The Prediction And The Discovery Of The X(4500) Particle

In September 2015 I wrote a paper where I predicted the existence of a new particle with a rest mass of $4500\ MeV/c^2$. *The particle which was discovered by CERN's scientists in 2016 seems to be a tetraquark. The particle which is known as X(4500) is a member of a family of possible tetraquarks.*

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July 8^h, 2016 (v1)

Keywords: *Valence quarks, sea quarks, tetraquark, rest mass, mega-electron volt, Large Hadron Collider (LHC), LHCb experiment, extrapolation.*

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1. September 2015 - The Prediction of the $X(4500)$ Particle

In a paper I wrote in 2015 [1] I used the interpolation approach to predict the existence of a new particle. The particle is now known as *X*(4500). Table 1 shows the three particles I used to make the prediction: *Y2, Y3* and *Y4.*

PARTICLE NAME	SYMBOL	QUARK CONTENT OR LEPTON	OBSERVED REST MASS *(MeV/c^2)*	OBSERVED REST MASS *(Kg)*	"ALLOWED" QUANTUM NUMBERS (*n*)	PREDICTED REST MASS *m* (*Kg*) (Equation 2.5)
Y2	*Y*(4140)	?quark	4140	7.380220033E-27	2725	7.3821250031E-27
Y3	*Y*(4260)	?quark	4260	7.594139454E-27	2777	7.59431590343E-27
Y4	*Y*(4380)	?quark	4380	7.808058876E-27	2827	7.804095291E-27

Table 1: *Rest mass of three exotic particles: Y2, Y3 and Y4 used to predict the existence of X(4500).*

We start by observing the mass of the particle *Y2*. The value for the mass of *Y2* is 4140 MeV/c^2.

a) **Step 1:** If we add 120 MeV/c^2 to this value we get the mass of *Y3,* which is 4260 MeV/c^2.
b) **Step 2:** If we add 120 MeV/c^2 to the mass of *Y3* we get the mass of *Y4*, which is 4380 MeV/c^2.
c) **Step 3 -The extrapolation approach:** Now we extrapolate and add 120 MeV/c^2 to the mass of *Y4*. Thus we obtain a mass of 4500 MeV/c^2. This mass corresponds to the recently discovered particle: *X*(4500). I applied this method in a paper I published in September 2015 [1]. The following table shows the predicted particle *X*(4500).

PARTICLE NAME	SYMBOL	QUARK CONTENT OR LEPTON	OBSERVED REST MASS *(MeV/c^2)*	OBSERVED REST MASS *(Kg)*	"ALLOWED" QUANTUM NUMBERS (*n*)	PREDICTED REST MASS *m* (*Kg*) (Equation 2.5)
Y2	*Y*(4140)	?quark	4140	7.380220033E-27	2725	7.3821250031E-27
Y3	*Y*(4260)	?quark	4260	7.594139454E-27	2777	7.59431590343E-27
Y4	*Y*(4380)	?quark	4380	7.808058876E-27	2827	7.804095291E-27
X (predicted)	*X*(4500)	Tetraquark?	4500	8.022E-27	(2878)	(8.024041186E-27)

Table 2: *The cyan row (darker blue colour) shows the predicted particle, X, with a rest mass of 4500* MeV/c^2

2. June 2016: The Discovery of the $X(4500)$ Particle

In 2016 the LHCb experiment at CERN's Large Hadron Collider reported the discovery a family of four tetraquarks which were named based on their respective masses: *X*(4140), *X*(4274), *X*(4500) and *X*(4700) [2, 3, 4]. The number in brackets is the mass of the particle in mega-electron volts. The quark composition of these four particles is identical but they differ in their masses and their quantum numbers (although they all have the same electric charge). The masses of these particles is different because the four valence quarks are arranged differently in three dimensions. In other words, the binding of the four valence quarks, due to the strong interaction, is different for each of the four particles.

In particular, we are interested in the particle X(4500), whose mass, quark composition and electric charge are shown on table 3.

CERN'S NOMENCLATURE (Observed)	AUTHOR'S NOMENCLATURE (Predicted)	OBSERVED MASS MeV/c^2	PARTICLE COMPOSITION (valence quark contents)	ELECTRIC CHARGE (times |e|)
$X(4500)$ or $X1(4500)$	$T_{c\bar{c}s\bar{s}}(4500)$	4500 (*)	Possibility 1 $(c\bar{c}s\bar{s})$	0
	$T_{ss\bar{c}\bar{c}}(4500)$		Possibility 2 $(ss\bar{c}\bar{c})$	-2
	$\bar{T}_{\bar{s}\bar{s}cc}(4500)$		Possibility 3 $(\bar{s}\bar{s}cc)$	+2

Table 3: *The mass, particle composition and electric charge of X(4500). * The observed or measured mass, considering the errors, is:* $4506 \pm 11 + 12 - 15$ [2]. *Note that the uncertainty in the rest mass is relatively very small and consequently is in excellent agreement with the predicted value.*

3. Conclusions

Using the interpolation approach I predicted the existence of a new particle – the X particle (tetraquark?) denoted: X(4500). The nature of the particle was unclear at the time of the mass prediction (and is still not totally clear). The mass prediction was made in September 2015 [1]. The particle was discovered in 2016 by CERN's scientists. The following table illustrates the timeline of this particle:

DATE OF PREDICTION OR DISCOVERY and (SOURCE OF PREDICTION OR DISCOVERY)	PREDICTION or DISCOVERY	PAPER
27 Sep 2015 (Predicted by the author)	PREDICTION New particle of unknown nature with a mass of 4500 MeV/c^2	*Numeric Formula for the Masses of Baryons, Tetraquaks and Pentaquarks (The "Alpha-12" Mass Formula),* vixra.org, viXra:1503.0140, (2015). [1]
25 Jun 2016 (Discovered by CERN's scientists)	DISCOVERY Tetraquark with a mass of 4500 MeV/c^2	*Observation of $J/\psi\,\phi$ structures consistent with exotic states from amplitude analysis of $B^+ \rightarrow J/\psi\,\phi\,K^+$ decays,*arXiv:1606.07895v, (2016). [2]

Appendix 1
Glossary

Valence Quarks

Quarks that are not a part of the virtual quark/anti-quark pairs.

Sea Quarks

Quarks that are part of the virtual quark/anti-quark pairs (that exist inside the particle).

REFERENCES

[1] Rodolfo A. Frino, *Numeric Formula for the Masses of Baryons, Tetraquaks and Pentaquarks (The "Alpha-12" Mass Formula),* vixra.org, viXra:1503.0140, (27/09/2015).

[2] CERN (The LHCb collaboration), *Observation of $J/\psi\,\phi$ structures consistent with exotic states from amplitude analysis of $B^+ \rightarrow J/\psi\,\phi\,K^+$ decays,*arXiv:1606.07895v1 [hep-ex], (25/Jun/2016).

[3] Symmetry Magazine (S. Charley), *LHCb discovers family of tetraquarks,* Retrieved from "http://www.symmetrymagazine.org/ article/lhcb-discovers-family-of-tetraquarks", (29/06/2016).

[4] CERN (S. Pandolfi), *LHCb unveils new particles,* Retrieved from: "https://home.cern/about/updates/2016/07/lhcb-unveils-new-particles", (1/07/2016).