Even scientists can't keep up with all the newly discovered particles. Our new naming scheme could help

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Physicists at Cern have discovered a plethora of new exotic particles being created in the collisions produced by the Large Hadron Collider over the past few years. So many have been found in fact, that our collaboration (LHCb), which has discovered 59 out of 66 recent particles, has come up with a new naming scheme to help us impose some order on the growing particle zoo

Particle physicists have a rather checkered history when it comes to naming things. As more and more particles were discovered over the course of the 20th century, the nomenclature became increasingly befuddling. For instance, in the group of leptons we have electrons, muons and then taus, but not tauons.

And when two rival teams in the 1970s were unable to agree whether a new particle consisting of two quarks (the smallest building blocks of matter) they had just discovered should be called J or ψ (psi), they ended up awkwardly smooshing the two names together to get J/ψ.

Even today, physicists are unable to agree whether to call the fifth heaviest quark "bottom" or "beauty"—and therefore use the two interchangeably. And let's not even get started on the appallingly named bestiary of particles predicted by the theory known as "supersymmetry," which suggests every particle we know also has a (yet undiscovered) super partner: sstrange [sic], squark, smuon or gluino anyone? Frankly, it's just as well they don't seem to exist.

Complex hadrons

The LHC has been a treasure trove for new types of particles called hadrons. These are subatomic particles made from two or more quarks. Conventionally, these come in two types. Baryons, such as the protons and neutrons which make up the atomic nucleus, are made of three quarks. Mesons, on the other hand, are made of a quark paired with an antiquark (each fundamental particle has an antiparticle with the same mass but opposite charge).

Although there are only six different types of quarks, and only five of these form hadrons, there are a huge number of possible combinations. In the 1980s, particle physicists devised a naming scheme for the hadron zoo, with a symbol for each particle that made it easy to discern its quark content, such as the Greek letter Π (pi) to denote pions, the lightest mesons.

Until recent years, all newly discovered particles fitted nicely into that scheme as either baryons or mesons. But scientists eventually realized that more complicated hadrons with more than three quarks could also be possible: so-called tetraquarks, composed of two quarks and two antiquarks; and pentaquarks, composed of four quarks and one antiquark (or the other way around).

The first clear tetraquark candidates were discovered by the Belle and BESIII collaborations, and labeled Z_c states (this was a random choice, X and Y had already been used to label other states). This was followed by the spectacular discovery of pentaquark states, labeled P_c, by the LHCb collaboration. Since around 2019, the rate of discovery has accelerated, with names such as X, Z_{cs}, P_{cs} and T_{cc} being assigned in a more-or-less ad-hoc fashion, leading to an alphabet soup of particles.

The absence of logic underlying the names given to the new particles led, perhaps inevitably, to some confusion. A particular problem was that the subscript "c" in the Z_c and P_c symbols was meant to imply that these hadrons contain both charm and anticharm quarks (sometimes called "hidden charm"). By contrast, the subscript "s" in the Z_{cs} and P_{cs} symbols implies that these hadrons also contain a strange quark ("open strangeness"). So then what should states that contain both open charm (a charm quark alone) and strangeness, as found recently by the LHCb collaboration, be named?

As the range of new states and their assigned names risked becoming further perplexing, we and colleagues in the LHCb collaboration decided it was time to try to restore some semblance of order—at least for the newly discovered particles. Our new naming scheme, follows some guiding principles. Firstly, the basic idea should be simple enough for non-experts to follow, achieved with a base symbol of T for tetraquarks and P for pentaquarks.

The scheme should also allow for all possible combinations to be distinguished; this is done by addition of superscripts and subscripts to the base to denote which quarks each particle is made from and other quantum information. But these should be consistent with the existing scheme for conventional mesons and baryons—achieved by reusing existing symbols.

Current names for exotic hadrons would need to be changed, however. For example, the Z_{cs} and P_{cs} states mentioned above will become known as $T_{\psi s}$ and $P_{\psi s}$, respectively (the J/ψ particle contains hidden charm), solving the problem of distinguishing hidden from open charm by reusing ψ for the former and c for the latter.

The final guiding principle behind the scheme is that it should be accepted by the wider particle physics community. Although the LHCb collaboration has discovered most of the new particles, which traditionally gives us some naming rights, there are other current and planned experiments in this area, and their contributions are essential for the progress of the field. There are also, of course, many theorists across the world working hard to interpret the measurements that are being made.

Both the general principles and the details of the new naming scheme have been discussed with these different groups, with positive and constructive feedback incorporated into our final version.

A naming scheme is an important part of the language used to communicate between people working in particle physics. We hope that this new scheme will help in the ongoing quest to understand how the so-called strong force confines quarks inside hadrons, for example—a feature that defies deep mathematical understanding.

New experimental results including the discoveries of new hadrons are fuelling improvements in theoretical understanding. Further discoveries could one day lead to a breakthrough. Ultimately, though, the success of the new scheme will be judged by how often conversations include the phrase: "Remind me, which one is that again?"

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