Science

Scientists at CERN observe three "exotic" particles for first time

Reuters


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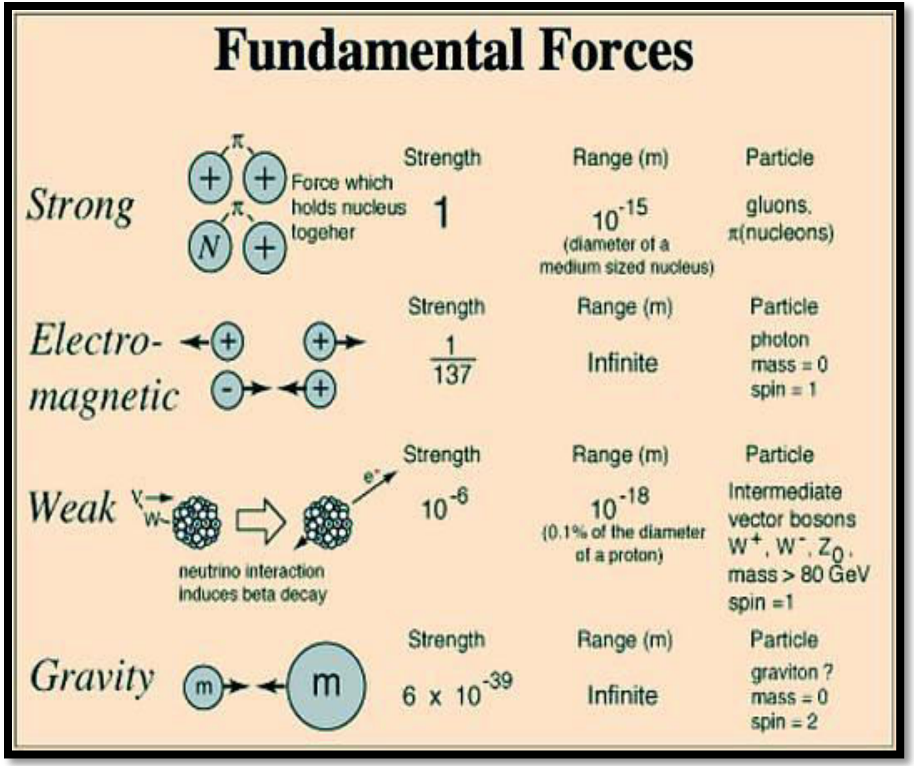
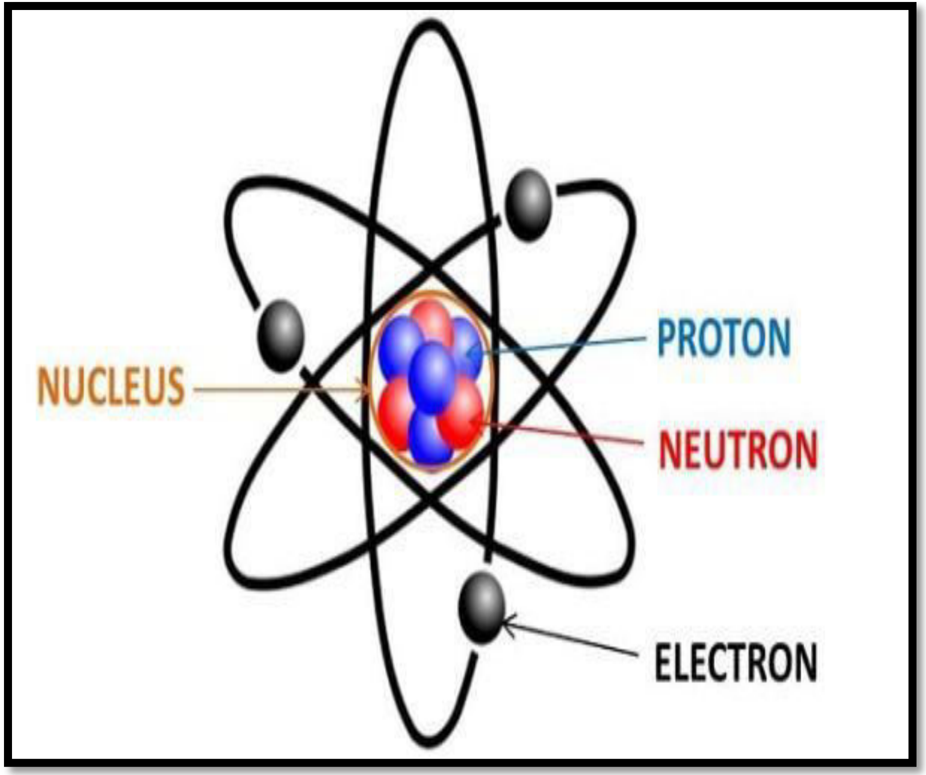
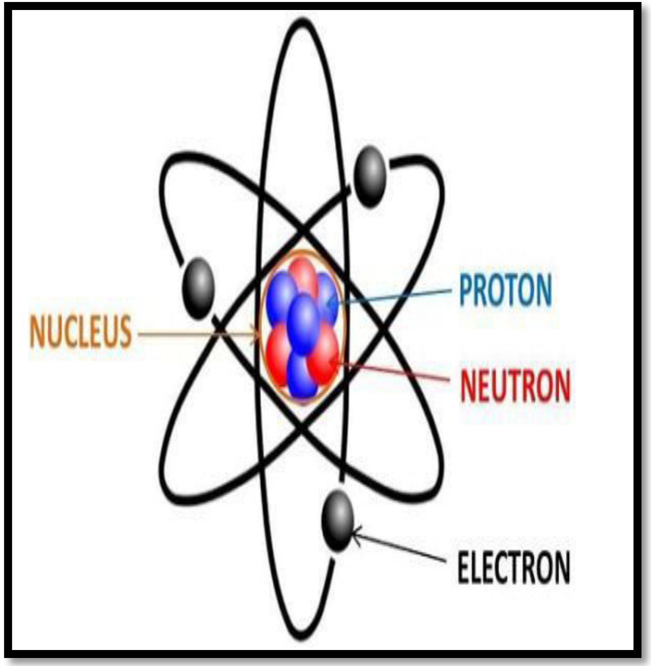
First Things First





What is a Quark?

- Atoms are made up of **two types of elementary particles: electrons and quarks.**
- Electrons occupy a space that surrounds an atom's nucleus. Each electron has an electrical charge of -1.
- **A Quark can be considered as a fast-moving point of energy.** Quarks make up protons and neutrons, which, in turn, make up an atom's nucleus.
  - Protons contain two up quarks and one down quark.
  - Neutrons contain one up quark and two down quarks.



Quark v Hadron

- **A Quark can be considered as a fast-moving point of energy. Quarks make up protons and neutrons.**
  - Quarks come in six different "flavors":
    1. Up quark
    2. Down quark
    3. Top quark
    4. Bottom quark
    5. Charm quark
    6. Strange quark

- In particle physics, **a hadron is a composite subatomic particle made of two or more quarks** held together by the strong interaction. Eg: Mesons, Baryons etc

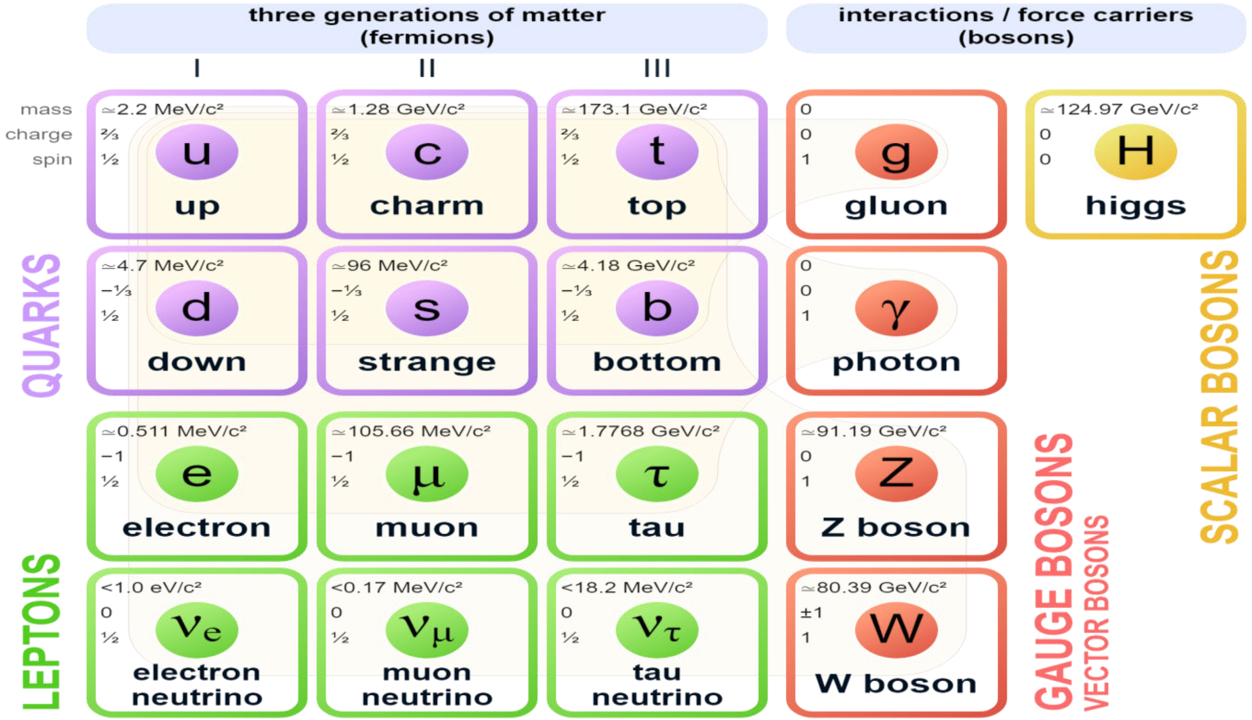
FYI

Quarks*							
quark type	**baryon number**	**charge**	**strangeness****	**charm****	**bottom****	**top****	**mass (MeV)**
down (d)	1/3	−(1/3)e	0	0	0	0	5–15
up (u)	1/3	+(2/3)e	0	0	0	0	2–8
strange (s)	1/3	−(1/3)e	−1	0	0	0	100–300
charm (c)	1/3	+(2/3)e	0	1	0	0	1,000–1,600
bottom (b)	1/3	−(1/3)e	0	0	−1	0	4,100–4,500
top (t)	1/3	+(2/3)e	0	0	0	1	180,000

*Note that antiquarks exist for all flavours of quark and have opposite values for all the quantum numbers listed here.

FYI

Standard Model of Elementary Particles



What is this LHC?

- The Large Hadron Collider is a giant, complex machine built to study particles that are the smallest known building blocks of all things.
- Structurally, it is a 27-km-long track-loop buried 100 metres underground on the Swiss-French border.
- In its operational state, it fires two beams of protons almost at the speed of light in opposite directions inside a ring of superconducting electromagnets.
- The magnetic field created by the superconducting electromagnets keeps the protons in a tight beam and guides them along the way as they travel through beam pipes and finally collide. Just prior to collision, another type of magnet is used to 'squeeze' the particles closer together to increase the chances of collisions.

What is this LHC?

What is this LHC?

- Since the LHC's powerful electromagnets carry almost as much current as a bolt of lightning, they must be kept chilled.

- The LHC uses a distribution system of liquid helium to keep its critical components ultracold at minus 271.3 degrees Celsius, which is colder than interstellar space.

- Three runs of LHC
  1. On July 4, 2012, scientists at CERN had announced to the world the discovery of the Higgs boson or the 'God Particle' during the LHC's first run.
  2. The LHC's second run began in 2015 and lasted till 2018. The second season of data taking produced five times more data than Run 1.
  3. The LHC, re-ignited after three years in April 2022, was cranked up to unprecedented levels of energy on July 5, and has begun smashing together protons at almost the speed of light. The third run will see 20 times more collisions as compared to Run 1.

Science

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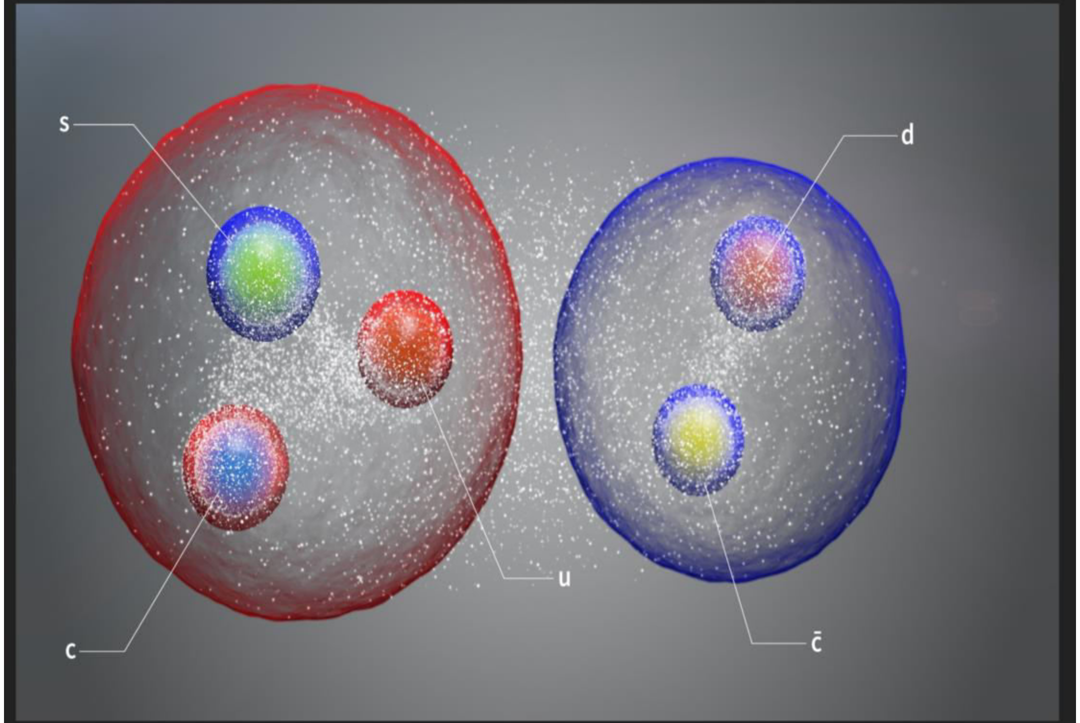
Exotic Quarks

The first kind was observed in an analysis of “decays” of negatively charged B mesons.

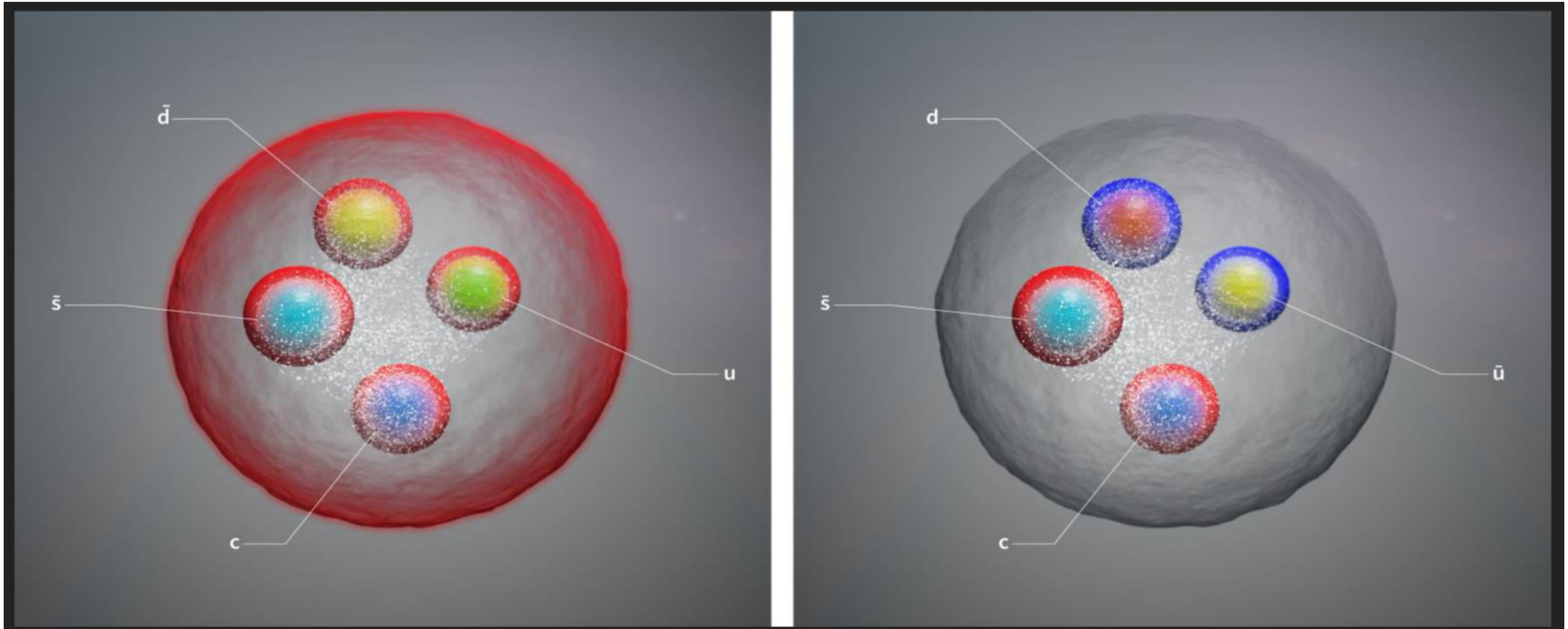
It is a pentaquark made up of a charm quark and a charm antiquark, and an up, a down, and a strange quark.

It is the first pentaquark found to contain a **strange quark.**



A new type of pentaquark, shown as a pair of standard hadrons loosely bound in a molecule-like structure, is made up of a strange, charm and up quark, plus a down quark and a charm antiquark. Credit: CERN

Exotic Quarks



Two new tetraquarks are illustrated here as single units of tightly bound quarks. One of the particles is composed of a charm quark, a strange antiquark and an up quark and a down antiquark (left), and the other is made up of a charm quark, a strange antiquark and an up antiquark and down quark (right). Credit: CERN

What next?

- CERN :
  - The more analyses we perform, the more kinds of exotic hadrons we find.
  - We're witnessing a period of discovery similar to the 1950s, when a 'particle zoo' of hadrons started being discovered and ultimately led to the quark model of conventional hadrons in the 1960s.
  - We're creating 'particle zoo 2.0

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