Quantum physics and oranges

A fantastic adventure to the world of tiny things

Your journey begins here

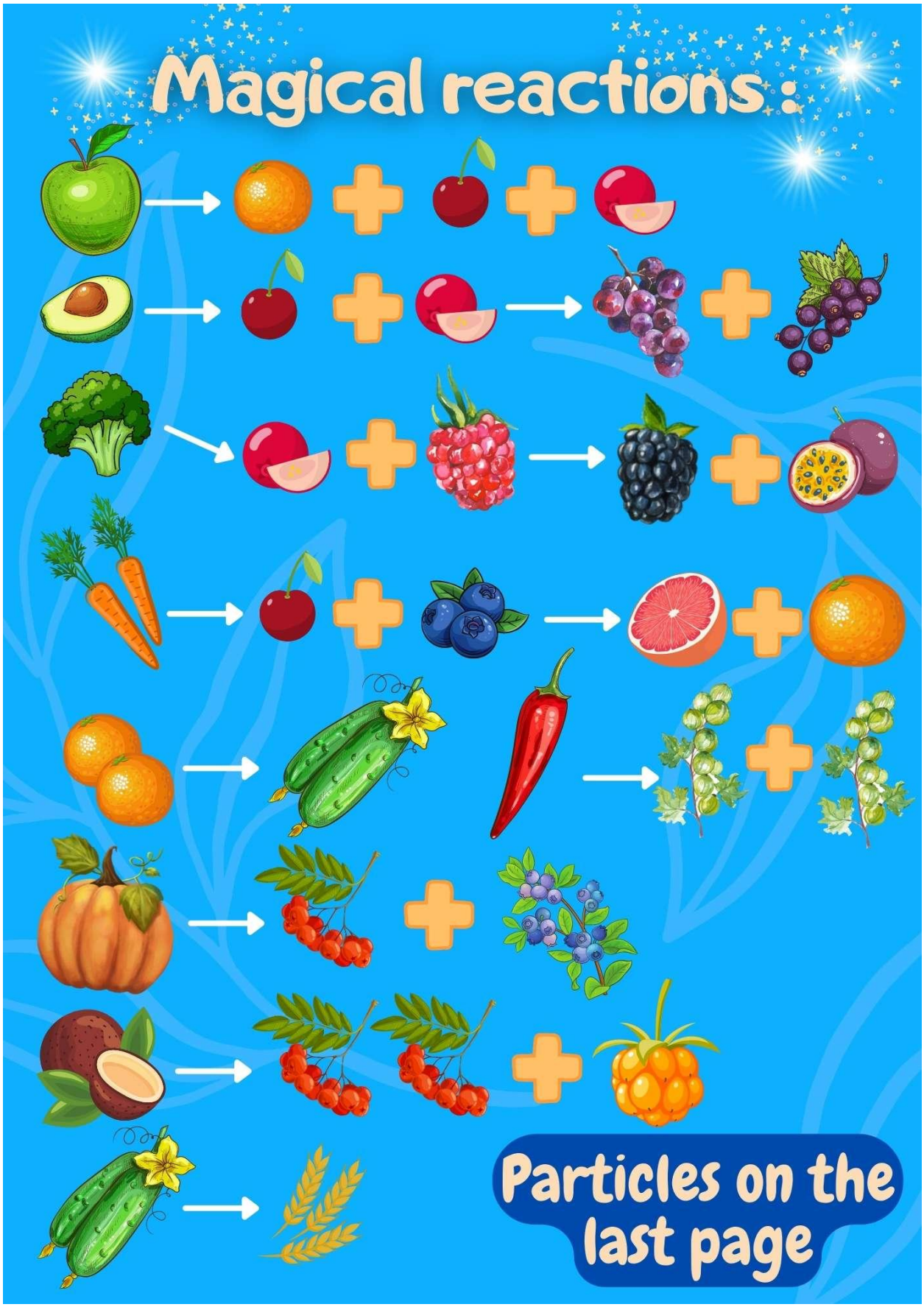
For curious explorers and their awesome parents

Fyodor Amanov

The 1st journey on our way to quantum world

Written and designed by
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Magical reactions :



Particles on the last page

The map of our adventure

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Our train, Hurry up !

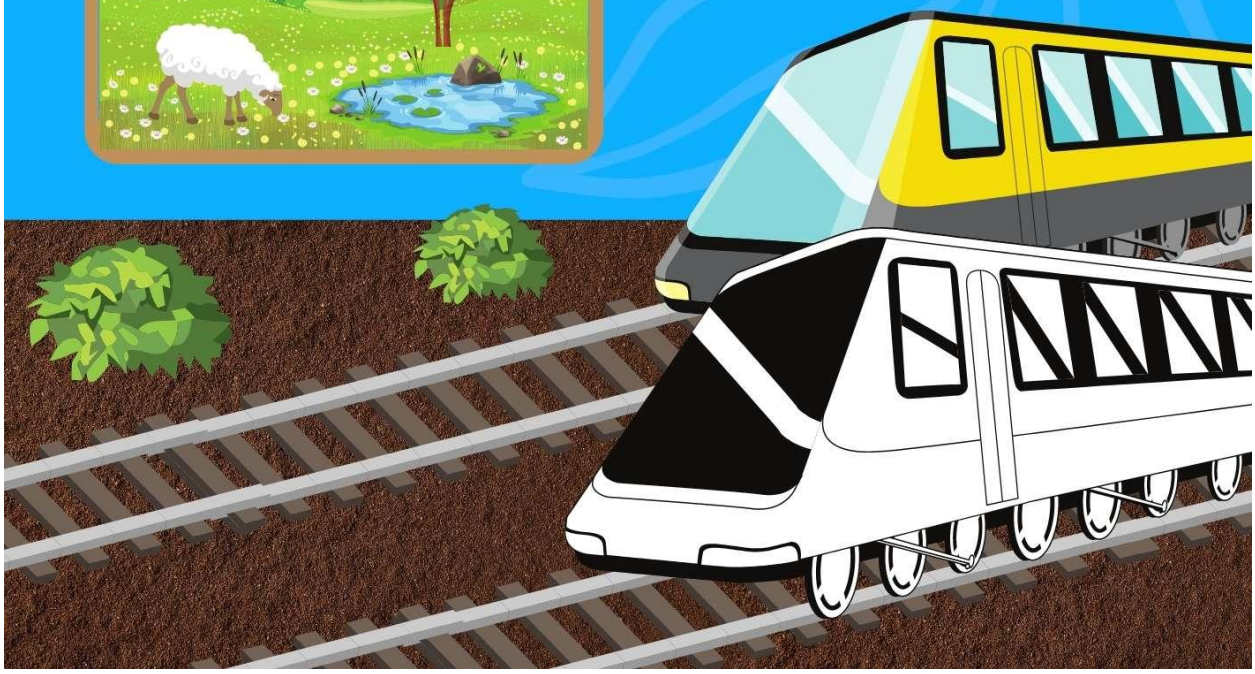


Oh, finally we are here.
You came on time!

Our train leaves in 5 minutes, we need to hurry up; the land of fantastic discoveries already waits us!



Let's go, here it stands, our mid-land express !)



A basket of fruits

Great, we are going !
Our places are 15 and 16, perfect, right next to the window.
Ohh, what a view opens out of it, take a look !







Oh, by the way, have you had a breakfast? I took some snacks... Tasty aren't they ?)

Hmm, while we are on the train, I want to tell you a story about the magical place we are going to...





You know, our magical land is the world of particles, better to say "small things" that we are all made of...

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It may seem strange to you, but your chair, this table, you and me: everything, is made of them. You will not notice particles with your eyes, it will be too hard, but believe me they do exist.





What's funny about the particles, each of those tiny things has its own, personal name, just like fruits, that are in your basket: oranges, apples, lemons, cherries, pears, strawberries and bananas- they are all unique. In addition, as fruits do, particles have their very special color, mass and even flavor. I think I'll tell you more after we have a short breakfast, alright?



A bunch of differences



Well, thanks for the breakfast time, now I think we can continue. Before we go into our quantum garden, we need to understand how one fruit may be different from another. Yes, different!



If you look around, everything seems different: cherries look more red than tomatoes, oranges are more orange than lemons, and apples may be different at all– some yellow and others green, some small and others big.

To say that some green object is an apple, you need to be sure it's not a cucumber. How will we do it? Well, I will tell you how, just look on the next page...



Size, color, smell- Mass, charge, spin





When you look at orange, how can you say it's not a lemon ?

First, orange is orange and lemon is yellow.
Second, orange is bigger than a lemon.





Third, if you smell them, their smells will differ just a little.

So, if you know something smells like orange, looks large and seems orange, you will say, "It's an orange "



Size- Mass

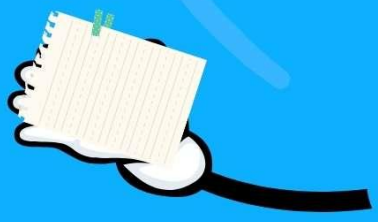


Remember you told orange is bigger than a lemon, you may say that a tomato is bigger than a cherry, and a watermelon is bigger than an apple.
Just as fruits may be smaller or bigger, particles (those small things) may be more MASSive or less MASSive. It's a strange word, but you may check it.



EXPERIMENT

Put a sheet of paper on one hand and a spoon into the other.
What's more difficult to hold ?)







Fun fact:

Mass tells you how difficult something is to hold
Particles may be difficult to hold too...

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Color- charge



We checked last time lemon is different from orange because of it's yellow. It was a color of lemon. "Quantum fruits" have something the same- charge.



When you look at particles they may seem Positive(+) or Negative(–). Doesn't it look like a color ?)

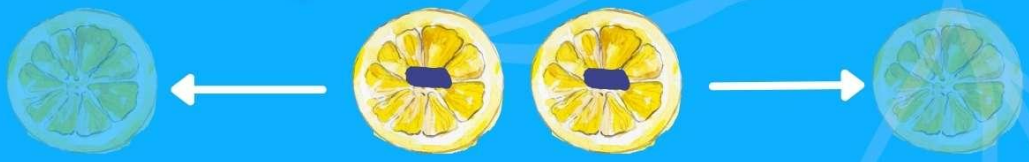
It's named CHARGE.

Charged particles can be going towards each other- attract , or running from each other- repel.



Fun fact:

If two particles have the same charge they run from each other.



If two particles have different charges they run to each other.



Smell- spin

As with an example of orange and lemon, smells may be different- just a little. Particles too have something as a smell, it's named **Spin**. Spin is hard to notice, but it makes each particle special.





Like smells of **Fruits** and **Vegetables** differ, spins of particles may differ too, as **Fermions** and **Bosons**.



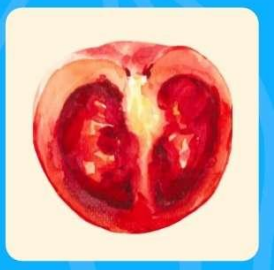
Fun fact:

The same may happen with particles: you may think it's Fruit , but it will be a **Vegetable**.

Game :
Find a spy







*one different from others in some way

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Station "Garden of discoveries"

Hmm, a bell; seems like we are reaching our station. We are better to box up our backpacks in advance...





Wow, what a fresh air, and it already smells like our garden! Let's not lose time, follow me...



This way...



Our garden of particles









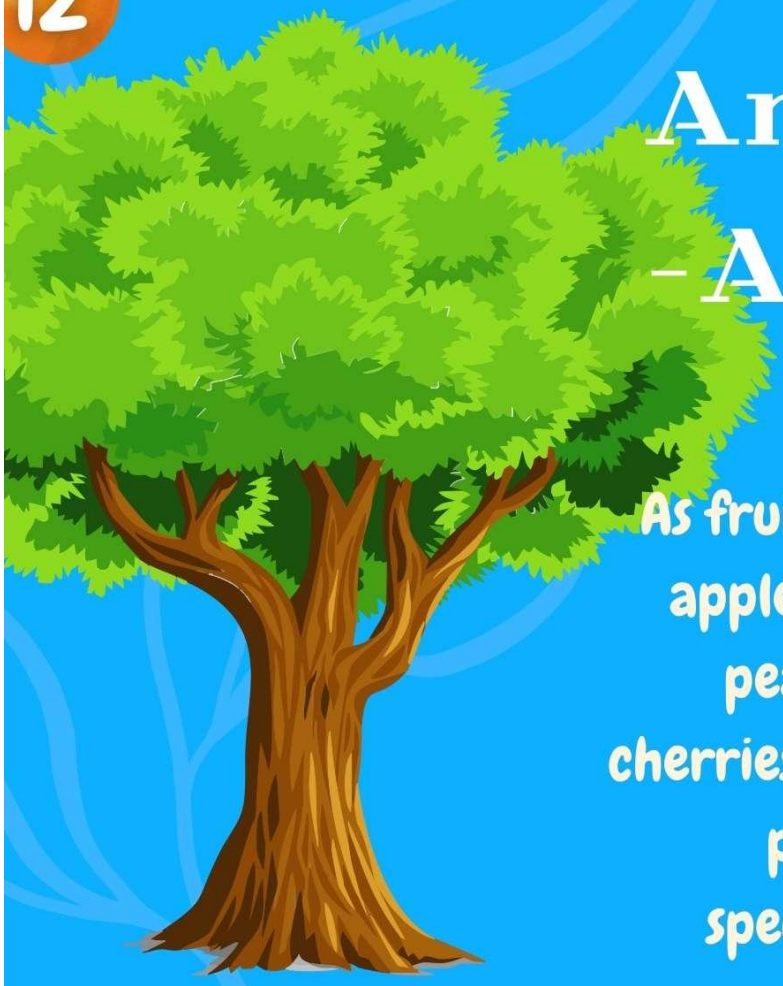


Well, we came to the gates of our garden. One step forward and we'll be in a land of magic.





An Atom -A tree



As fruits grow on trees:
apples on apple trees,
pears on pear trees,
cherries on cherry trees;
particles too have
special trees- **Atoms**.

They are really important, they build our world; we are formed of atoms; our chairs, homes and fruits are too built of them!









HMM, LET'S SEE, WHICH FRUITS WE HAVE THEN GROWING...

A funny orange-proton



Mass (size): Heavy(big)

Charge (color) : + (positive)

Spin: Fermion (Fruit)

Oranges are important in our life: they make us healthy, happy and energetic, so they found a friend in garden of particles: a quantum orange or **Proton**. Protons form Atoms. Being so great, they decided to live in Heart of an atom – **Nucleus** . They live together as a family, forming groups as huge as number of pages in this book, and even more...

Fun fact:

If an atom was a **Big Ben**, then its nucleus would be a fly. **Nucleus** is tiny... and protons are even smaller !



Protons



Nucleus



Atom

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A happy apple-neutron



Mass (size): Heavy(big)
Charge (color) : No charge
Spin: Fermion (Fruit)

Neutrons are as important as protons, they make things heavy and build the nucleus of atom. They bring new atoms in the world...



What if atom was a basket ?
Well, then we could put our quantum fruits inside.
We put one orange. Seems like it is an atom, but only with one proton.
What if we add one apple? Now we have one proton and one neutron in our basket. Look, something new... Is the basket heavier now? If you smell it, will you feel another aroma?
Seems like we made an absolutely **different atom !**



Fun fact:

Some quantum fruits may have no charge at all, it means even if they meet with a particle of positive or negative "color" they will not be running to them, nor from them.

Friendly cherries- electrons



Mass (size): soft (tiny)

Charge (color) : – (negative)

Spin: Fermion (Fruit)

Electrons are really interesting, they seem to be absolutely different from all other "quantum fruits" we talked about. If a proton was your home, electrons would be dust inside it- so small, just tiny they are.



More than this, electrons have a negative charge, so they could run to protons (be attracted). Because of their qualities, they play a role of postmen in atoms. Remember your friend sharing cherries with you, atoms do so too: they share electrons between each other. In this way they find "friends".

Fun fact:

When atoms exchange cherries (electrons), they can create whole gardens with different trees growing in them.

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A juice carrot- photon



Mass (size): No mass

Charge (color) : No charge

Spin: Boson (Vegetable)

We meet with the first "vegetable" in our garden. Seems it is even more interesting than electron. **Photons**- quantum carrots- **do not have mass** at all. Even if you hold a million of photons in your hand, it will feel like nothing, not a bit of mass. Just as quantum apples (neutrons), **photons do not have a charge**. It means they will not be attracted by any particle, they are just like free travelers.

You would ask, "What for we need them then?"

I answer: they are super important, the world we see is made of photons. Quantum carrots are particles of light. They tell you about ***colors***, ***nature*** *and* ***your surrounding***. *Thanks to them we see the world.*

EXPERIMENT

In the afternoon, close your eyes, open your mouth and stand towards sun. Feel warmth? Those are photons of sun light!

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A sweet-cherry - muon



Mass (size): Heavy (big)

Charge (color) : – (negative)

Spin: Fermion (Fruit)



*As in our garden some fruits may be relatives: oranges and tangerines, peaches and apricots, cherries and sweet cherries; in quantum garden some particles may be relatives too. For example, quantum cherry and quantum sweet-cherry are relatives, they are named electron and **Muon**. We already know electron, but what's then a **Muon**?*



Well a muon is a heavy electron, it would be really hard to hold it in your hand comparing to electron. Imagine holding a toy car and a whole home you live in, this is what you would feel like.







Fun fact:

Muons do not live long, they turn into electrons and travel in our world.

Game :

How many cherries are there ?
How many sweet-cherries?
If all sweet cherries turn in cherries, how many cherries will we have ?



Angelina Mayorova

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Flavorful grapes- tau



Mass (size): Super heavy (huge)

Charge (color) : – (negative)

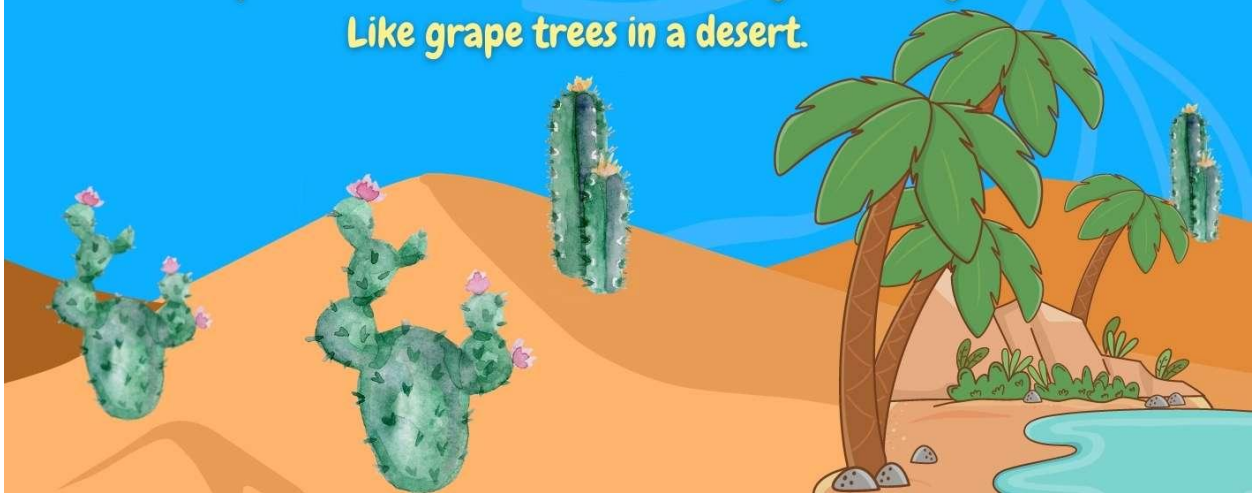
Spin: Fermion (Fruit)

*As we found, cherries (electrons) are relatives with sweet-cherries (muons). It's interesting, but they have one more relative- grapes (**Tau**). If sweet cherry was bigger than a cherry, Tau is just as huge as grapes. It's just super heavy, just like **all your town in one hand** and your home in the other. Where are such giants coming from? They are almost from another world, with atoms huge in many times than ours.*



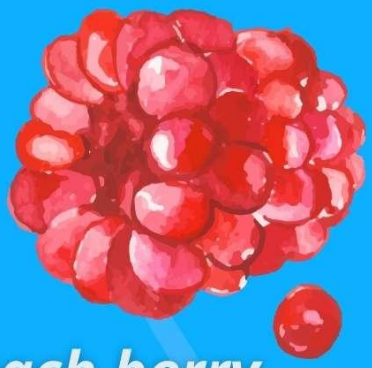
Fun fact:

At some places we have taus too, but they are really rare. Like grape trees in a desert.



Blackberry, raspberry, strawberry- Neutrinos





It's interesting, but for each berry
(cherry, grape and sweet cherry)
In our quantum garden
we found a "couple"
They follow them everywhere
Each having a pair, turns into other
So meet an impressive quanta





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Tasty raspberries - Electron neutrinos



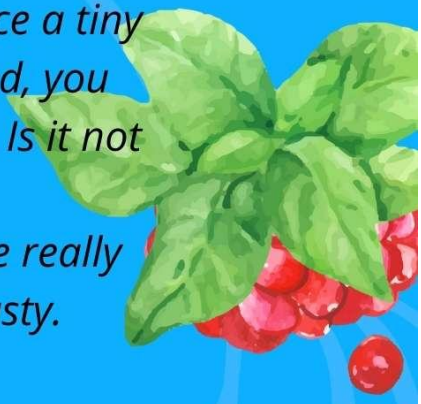
Mass (size): Super soft (nano)

Charge (color) : No charge

Spin: Fermion (Fruit)

When you go searching for raspberries, you don't see them first. You must have a keen eye to notice a tiny red spot among green leaves. When noticed, you carefully move your hand closer and take it. Is it not yummy? Yes, it is.

*Just the same goes with **neutrinos**: they are really hard to notice, but when did, result is tasty.*





Fun fact:

Electron neutrino is many times softer than an electron, but when coupled they form something interesting and heavy... (Tell you soon)



Blackberry- Muon Neutrino

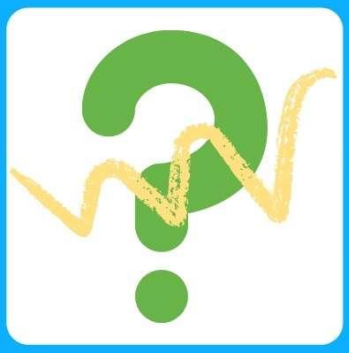


Mass (size): soft (tiny)
Charge (color) : No charge
Spin: Fermion (Fruit)

Just as raspberries do, blackberries try to hide in leaves and don't show so easily. To notice it you have to wait.
Muon neutrino behaves in the same way:
you have to spend enough time to see one.
You would say, "Hmmm, looks like muon neutrino is the same as electron neutrino!"
I will notice, "Yes, they are similar, but muon neutrino is much heavier! Just as electron and muon are".
Each one has its own pair.

Game :
Find a pair neutrino for muon

Mass: Heavy Vegetable



Mass: Super soft Fruit





Mass: Soft Fruit



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Strawberry- Tau Neutrino



Mass (size): Heavy (big)

Charge (color) : No charge

Spin: Fermion (Fruit)

You go in your garden, take a look and suddenly see a big rosy spot hiding nearby, in grass; it seems huge and tasty, so you come closer and take it. Yum, what a wonderful berry, big and yummy. You know, in our garden we have a berry which looks the same, it's Tau neutrino.



As Tau, Tau neutrino is huge. If you look at raspberry (electron neutrino) and strawberry (Tau neutrino), you will see the difference right away.

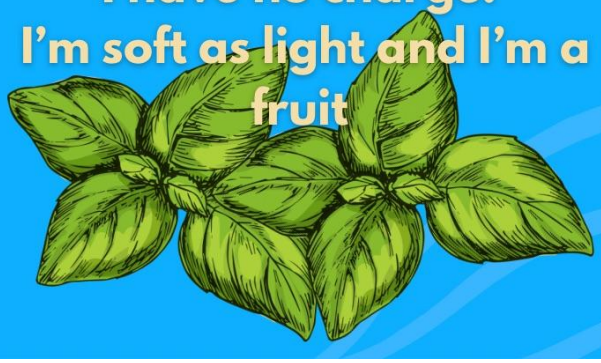




Game :

Guess who I am.

Who am I ?)
I have no charge.
I'm soft as light and I'm a fruit







A funny quiz



1. I am soft, I don't have a charge and I'm a particle of light.

I am a ..... (name Me)



2. I make particles "smell", you will not notice me so easily.

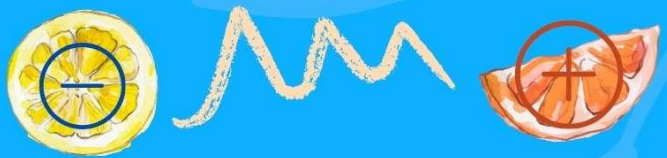
I am the ..... (name What I am)



3. I form atoms and sit in their nucleus, my charge is positive.

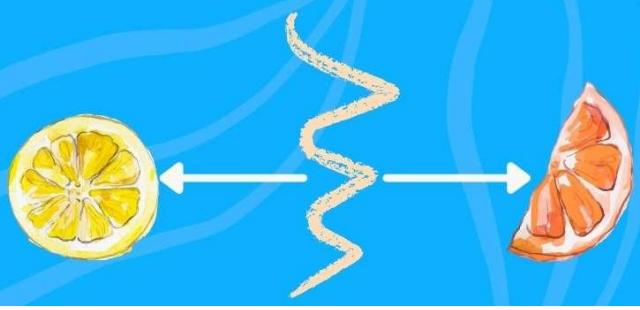
I am a ..... (name Me)

See through the time...





Or







MY SMALL SECRET

There is a part of my garden, which I do not open for everyone...
But for you my friend, I will.
Look, here we grow exotic fruits and vegetables which you would not see in your daily life





Anti oranges





Well, look, in our garden we have a special greenhouse, where we create new fruits and vegetables, make them smell different or have another color.



Here, just look at the trees, they seem absolutely different. For example this is Anti-orange, or Grapefruit. Or look at those berries, they are called Anti-cherries, or Blueberries. And many more following...

"But how did they change ?", you would ask me.

Hmm, look for example:

Grapefruits have a negative charge and called Anti-protons, but protons (oranges) had a positive charge.



Blueberries have a positive charge and named Positrons, but their pair was cherry, and it had a negative charge.



Fun fact:

Anti fruits change their **charge** and **color** only.
Oh, and most importantly, when **fruit** and **anti-fruit** meet, they disappear... (annihilation)



You will be amazed, but you can create any fruit just from **carrots**.
Rule is this : **two carrots** = fruit + **anti fruit**



Game :

Make some coconuts and mangoes (anti coconuts) from 4 carrots. Draw them!



Secret of neutrinos





Remember last time I told you something impressive about an electron: when it meets an electron neutrino, two soft particles form something really heavy...





Let's see then how...

28 Creamy avocado-W boson



Mass (size): Super mega-heavy (enormous)

Charge (color) : + (positive) or – (negative)

Spin: Boson (Vegetable)



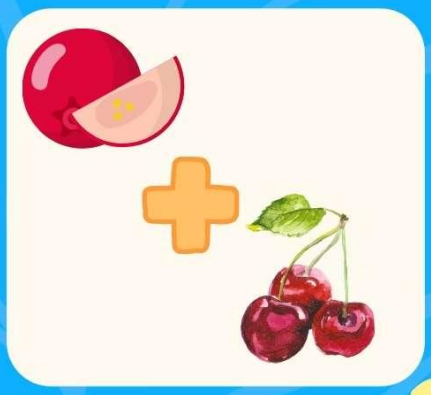
Get by: mix of an electron and an electron anti-neutrino, a muon and a muon anti-neutrino, or a tau and a tau anti-neutrino

Imagine if you could make an avocado by mixing one cherry and a cranberry, it would be interesting, wouldn't it?!
The point is, you can make it in our quantum garden, you just take a cherry, then put it next to a cranberry and say, "Bada-bim, Bada-bum"; here is your avocado.
Do you want some currants? Yes? Then take your avocado and say again "Bada-bim, Bada-bum", you will have a few currants and some grapes ! How did it happen?!
In the world of quanta you can make almost any fruit from a combination of others, you just need to know the right components :)





Magical turnings :









Game :

Here is your magical wand. Hmm, can you turn carrots and currants in cherries ?

Hint: Take a look at page 26





There are a few ways !

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Fresh broccoli- Z boson



Mass (size): Super mega-heavy (enormous)

Charge (color) : No charge

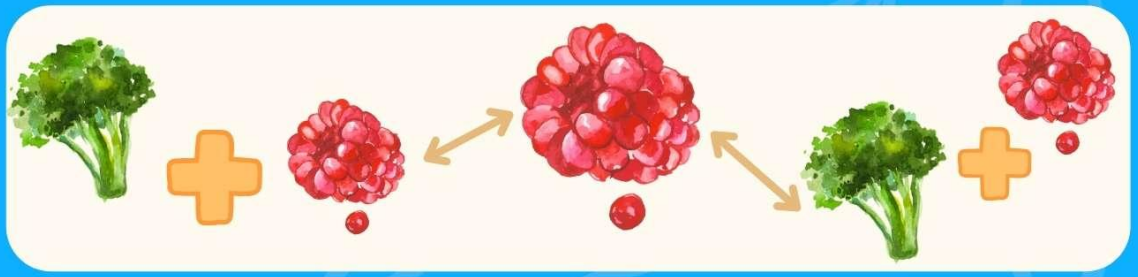
Spin: Boson (Vegetable)



Get by: mix of a neutrino and an anti neutrino (e.g. cranberry and raspberry)

Imagine a magic vegetable which could make any fruit bigger, not for long but for some time. Such a vegetable exists, it's broccoli or Z boson. By mixing it with any fruit, you would get this fruit, but of a bigger size. For example, you mix a raspberry with broccoli and you get a raspberry of apple size. Yum... But eat it fast, soon it will turn back into the usual raspberry.





Huge fruits- Hadrons



Mass (size): Heavy, Super heavy and Super mega-heavy (enormous)

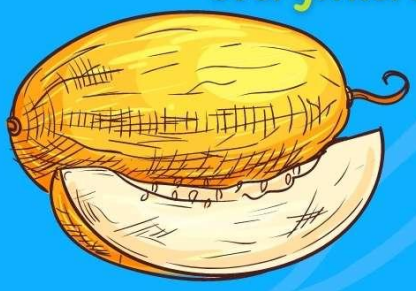
Spin: Fermion (Fruit)



You know fruits may be different: small as berries or huge as coconuts and pineapples.
You may ask then, " Where are coconuts and pineapples growing ?"
Right here!
Look around, there grow mangoes, and next to them placed pineapples, oh and a little bit to the left grow coconuts. Is it not impressive? Yes, it is, but, you know, all of those have one single name- Hadrons.



Hadrons may be different- some rare and others more common, for example, orange (proton) is a Hadron and apple (neutron) too!
Still you will not meet coconuts and mangoes everywhere, so they are more rare Hadrons: much heavier and more exotic.





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Huge vegetables- Mesons





Mass (size): Heavy, Super heavy (huge) and Super mega-heavy (enormous)

Spin: Boson(Vegetable)

Well, we saw huge fruits in our garden, but are there any big vegetables ?

Of course!

Turn to the right and you will see growing tomatoes, peppers, pumpkins, corn and eggplants.

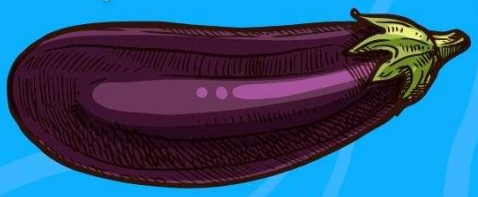


Yes, they may not seem so tasty as fruits, but if we cook them right, the meal will be delicious.

To tell you the truth, those big vegetables have a special name too! Mesons- that's how they are called.

To prepare them right, you need to mix them with other vegetables and surely your soup will be tasty.







Fun fact:

Mesons are just like messangers between Handrons, they help them to share their colors, emotions and even smells!

The tastiest–
The smallest

Look, under this tree grow wonderful berries. You would not meet them anywhere in the world except for this place. Here they are, Quarks! Tiny berries, but each has its own flavor, smell and even color...
Let's taste them...

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Mass (size):
soft (tiny)
Charge (color) :
+ (positive)
Spin: Fermion
(Fruit)

Rowanberry
Up
Quark (u)

*Look, seems I found an **Up berry**! Taste them , they are small red berries, yet how they smell... Mmm, yummy.*
You know, those small berries are amazing, they are a part of almost every fruit in our garden. Imagine how hard it is to be responsible for a whole quantum world!





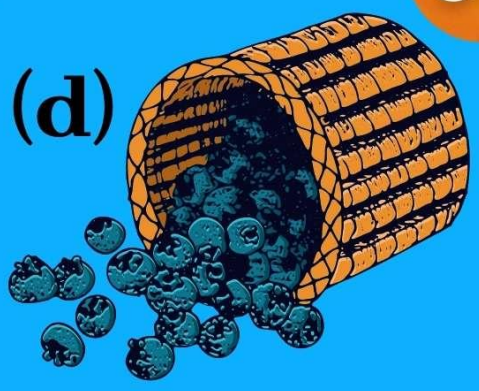
Secret

If you put two Up berries and add one special berry, you will make an orange, but be careful, once you made an orange, it will stay orange for a long time...





Bilberry- Down Quark (d)



Mass (size): soft (tiny)

Charge (color) : – (negative)

Spin: Fermion (Fruit)



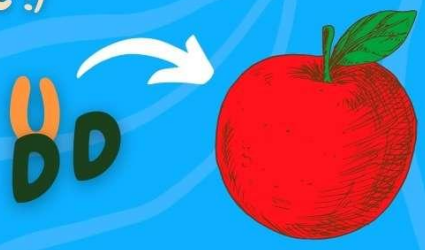
Remember we mixed a special berry to make an orange, Down berry is exactly what we mixed. Bilberries are as important as Up berries, they are the second most popular berries, almost each fruit has at least one Down berry.

Secret

To make an orange we mixed 2 Up quarks with one Down.
To make an apple (neutron) we can mix 2 Down quarks and one Up.
You decide what to make :)







Recipes

Game : Make and name

Π meson

Mix: 1 Down + 1 Up
Magical word: Pumpkin





Neutron

Mix: 2 Down + 1 Up
Magical word: App-le

Proton

Mix: 1 Down + 2 Up
Magical word: O-ran-ge



Choose two reactions and draw them right here !

Mass (size): Super heavy (huge)
Charge (color) : +(positive)
Spin: Fermion (Fruit)

Cloudberry Charmed Quark (c)



Look, something is shining there, under a coconut .
Let's go ...

Look at them, aren't they charming.
They are, and because of it,
we call them Charmed Quarks.
They are rare in our garden, so watch out for them not to miss such yummy berries.





Secret

To make a coconut (Σ** charmed), you can mix two Up quarks and one Charmed .

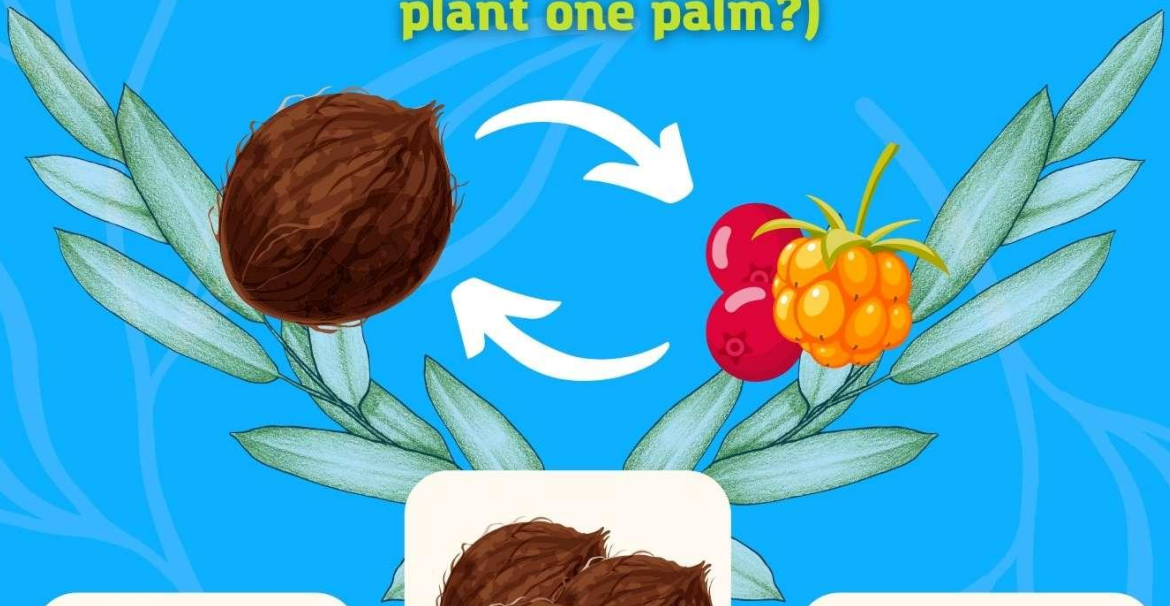
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38

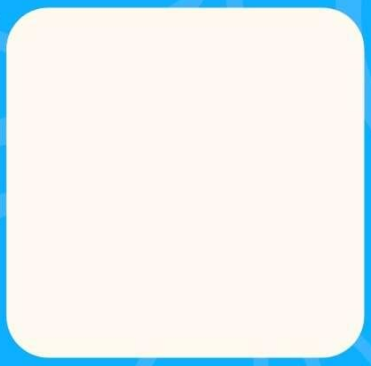
Game :

You are a king of an island; you decided to grow coconuts; to plant a coconut palm you need 3 coconuts. How many quarks of each kind will you need to plant one palm?)















Mass (size):
Heavy (big)
Charge (color) :
– (negative)
Spin: Fermion
(Fruit)

Gojiberry
Strange
Quark (s)

Oh, you found them!
The berries are the tastiest in our garden, but they are a little strange, look at their shapes. I haven't met anything so interesting ever!



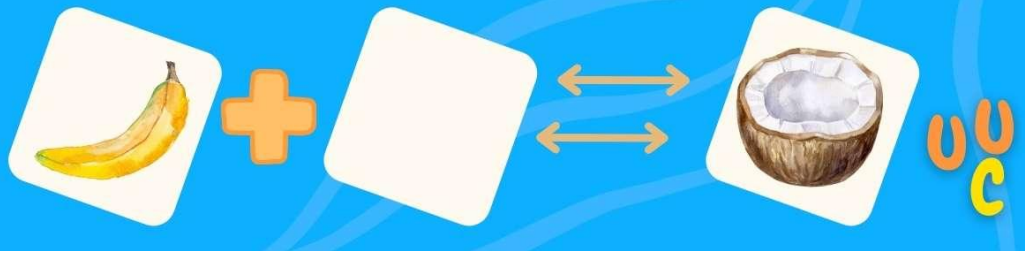
Secret

Let's take a break and taste a banana.
Well, we can make it from two Up quarks and one strange quark.



Game :

Turn a banana into a coconut.
Note: Strange + anti W boson = Charmed
Coconut = up + up + charmed



40

Gooseberry Top Quark (t)



Mass (size):
Super-mega heavy (enormous)
Charge (color) : +(positive)
Spin: Fermion (Fruit)



Look, we found a really special berry, it's *super heavy*. Imagine how tasty it is ! Yet, remember the rule:

everything that weighs a lot in our garden can soon turn into something else...

Hurry up to eat it !

Secret

Do you want to make a pineapple?) You will need one Up, one Down and one Top quarks. Let's make it



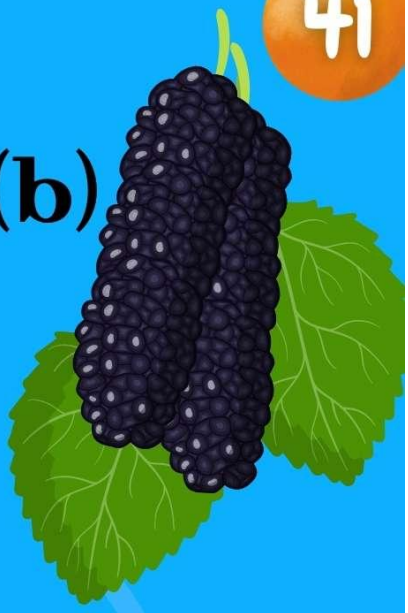
Game :

You are a head magician in your kingdom. You want to make a pineapple and three oranges for your birthday party . How many Up berries, Down berries, Top berries will you need ?

$u\bar{u}$ $u\bar{t}$ $d\bar{d}$ $d\bar{d}$

41

Mulberry
Bottom Quark (b)



Mass (size):
Super Heavy (huge)
Charge (color) :
– (negative)
Spin: Fermion (Fruit)



We came to the last quark, it grows under a special tree- apricot. Taste it, the flavor is just like sweet, soft and caramel, with aftertaste of honey.

Secret

Bottom quarks are so heavy that they quickly decay into their pairs- charmed quarks.



Super-interesting:

If you make an apricot from up, down and bottom quarks, and then add one avocado you will make a peach (P*) newly invented fruit!

2019 discovery

42



Baking Cookies :

You are a baker and want to make orange cookies with peach filling. Which particles will you need ? Finish the reactions...





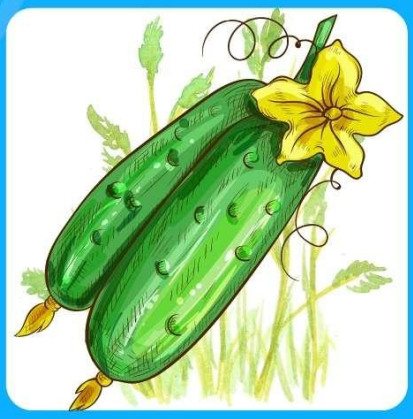
U D W b S U*

Anti U quark



Su*

A fresh Cucumber Gluon



Mass (size): No mass

Charge: No charge

Spin: Boson

(Vegetable)



You know, we have one really interesting plant in our garden, it grows winding other trees around. It connects them, like a link. Did you guess its name ? Alright, it's a cucumber. You know, it's this tasty thing in salads. Just as their leaves, cucumbers link different tastes in salad and make them special. Would you amaze if I told you that they have a friend in the quantum world?

Let's see, it's a gluon. It seems to be like a cucumber, gluon tries to link the other fruits. For example, if we add some gluons to quarks, we could make almost all quantum fruits: apples, coconuts, oranges, pears, and even some vegetables! They are the essential ingredient of our garden !

Game : Cut out some real fruits



A rainbow of quarks



*Look, on this shrub, something strange is going, the quarks change colors! First **green**, then **red** and after it **blue**. How is it possible?*



Oh, I forgot to mention, quarks are really funny, they always play in games with gluons.

Look closer, you see, the gluons jump from one tree to another and carry a small bag in their hands, it is the paint!

EVERY TIME THEY JUMP TO SOME QUARK THEY TAKE ITS COLOR, AND LATER PAINT ANOTHER QUARK IN THE SAME COLOR.





Secret

When gluons jump between quarks, they glue them together, in this way they make oranges, apples and many other fruits.



Fun fact:

If you combine red, blue and green colors in our garden, we will make a white color!

Colors in particles work in the same way , because of this oranges do not become blue or red

red + blue + green = no color



Super-interesting:

Do you remember about Anti-particles? Yes, those that changed their color and charge ? Anti-Quarks too chose different colors: they turn in anti-blue, anti-green and anti-red.

Color + anti-color = no color



Game :

What is a color ?)



46

Chili-Higgs boson



Mass (size): Super-mega heavy (enormous)
Charge: No charge
Spin: Boson (Vegetable)



Without chili pepper your lunch would not be so tasty; it's amazing that in our quantum garden we have a vegetable, without which our world would just not be so "Yummy" too...

Fun fact:

You can make some chili pepper by your own! Just use the reaction



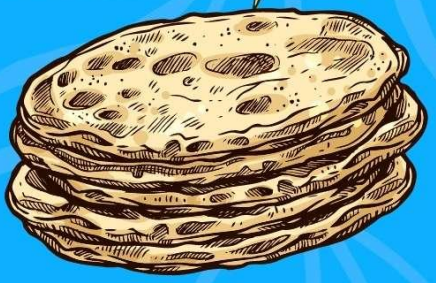
Imagine you cook a meal- first you pour some oil, then add onion, fry it, after it lay potatoes with carrots, and finally add mushrooms. Ten minutes after you taste it, "Hmm, yummy but not so spicy", you think. You look around and see a chili pepper, "Huh, good idea", you add just a few seeds and now your meal is ready: delicious and appetizing !

Ready to see it? Look, it's the Higgs boson: a spice vegetable, a particle which gives other fruits and vegetables their taste, without it, we would not enjoy eating them at all, so thank you, Higgs boson.

The unknown vegetables

Recently we created those special vegetables, but they are only a part of our experiment– we are still working on them, so I ask you not to eat them. We have to cook them first...







48

Mass (size):
Super-soft (nano)
Charge: No charge
Spin: Boson
(Vegetable)

Sunny wheat-Graviton



Have you ever seen wheat? It's this fantastic plant, we bake bread from it! What could taste better than fresh, hot bread or better flatbread? I do not know, even fruits can not be so tasty, but I want to tell you that if you eat wheat without baking or cooking, it will not be yummy so much ...

Well, we have the same experimental vegetable in our garden, it's a **Graviton**, an amazing vegetable, without it you would not stay on the ground actually. Gravitons build our homes, parks, buildings, so they are just as important as wheat is, but without "baking" gravitons are not so tasty either...





Fun fact:

Graviton is really hard to find, just like wheat seeds it can lie in the ground until the very spring...

Grass

Dark matter

49



Mass (size) :
Unknown
Charge:
No charge
Spin: Unknown

Grass? Yes! It's hard to say: is grass a vegetable or fruit, I think neither, but it's really important in our life. It gives us a chance to breathe, it creates air, and as well can you imagine summer or spring without green grass? I cannot!

To tell it fairly, just as grass, ***dark matter*** *lives with us and gives us a chance to live !*

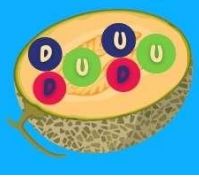
Fun fact:

In our world we cannot say exactly which particle is a **dark matter**, that's all because dark matter hides from us: it doesn't mix with oranges, apples, carrots or cherries, but we hope that one day we will make a salad with it...



Super-interesting:

Some of our smart gardeners think that **Dark matter** can be made of oranges with an apples squeezed together. The particles are named interestingly–"Stable deuterium".





Time to create !



u D W b s c t e τau



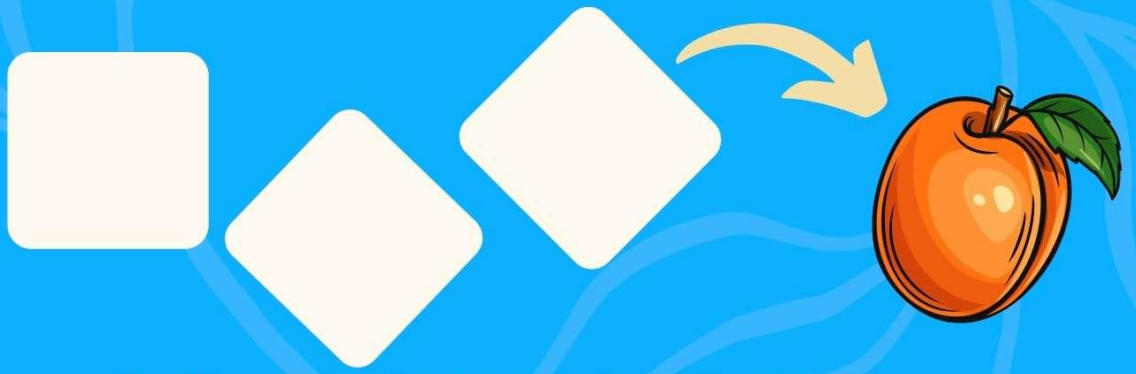
electron anti-neutrino



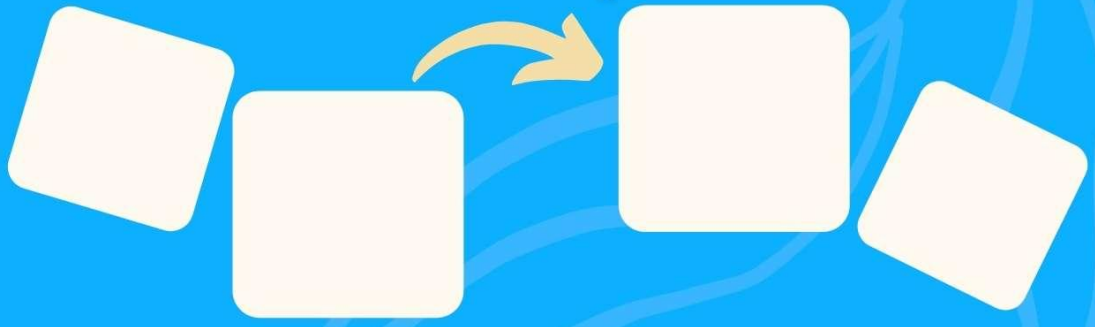
Tau anti-neutrino



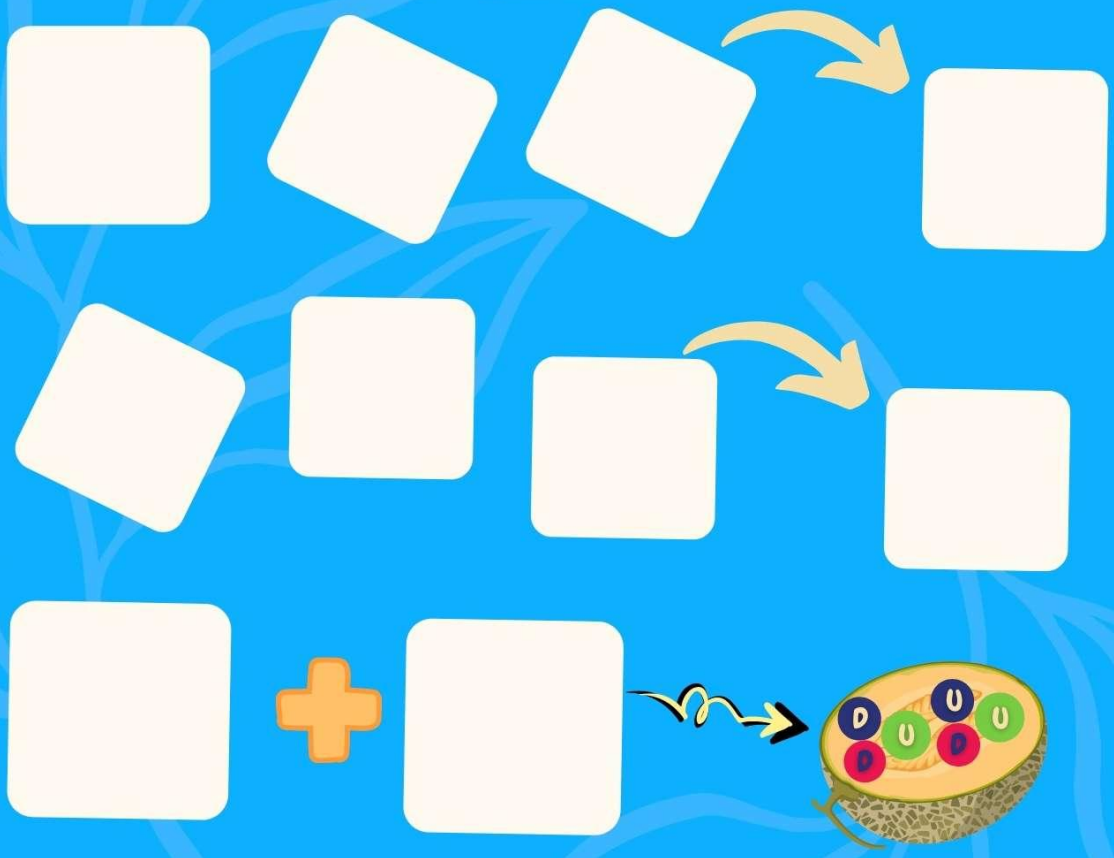
1. You get to bake an apricot cake, but it seems you have not a one at home... Make them yourself!



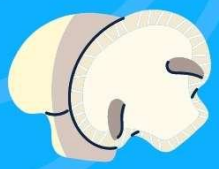
2. You are a farmer and you have some cranberries and cherries, how can you make currants from those ingredients ?)



3. You are a great scientist and want to create some dark matter, how will you do this ?



4. Write your own reaction ! Create !

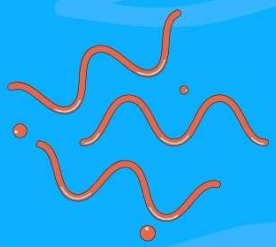


The laws of our garden

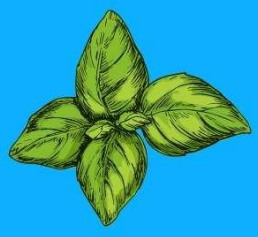


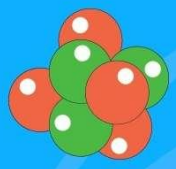
Maybe in your family you have some rules: be happy, go to sleep early, don't eat too much chocolate and eat more vegetables. Just as you may have some rules, our fruits have some too, so to be more friendly with particles and to understand them better, you get to learn these rules...















The laws of beauty







Look around, all the fruits actually seem so beautiful: colorful, fresh and symmetrical. Yes, symmetrical. Hmm, let me explain: you call something symmetrical in case whatever you choose to do with it- rotate, move or even put in your fridge until tomorrow- you will likely have the same fruit. Imagine how hard would it be, if when you put an orange into fridge, next day you have a potato. Not so yummy... so let's learn the three rules of beauty, they work with every fruit in our garden:

1 If you decide to take a fruit from your plate, it will not turn in a carrot suddenly. (place symmetry)

2 If you spin your fruit around itself, you will likely have the same fruit. (rotation symmetry)

3 If you wait one minute before eating an orange, and it will be the same orange. (time symmetry)



Game :

Find symmetries





1



2



3

54

Funny Ψ (psi)

Or how to harvest cherries



Once in our garden we had to harvest a lot of cherries, it was hard work, since we have thirty three cherry gardens, we had to know which garden to start with... We asked each cherry tree- how many cherries it has, and drew the map...





The map says: cherry trees from the first garden have a lot of cherries, from the second- some, from the third- not so much, from the fourth- a lot, fifth- some, sixth- not so much. Stop, seems like it repeats- a lot, some, not so much. Hmmm, maybe we should just remember this : a lot, some, not so much! Seems like a magical spell! It does and it even has a name Psi.

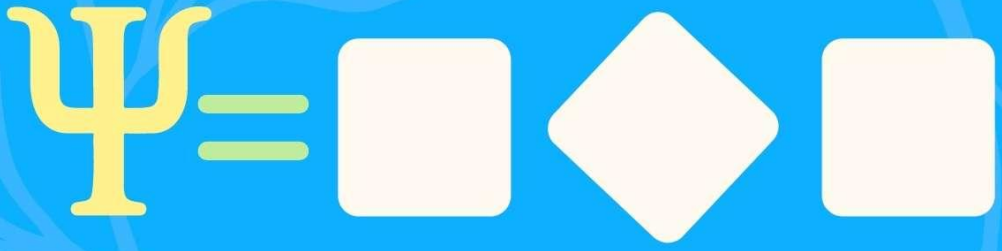
Fun fact: - Every time you need to remember something big, just find a Psi spell for it!

Game :

Be a wizard, use a Psi spell !







Interference-harvesting carrots



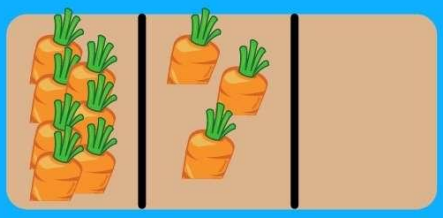
You know, last time to harvest cherries we used a Psi spell, why not to use it again for carrots?)
Hmm, let's then ask carrots how many of them grow in each field...

56

Carrot one tells:



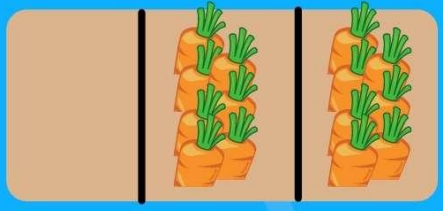
A lot- 1st field, some- 2nd field, no carrots at all- 3rd field



Carrot two tells:



No carrots at all – 1st field, a lot- 2nd field, A lot- 3rd field



Stop! Whom to believe? Strange, two carrots say absolutely different things... What should we do then? From which field to start?
Well, let's use another spell, Interference.



$$\Psi = \Psi + \Psi$$

The spell does:
It adds two Psi spells and gives us a new truthful Psi.

$$\Psi \; \Psi$$



When to use:
When you have two different PSIs about one thing.





Look, what we will get...

Carrot 1 + Carrot 2 = Psi

Field 1 = A lot + nothing = some

Field 2 = some + a lot = a lot

Field 3 = nothing + a lot = some



Seems the second field has more carrots, let's start with it then !

Game :

Find the truth !





First currant tree:

We have a lot of currants this year

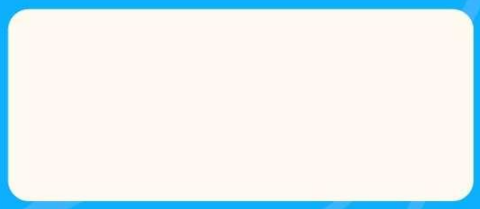


Second currant tree:

We have a little currants the year









58

The Uncertainty principle



A good gardener

Once in our garden happened an amazing story, which later became so famous that almost everyone now knows about it... You haven't ? Alrighty, then listen...

Long ago in our park lived a wonderful gardener, his name was Heisenberg; he cared about each tree, watered them and helped as much as he could.

One day Mr. Heisenberg received a task: he had to gather different quarks and count them as exactly as he could, but he had only a day to do it... It was an impossible task, just imagine- if you harvest 12 buckets of different berries, how will you count them all? There would be no way...



Mr.Heisenberg knew about it, and so he did differently: he decided to harvest only half of a bucket of each quark berries and then count them. He did it! He counted each berry, exactly! Not thinking for too long he made up the rule:

- If you gather too many berries, you will not be able to count them, and if you gather just a few berries, it will not be enough, so the best thing to do is to gather not too much, and not too little.



Game : Parents with only

Make some cookies for your family dinner and count them.
P.s Not too much and not too little :)

My recipe : Oatmeal cookies

Ingredients:



— Butter (topbutter) 100g
— Flour 4-5 table spoons
— Sugar 3 table spoons
— Oatmeal 6 table spoons
— Cocoa 3 tea spoons

Optional :

—Sesame quarter of a tea spoon
—Orange peel (up to your taste)

Baking plan :

1. Melt butter. Add sugar, whisk until dissolved.
2. Separate in 2 cups, in one add cocoa and in the other Sesame with Orange peel. Whisk.
3. Add oatmeal and flour in each cup, mix .
4. Smear your baking tray with oil or butter, make up your creative cookies.
5. Put into your oven for 18-20 minutes .

Bon appétit !

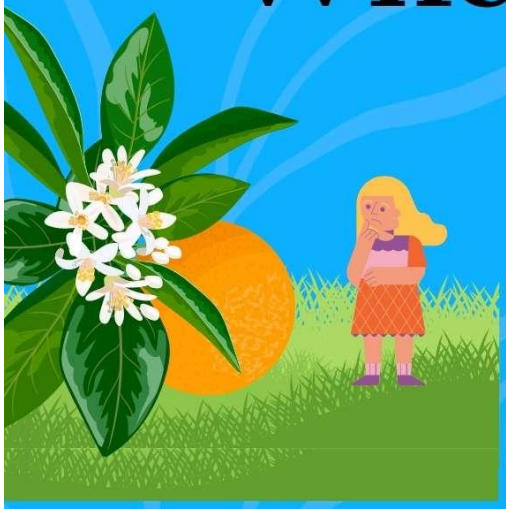






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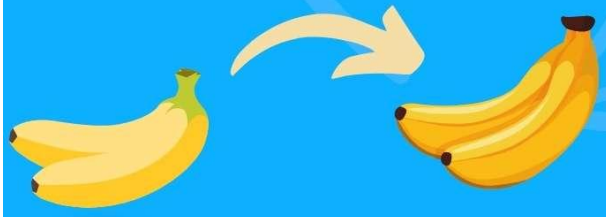
When to eat!



You know, sometimes you want to take a fruit and eat it, but then you look at it and think, "Maybe you will grow larger..." Well, our fruits decided to make a rule for us, so that we always know when we can pick an orange and eat it!

What we do:

1. Ask a fruit its Psi spell.
2. An hour later, ask the fruit its Psi spell again.
3. If its first Psi the same or larger than the second, take the fruit and eat it)



For example:

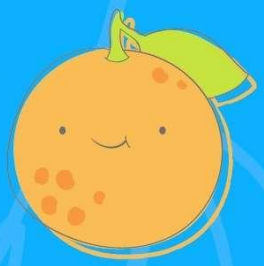
Orange

1st Psi=10

2nd Psi=9

Result: Take it)





Game :

Is it time to eat the apple ?)



1



2



Ba-ba-ba-bam!

Look at this; it's our **fruit collider** ! Remember you've made a lot of magical turnings yourself, well to tell it fairly we now stand at the exact place where such magic is done. You are able to **create any fruit, vegetable or berry** here, just come up with a reaction, put fruits you need in the collider and you did it! You made a new fruit! Use your imagination, be a wizard...







1

2

P.S. there is a table on the cover with some reactions, you can use it to make something amazing!

62

Open your own magical world!

You know, now after all the adventures we had and all the stories heard, I want to say to you my friend, you are a magician! A real one, I tell it fairly, I hardly know anyone who can turn apples into oranges or create strawberries from avocados.

I just wish to add that even though we went through our garden, it still keeps a lot of secrets, you only need to be curious. Look around, I know you can discover really interesting things.

Thank you for everything, this garden is yours too now...

Congrats video from our garden

Your honor certificate



This book would not be possible without :

– My family(especially: mom, dad and grandma).
Thanks for support and belief in me!

– My friends: Nigina Abdukhalimova, Shahlo Kuchkarova, Samir Soleev, Javohir Makhmudov, Samira Asrokulova and Gaziza Esenova.
Thanks for your loyalty and compassion .

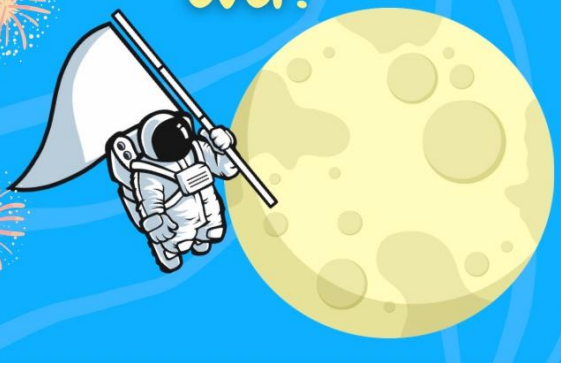
– My great mentors:
Leonardo Susskind
Marina Mogilko
Anelia Verteeva
Ramziya Buranbaeva
Lilya Begisheva





Thank you, you are the best in the world, the most fantastic tutors ever.





See you soon !

A little more funny quanta !



Teleportation and quantum physics



Turn small and see the atoms



Anti-particles and how they are made

65

Game solutions

9







Peppers

A tomato

17



1 cherry and 6 sweet-cherries, 7 cherries

21



Mass: Soft Fruit

22



Electron neutrino

66

I am a .....Photon..... (name Me)

I am the .....Spin..... (name What I am)

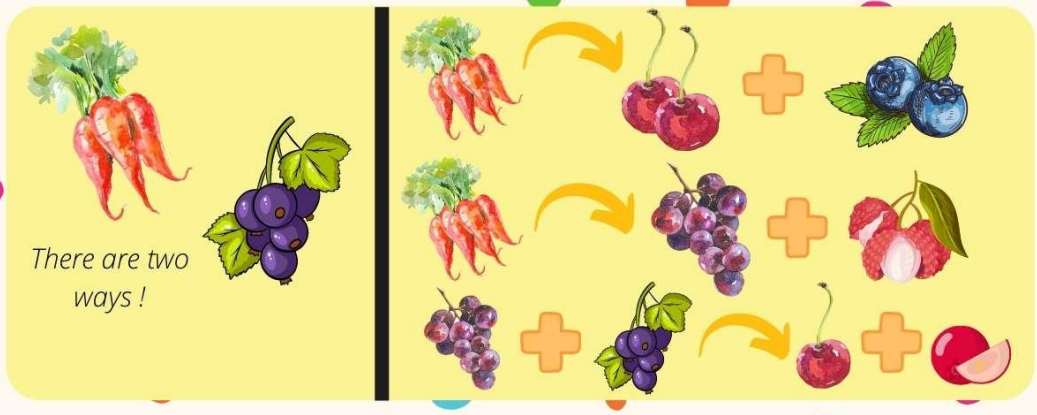
I am a .....Proton..... (name Me)





23

26



29

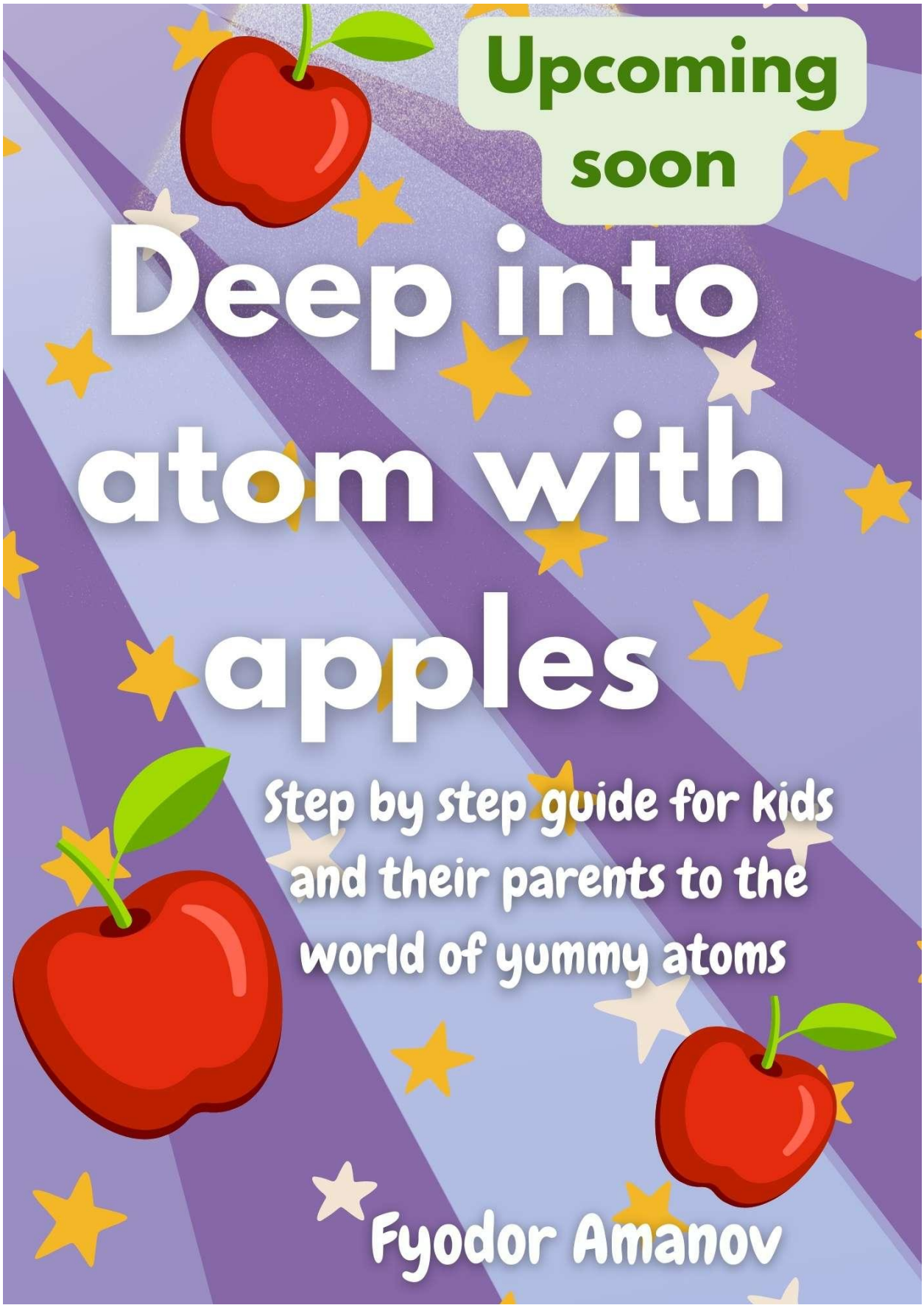


38


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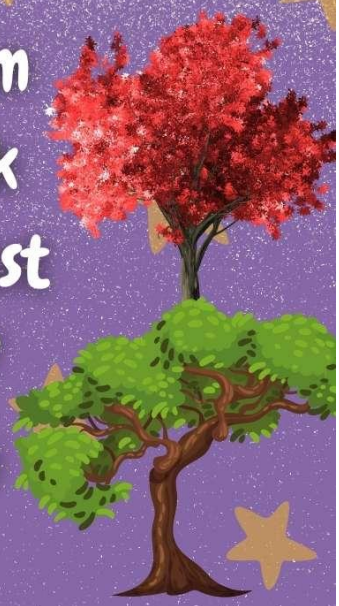

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50


69
53
55
57
60
Some currants
Yes, taste the yummy apple


Upcoming soon
Deep into atom with apples
Step by step guide for kids and their parents to the world of yummy atoms
Fyodor Amanov

Our adventure !

Hello my friend, how glad I am to see you on this ship, I think you know it's one of the fastest ways to reach the islands of Leaf, so soon we will be able enjoy whole their beauty !







You have never visited them ?! Oh, I guess then they will amaze you... Let me tell you a short story...

Upcoming soon

The table of tasty "things"

Quarks rare berries

+ CHARGE


U
Up


C
Charmed


T
Top


D
Down


S
Strange


B
Bottom

Light Heavy Super-Heavy

Bosons vegetables

0 CHARGE 0


γ
Photon


W
W boson


g
Gluon


Z
Z boson


G
Graviton


H
Higgs boson

Light Super-Heavy

Leptons common berries

0 CHARGE


e
Electron


μ
Muon


τ
Tau


ν_e
Electron neutrino


ν_μ
Muon neutrino


ν_τ
Tau neutrino

Light Heavy Super-Heavy


$\bar{\nu}_e$
Electron anti-neutrino


$\bar{\nu}_\mu$
Muon anti neutrino


ν_τ
Tau anti neutrino

A few lines about me

My name is Fyodor and I am from Uzbekistan - the country of limitless kindness and flavorful fruits. I tell it fairly, we have a huge diversity of fruits: apples, melons, watermelons, pears, raspberries, blackberries, currants; you likely got the point - the number is endless; likely because of this I feel so inspired to write and create...

Continue here:

I have some other activities except for writing:

- I adore solving math probs (especially the most bewildering ones)
- I'm in love with playing piano
- I'm up to learning foreign languages: Korean, English
- I'm teaching English to non-natives
- I am saturated by books (especially the non fiction)
- And sure thing, I'm crazy about Quantum physics (the most beloved and fantastic)

Contact me :

Email:

YouTube (quantum)

YouTube (English)

TikTok (Quantum)

Telegram