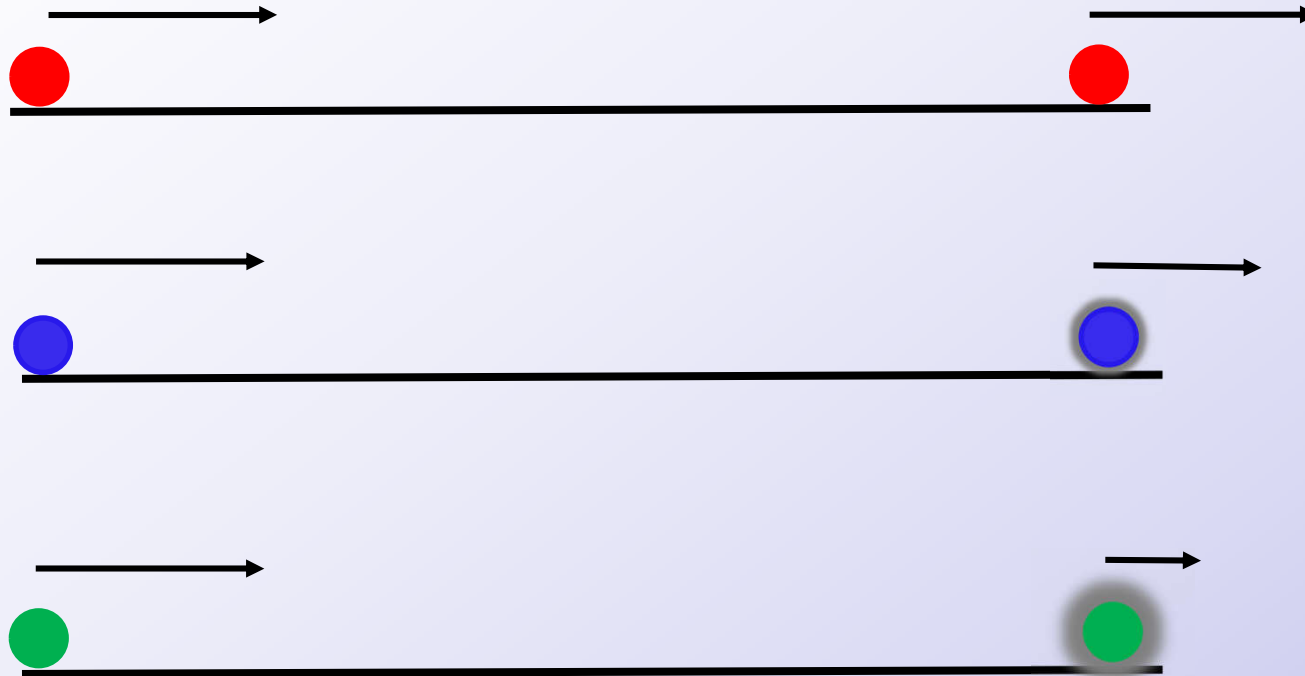
weak magnet



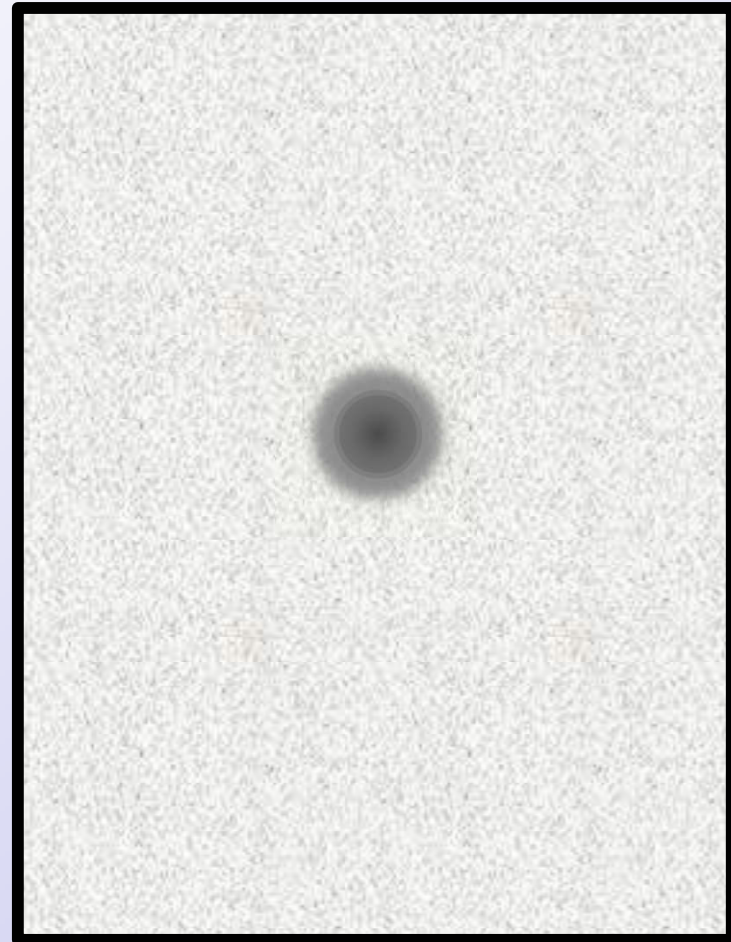
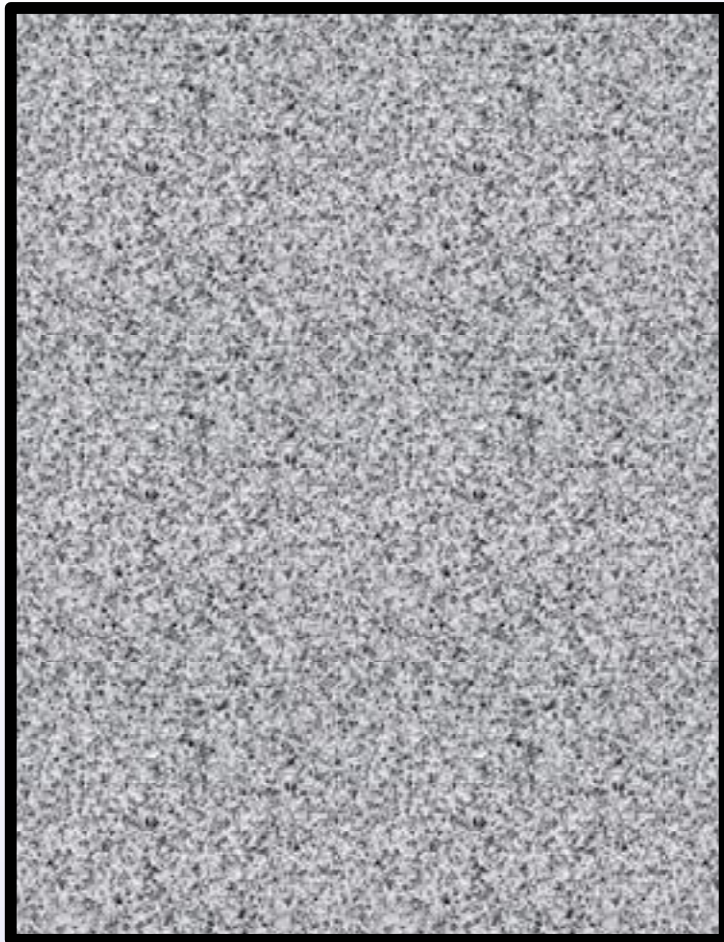
strong magnet



... how it works ...



... Higgs boson ...

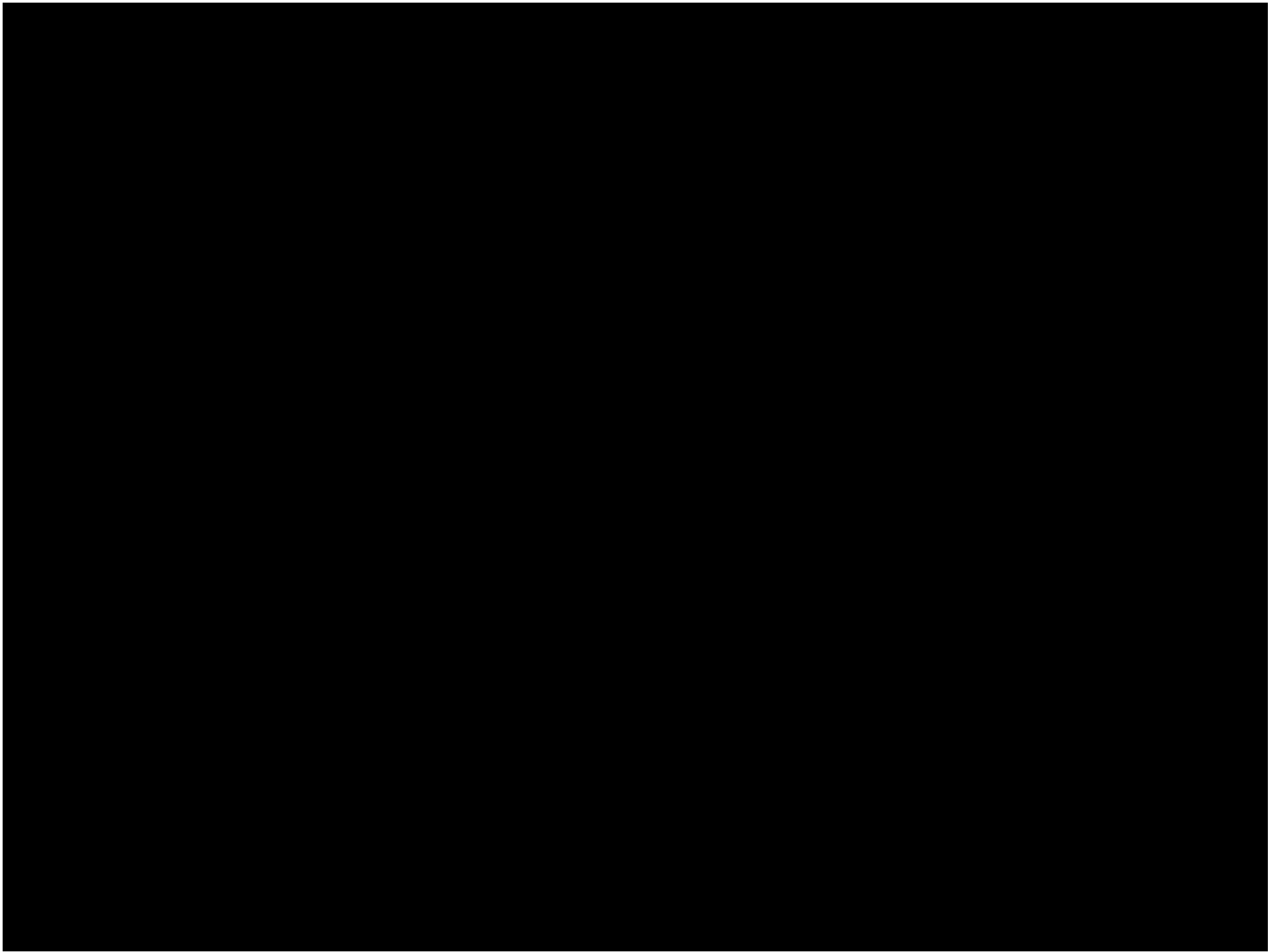




... no analogy ...

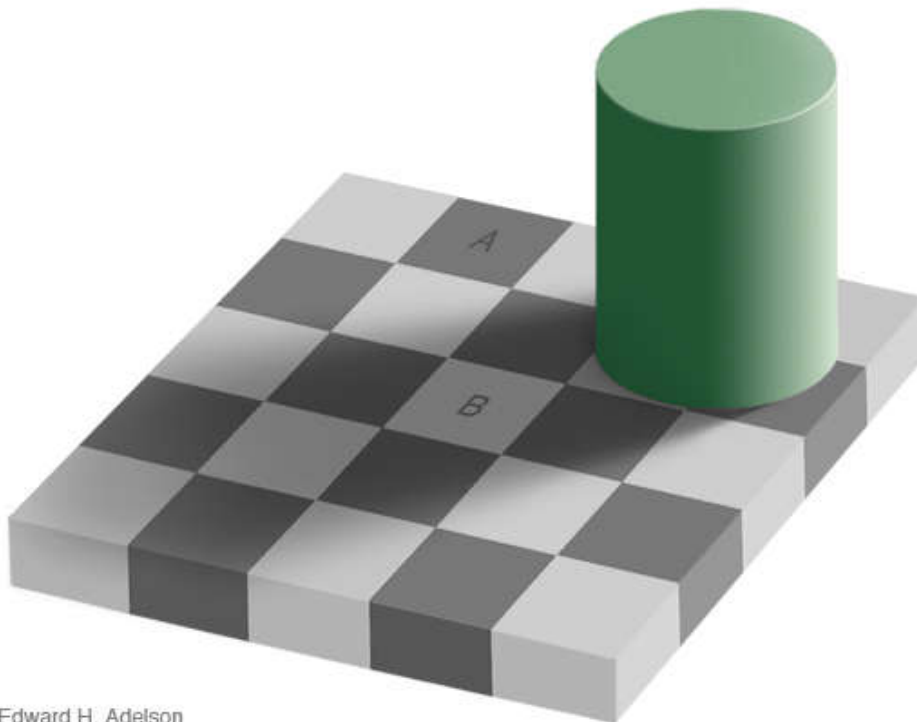
... this is the end ...

Thank you

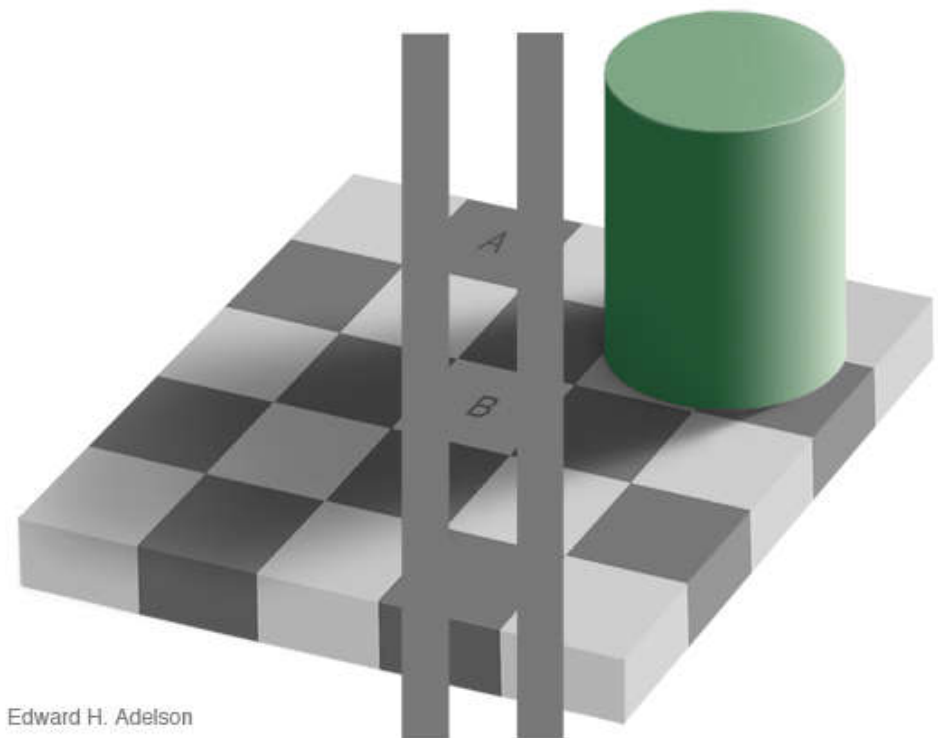


... illusion ...

... is square A the same shade as square B ... ?
... surprised ... ?

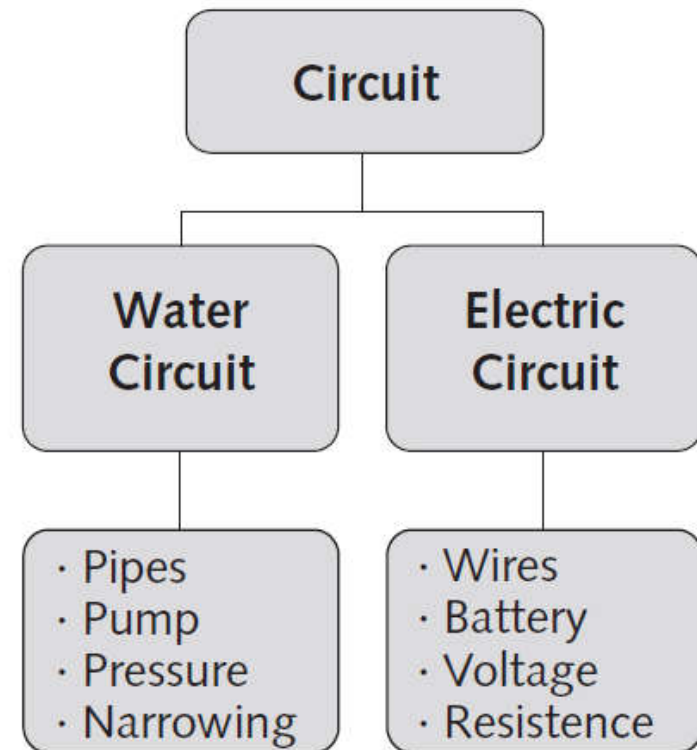
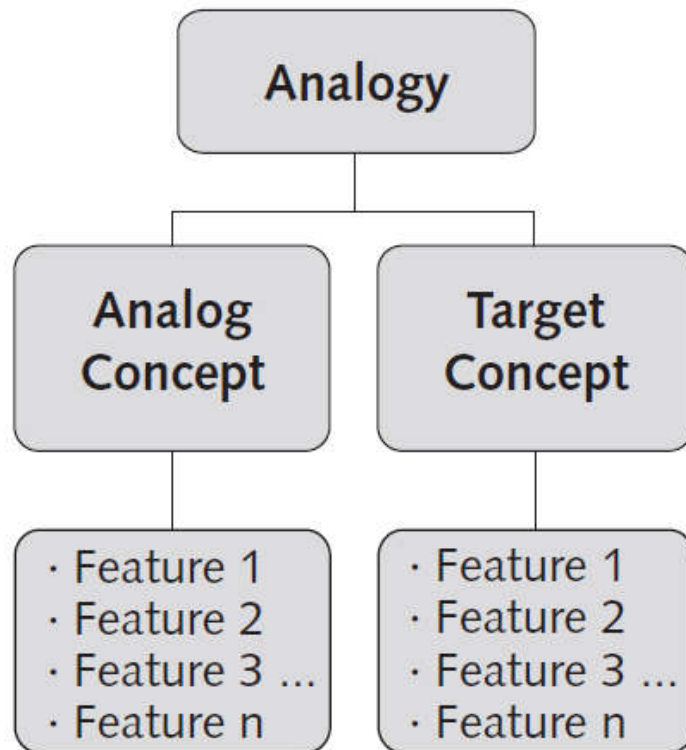


Edward H. Adelson



Edward H. Adelson

... example ...





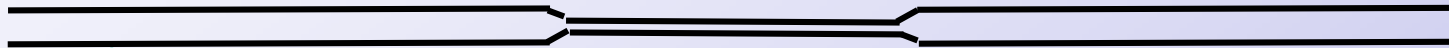
... practical help ...

... here it is easy to think that the water flow is the current in the circuit ...

... do electrons flow through the wires in a circuit like water flows in a pipe ... ?

... I would also get students to blow through a capillary tube and a wide-bore tube to understand what resistance to air/water flow is ...

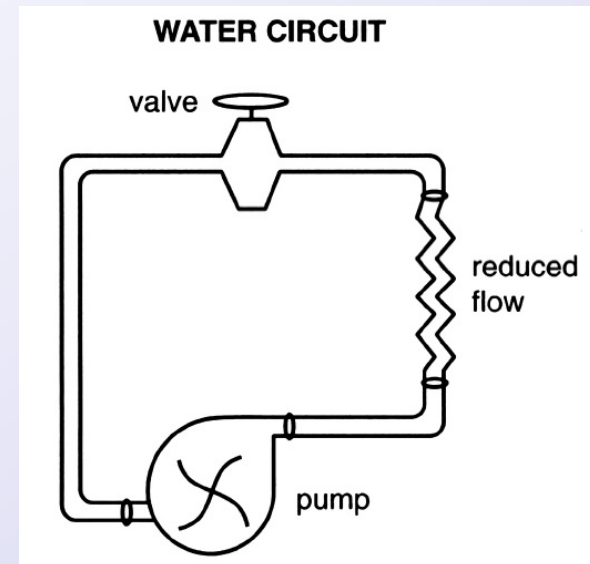
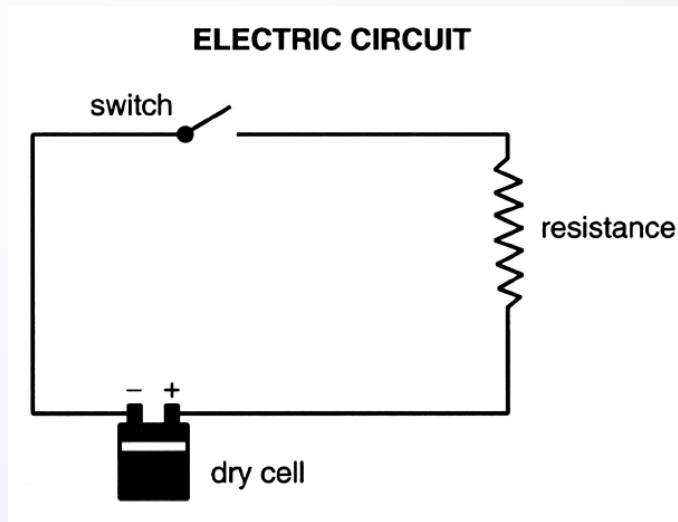
... here is the analogy ...



... the constriction acts as a resistance ...

... but usually this appears as ...

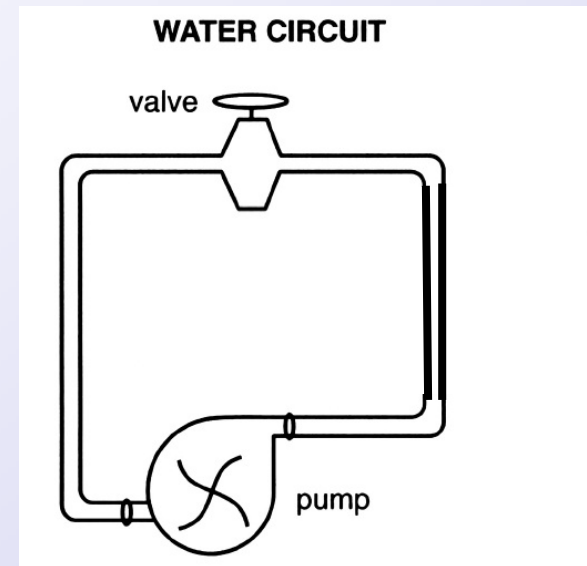
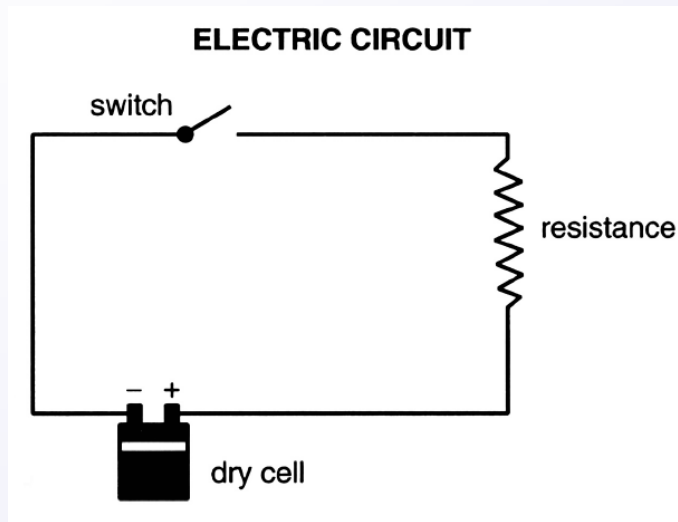
... the analogy ...



- ... notice there is no flow meter or ammeter ...
- ... and no pressure gauge or voltmeter ...
- ... that's good ...
- ... but why a squiggly pipe and not a thin tube ... ?

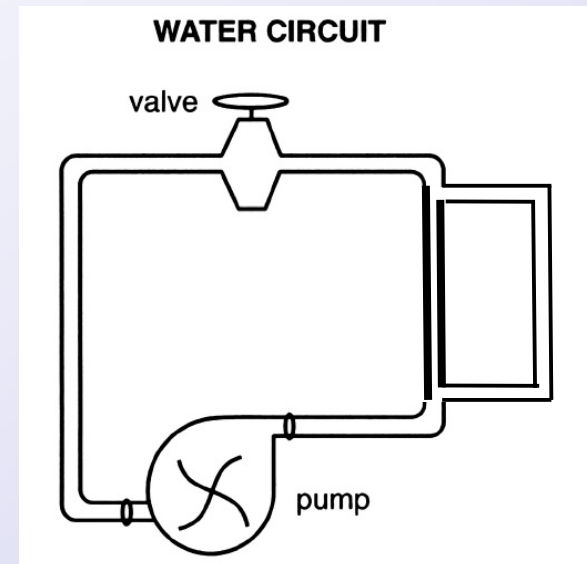
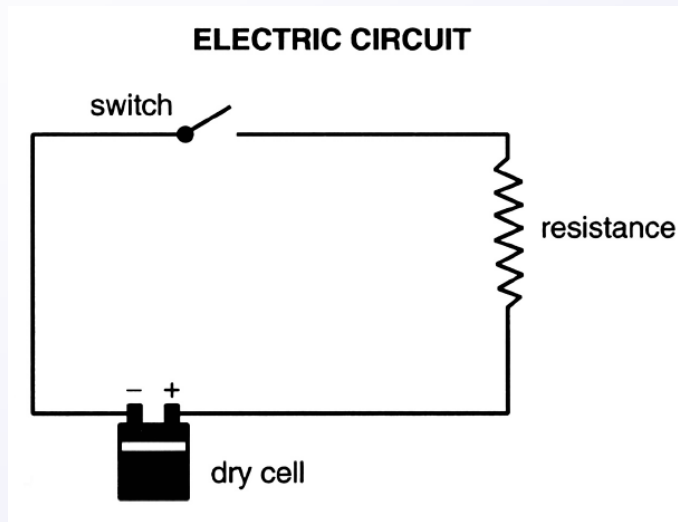


... the analogy + ...

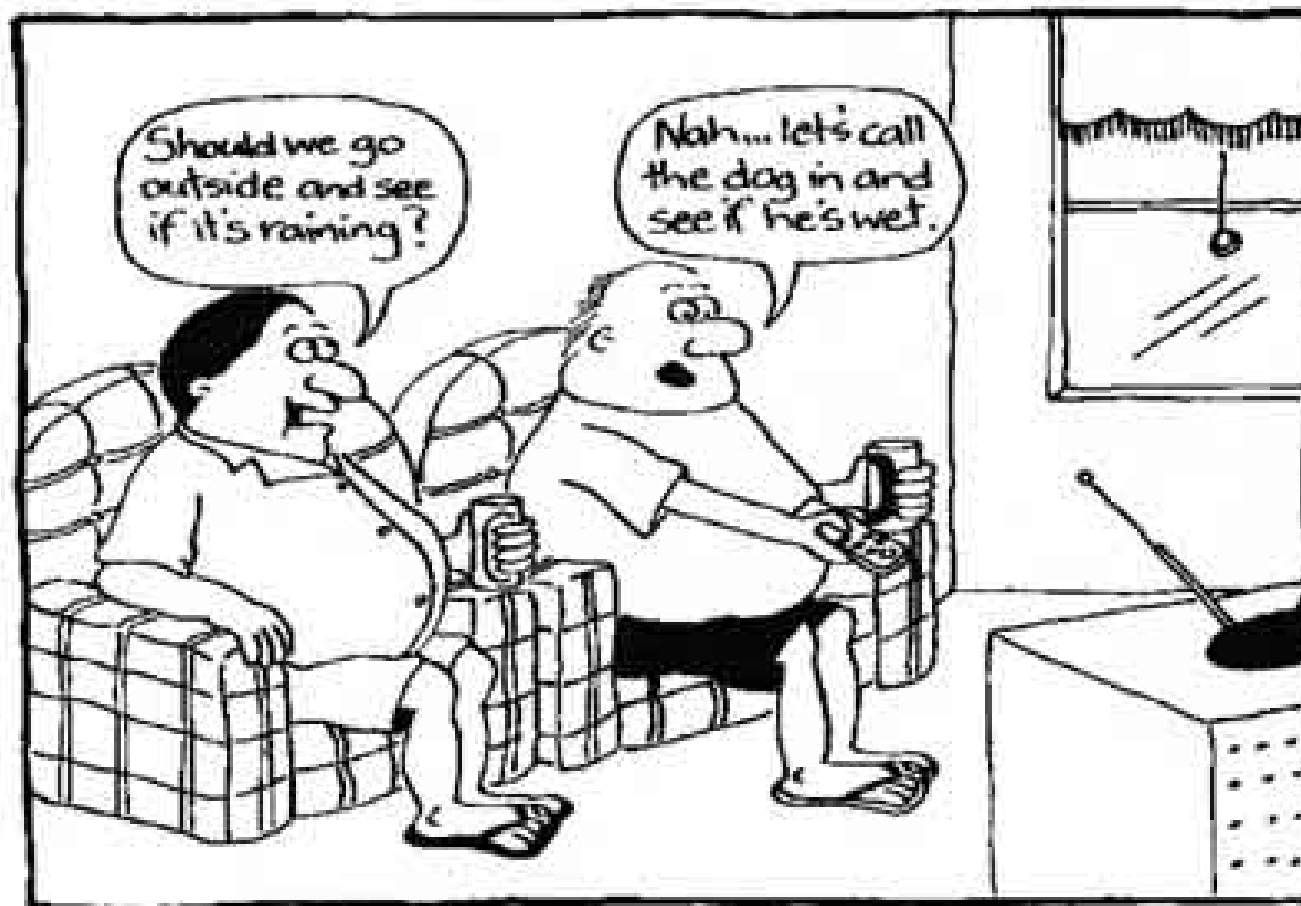


- ... what happens if you narrow the bore of the tube ... ?
- ... does the pump 'work' harder ... ?
- ... does the pressure in the whole system increase ... ?

... the analogy + + ...

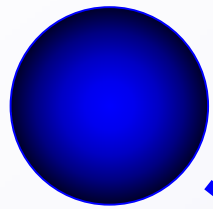


... what now ... ?
... well I guess it sort of works ...
... but now complications arise: pressure etc ...
... the analogy has gone too far ...

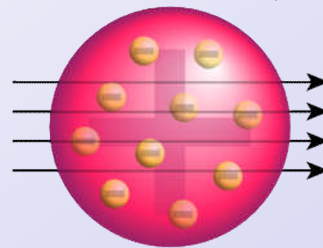


TYPICAL DISCOURSE BETWEEN MEMBERS OF THE HUMAN ENERGY CONSERVATION SOCIETY.

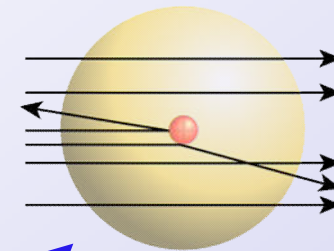
... atomic evolution ...



Dalton – billiard ball

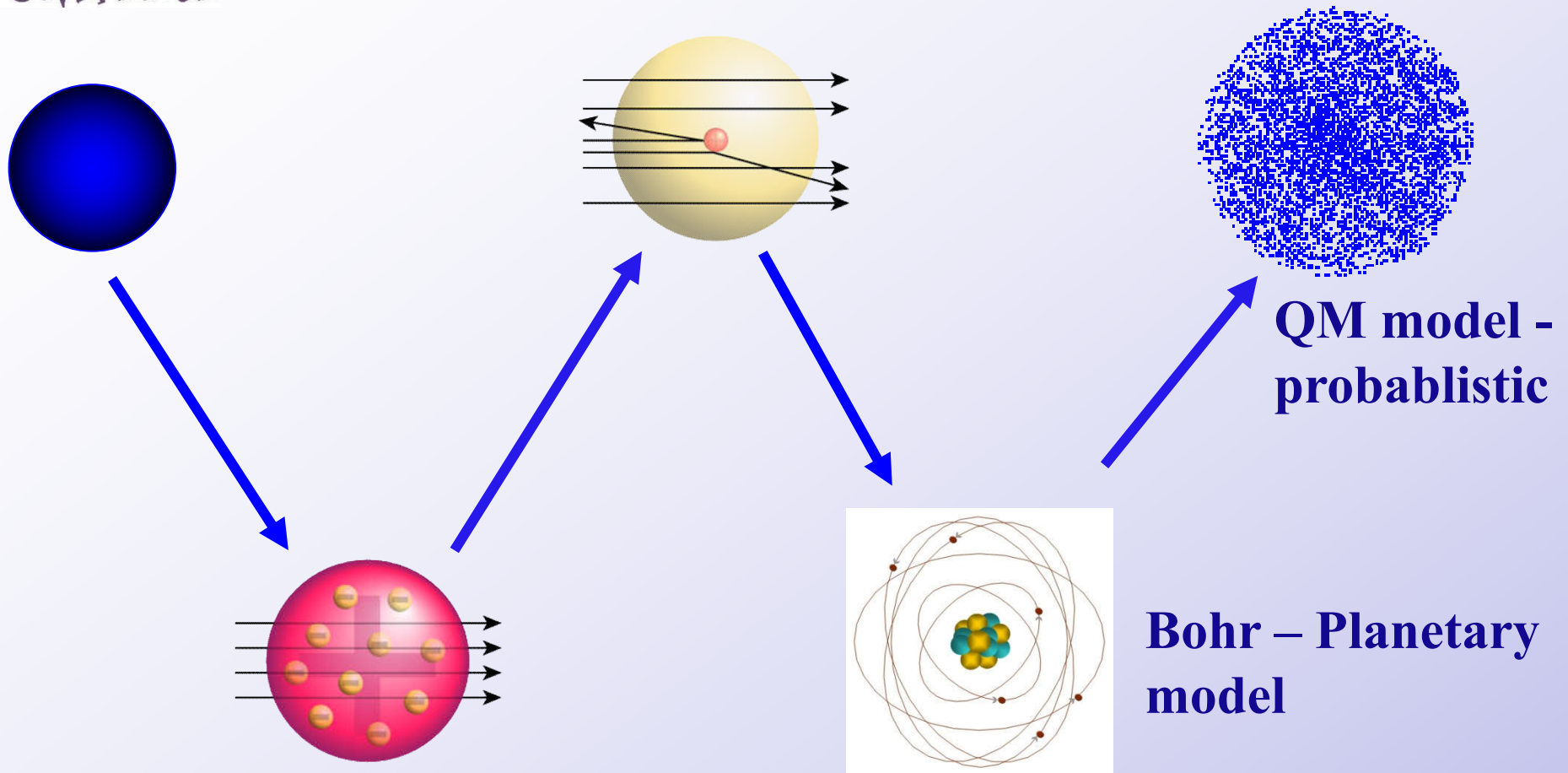


Thomson – Plum Pudding

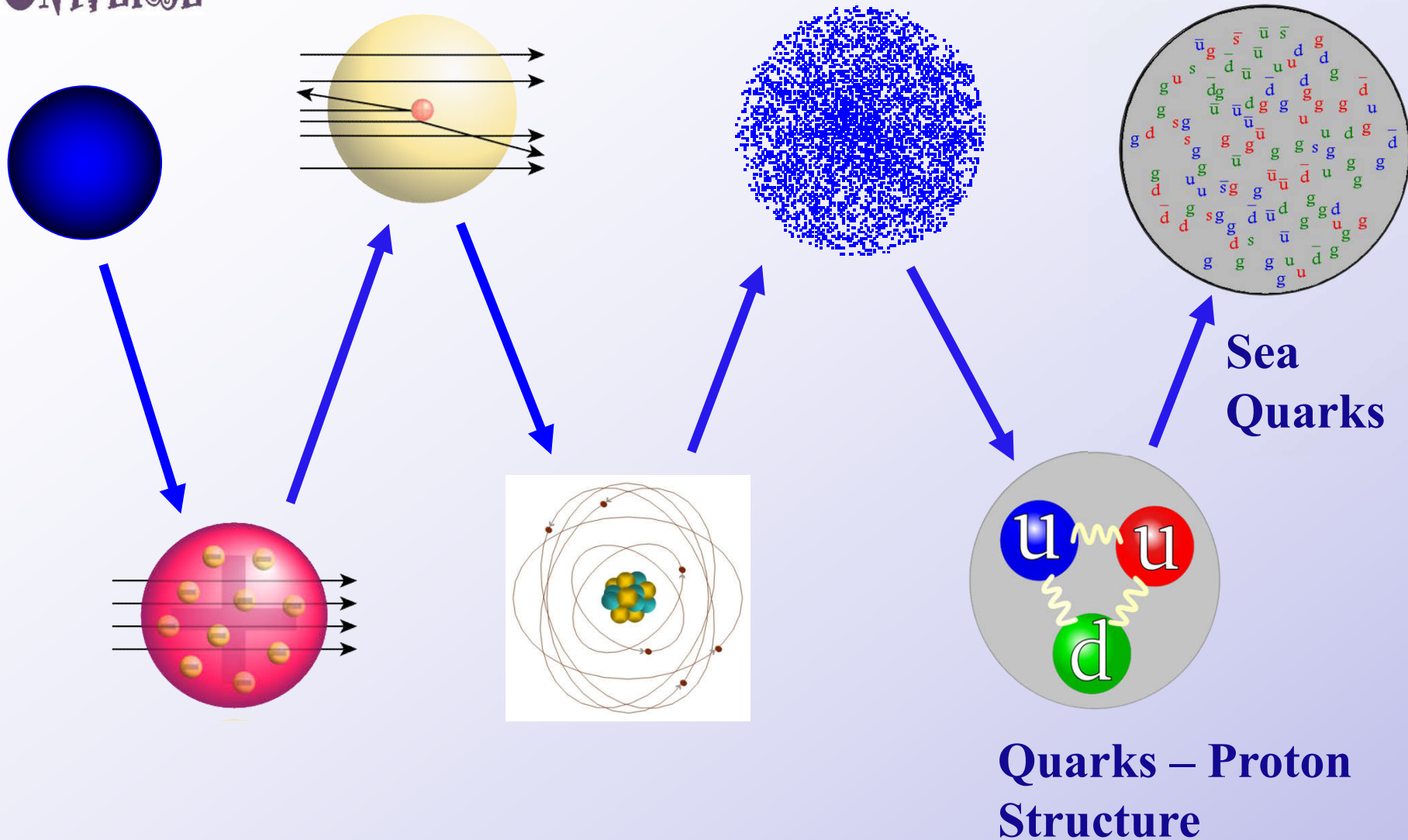


**Rutherford
- Nuclear model**

... atomic evolution ...

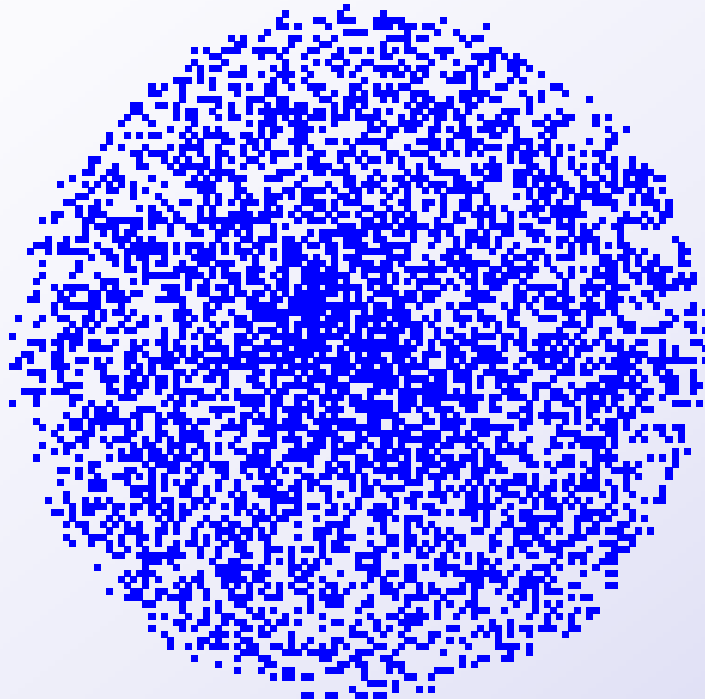


... atomic evolution ...





... not a good model ...

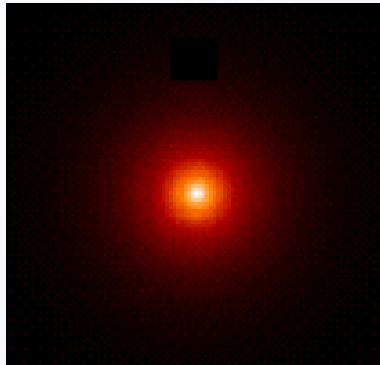


... while the jiggling is OK,
it doesn't really show where
the electron is or isn't ... !
... what's needed is a QM
model ...



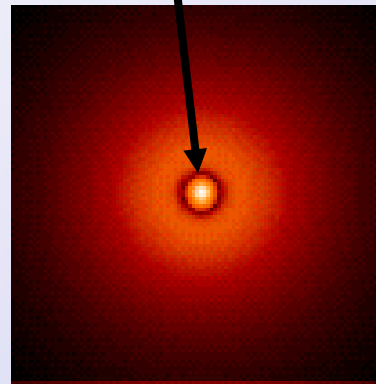
... views of the QM model ...

Higher energy level.

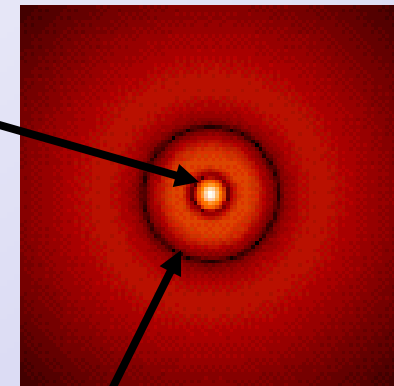


Hydrogen atom in its
'ground state'

Electron cannot be
found here ...



Higher energy still

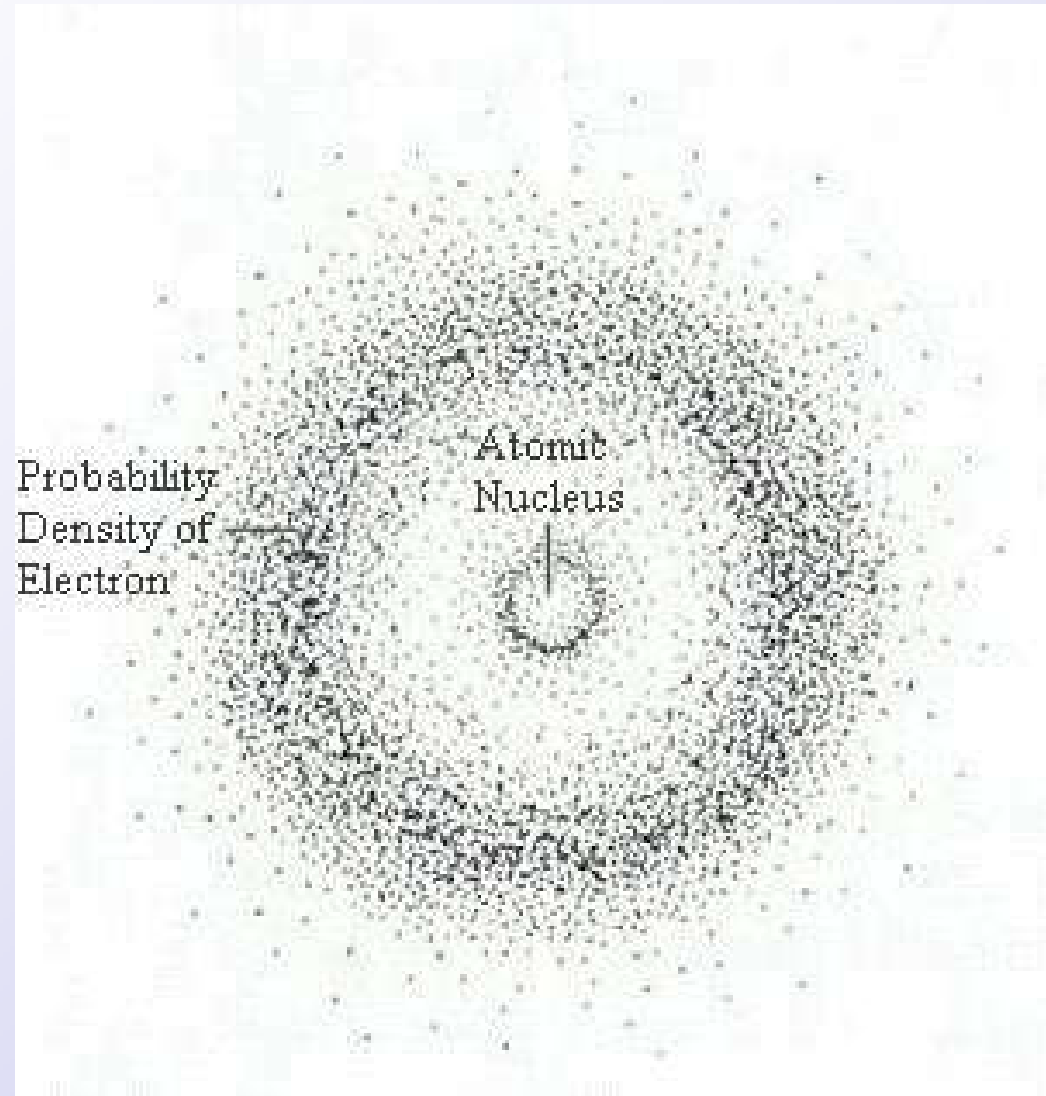


... or here ...



... in other words ...

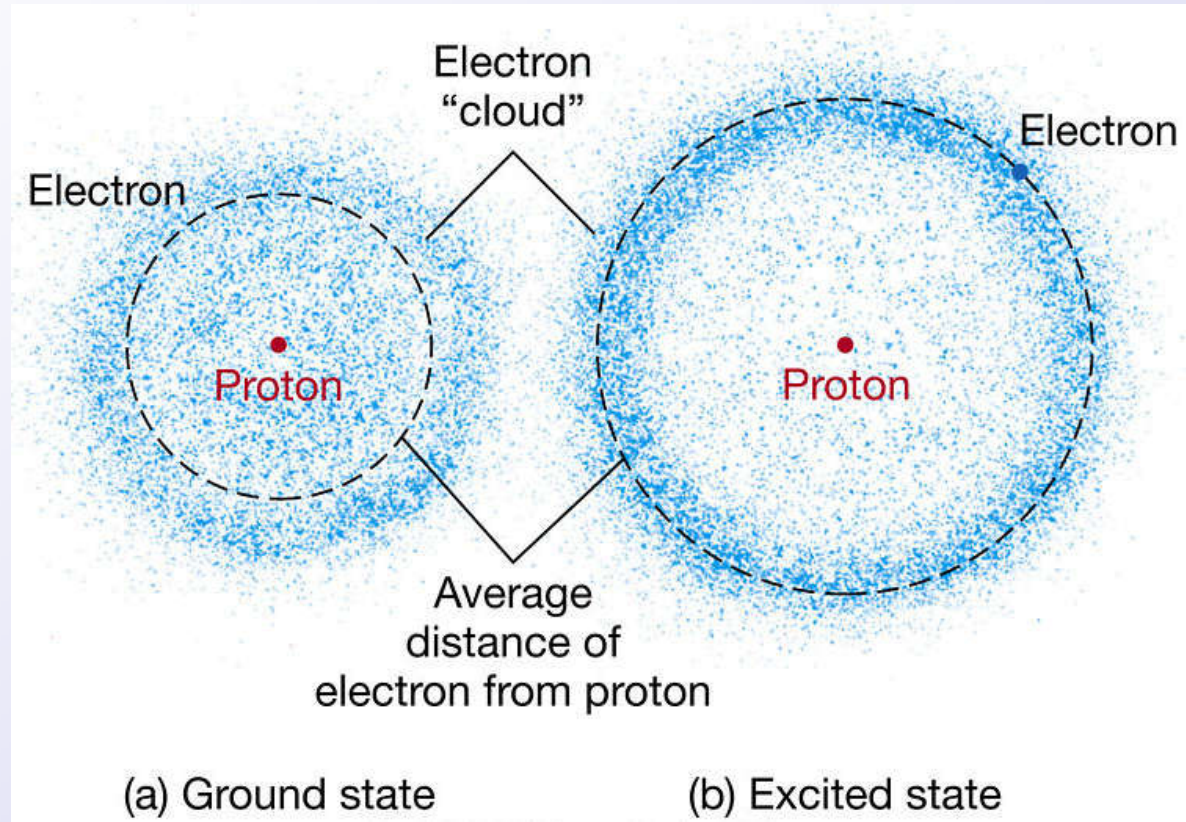
... the QM model used the uncertainty principle to work out the most probable place to find the electron at any time and energy ...





... electron cloud model ...

... in this model the electron was likened to a cloud ...





Let me give you an analogy. Imagine an infinite field of snow extending throughout all of space, flat, featureless, going in all directions ah maybe the middle of Siberia. Now imagine that you are trying to cross this field of snow. So maybe you are a skier, and you skim across the top. That's like a particle that does not interact with the Higgs field. It doesn't sink into the snow. It goes very fast. It's like a particle with no mass, traveling at the speed of light. But maybe you've only got snowshoes. In that case, you sink into the Higgs "snowfield." You've got less speed than the skier, less than the speed of light. That's like a particle with mass because you are connecting, interacting with that Higgs snowfield. And then finally, if you've just got boots on, then you sink deeply into the snow. You go very, very slowly, and that's like a particle with a big mass.

So, think of this Higgs field as being like this universal field of snow. Now, where does the Higgs boson come in?

We all know what snow is made out of, right? It's made out of snowflakes. In the same way, this universal Higgs snowfield is made up of little quanta. Those quanta are like snowflakes. That's what we call the Higgs Boson.

The Higgs Boson has its job of giving masses to all the other elementary particles.

If you look at the basic equations of the standard model, as written on my t-shirt, they are very symmetric. The way in which the different particles appear is the same. At least on the top two lines, there's nothing to distinguish particles which have different masses, for example. But this symmetry has to be broken. Electrons are lighter than neutrons; the top quark is much heavier than the quarks that make up everyday nuclei.



[John Ellis] Source: LYBIO.net

So the top two lines, the symmetric lines, cannot be all there is. There has to be something to discriminate, distinguish between the two different types of particles. That's the job of the Higgs boson. That's the job of the two bottom lines. Depending on how those different types of quark, or electron and the neutron, depending on how they connect to that Higgs field, that Higgs boson, we believe they get different masses. The symmetry between these particles is broken.

...and God said:

$$\mathcal{L}_{\text{QED}} = \psi^\dagger \gamma_0 (i \gamma^\mu D_\mu - m) \psi - \frac{1}{4} F_{\mu\nu} F^{\mu\nu}$$

where,

$$\{\gamma^\mu, \gamma^\nu\} = \gamma^\mu \gamma^\nu + \gamma^\nu \gamma^\mu = 2g^{\mu\nu}$$

$$D_\mu = \partial_\mu + ieA_\mu$$

$$F_{\mu\nu} = \partial_\mu A_\nu - \partial_\nu A_\mu$$

... and there was light!

And God said

$$\oint \mathbf{E} \cdot d\mathbf{A} = q / \epsilon_0$$

$$\oint \mathbf{B} \cdot d\mathbf{A} = 0$$

$$\oint \mathbf{E} \cdot d\mathbf{S} = -d\phi_0 / dt$$

$$\oint \mathbf{B} \cdot d\mathbf{S} = \mu_0 i + \mu_0 \epsilon_0 d\phi_1 / dt$$

and THEN there was light.



Friends with the

and God said "let there be light"

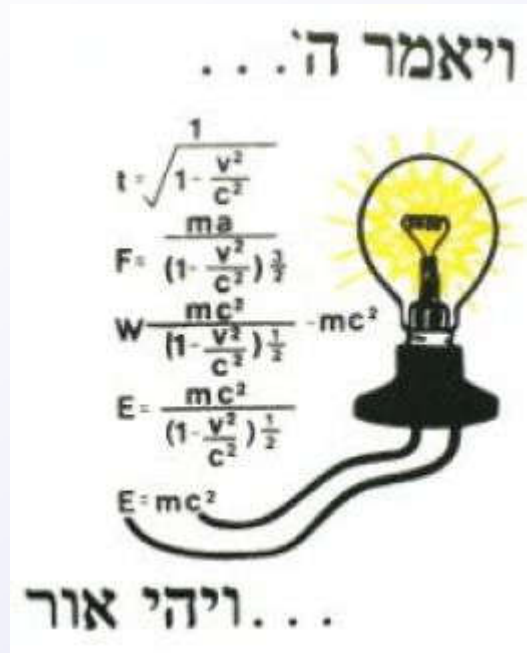
$$\nabla \times \vec{E} = -\mu \frac{\partial \vec{H}}{\partial t}$$

$$\nabla \times \vec{H} = \vec{J}_c + \epsilon \frac{\partial \vec{E}}{\partial t}$$

$$\nabla \cdot \vec{D} = \rho_v$$

$$\nabla \cdot \vec{B} = 0$$

... and there was light



And God Said

$$\nabla \cdot \vec{D} = \rho_{\text{free}}$$

$$\nabla \cdot \vec{B} = 0$$

$$\nabla \times \vec{E} = -\frac{\partial \vec{B}}{\partial t}$$

$$\nabla \times \vec{H} = \vec{J}_{\text{free}} + \frac{\partial \vec{D}}{\partial t}$$

and *then* there was
light.