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Exotic cosmic ray families: a new class of events or an unknown mode of activity of a known source

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Cosmic ray experiments with x-ray emulsion chambers, ever since they became to work, praised that which they could not explain. At present stage, using standard physics, it is possible to answer some string of puzzles of the past (for instance, Centauro). A history teaches us that a project of unique complexity hardly brings correct result right the first time. The cosmic ray study shows that the unusual is normal. We discuss the present status and the perspectives.

1. Introduction

The basic realities of experiments with x-ray emulsion chambers are astounding if not mysterious [1-7]. A comprehensive, thorough exposition of the emulsion chamber' curiosities would require many thick volumes. For a long time there have been a debate on the source of the exotic origin: either astrophysical source (that is mainly problem of primary cosmic ray composition), or nuclear physics (new particle interaction mechanism). Certainly, the source could be also attributed to both, exotic particle and exotic interaction. It is becoming clear that with increasing number of exotic events of all kinds, one has to go back to the original data set and the original thought frame, in order to re-analyze and, if necessary, re-evaluate, previous conclusions and assumptions (see Table 1). A history teaches us that a project of unique complexity hardly brings correct result right the first time. Our goal is not to explain well-known oddities, but rather to offer fresh material to share. The choice of topics is based on recent scientific revelations and our own sense of what is likely to fascinate scientists. The puzzles and patterns.

The Centauro-I event has challenged numerous models of theoretical physics since its reported discovery in 1980th . As we have shown [8], "the Centauro type event" could only be created under certain "experimental conditions". Usually, "exotic families" appear in the detector as unexpected signal. It is some kind of "by-product" signal, quite different from the original detector intent. Previous experiments were not specifically designed to hunt for Centauro. The data were typically cut down to include only specific interpretation scenario. History teaches us that sometimes in experiment the complex outcome of the detector setup is not predictable. Taking into account the details of the real Chacaltaya chamber setup [8.9], changes the whole story. Since there were gaps in the detector , which were comparable with a geometrical size of a narrow air family, we could expect two possibilities. Either family showers pass through the gap (the whole family, the part of the family , or some family showers), or do not. This predicted pattern of the detector behavior was observed and confirmed in experiment [8,9]. Thus, an assumption had been tested.

As a positive outcome of the whole study, we got new insights about detectors in cosmic ray experiments. Through a comparison of different data sets we found [10] that the apparently inconsistent results of the experiments with emulsion chambers are most likely from the differences in the estimation of the detector response. The experiment with x-ray emulsion chambers involves many choices. It is crucial, that all of these choices were made without any prior knowledge of the outcome of the experiment. Otherwise, the statistical significance of the result would be extremely questionable. For instance, in case of Centauro there is no automatic correlation between the location of a shower in the lower detector and identification of shower as a hadron. It is only when both the upper and lower blocks are involved that we may have to invoke new physics. If a signal is observed only in the lower chamber, then we should not reject any mundane explanations that are perceived to be improbable.

Thinking sometimes about miniscule probabilities of the event occurrence (see, for instance, estimations for an exotic event from [5]), it's easy to cross the border into speculation about what is impossible. How unlikely must an event be, before it can be dismissed as impossible? To be qualified as unusual, the event must be rare. If an event has happened, its chance of occurring becomes 100 percent. The problem with cosmic ray experiment with emulsion chamber is that the unusual is normal. There are hadron rich, gamma rich, wide, narrow, etc. events. A particular set of outcomes can be unlikely. But one of them must occur.

The world is full of probabilities, rather than certainties. Since world is made from subatomic particles, one may expect that some outcome of the quantum world could happen on macroscopic level. Even extremely improbable events must occur, if one takes many billions of years. Science is based on observation. People who look for associations, usually find them. The anomalous event may have an actual effect on the mood and emotions, originating from expectations and belief. A collective mindset can be created, especially considering event with mythical link. In this sense, some of the event's peculiarities may be valid.

2. Discussion

Dealing with unusual events with peculiar characteristics, we have a situation, when, from a single measurement one has to deduce two unknowns: the composition and the dynamic of particle interactions. Nevertheless, there are certain objective patterns we would expect to see, either in the detector response, or in the behavior of secondary particles from certain primary particle origin, that might tell us a story [11].

We have to mention that mundane explanation [7-11] is based on the assumption of inelasticity $K \sim 0.5$. From our result on inelasticity, the average value $\langle K \rangle$ is the same for light nuclei and for a lead nucleus. The absence of the nuclear target effects contradicts certain types of nuclear models, where the incident particle is simply followed through its successive collisions throughout a target nucleus. This may suggest the importance of the coherence of successive sub-collisions in nucleus.

The composition of cosmic rays reflects their abundance in their sources. The evidence for this assumption is found, for instance, in the composition of solar cosmic rays. Abundance of high energy cosmic rays in heavy elements, richer than the cosmic abundance, will point to a supernova origin. The abundance of heavy nuclei will be a clue for the study of acceleration mechanism of cosmic rays as well as the structure of the objects in the universe.

Where can we expect the signal of the new? We can express it as follows.

There is always a possibility to meet an unexpected signal in a traditional cosmic ray detector (chance discovery). Most likely this signal will be apart from original intent of the detector.
The new signal will appear while studying extreme conditions. Extremely high densities, as in heavy nucleus-nucleus collisions, extremely short time periods (considering the very early stage of hadron formation), extremely high energies cosmic ray particles , and extremely large objects of astrophysical origin. In those cases statistics, total exposure and accuracy of emulsion chambers would not be enough.

3. Conclusions

One need a range of careful observations, a set of objective patterns and predictions, in order to test the hypothesis of “reality”. This approach also can have a “failure of imagination”. It will only prove the subtle way of nature.

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References

[1] C.M.G.Lattes et al., Phys. Repv. 65, 151 (1980).
[2] S.Hasegawa et al., Nucl. Phys. B474, 141 (1996).
[3] L.T.Baradzei et al., Nucl. Phys. B370, 365 (1992).
I.V.Rakobolskaya et al., Peculiarities of Super High Energy Hadron Interactions (MGU press, Moscow,), p.256 (2000).
[4] T.Arisawa et al., Nucl. Phys. B424, 241 (1994).
[5] M.Ichimura et al., ICRR-Report-225-90-18, (1990).
[6] A.V. Apanasenko et al., Proc of 15th International Cosmic Ray Conference, Plovdiv, Bulgaria, vol.7, p.220 (1977).
A.V. Apanasenko et al., Proc of 17th International Cosmic Ray Conference, Paris, France, vol.5, p.319 (1981).
L.A. Goncharova et al., Proc of 22nd International Cosmic Ray Conference, Calgary, Canada, vol.4, p.21 (1993).
V.I. Osedlo et al., Proc of 27th International Cosmic Ray Conference, Hamburg, Germany, edited by M.Simon, E.Lorenz, M. Pohl (Dat-Hex., OG Katlenburg-Lindau, p.1426 (2001).
[7] V.Kopenkin and Y. Fujimoto, 29th ICRC, Pune (2005) .
[8] V.Kopenkin and Y.Fujimoto, and T.Sinzi, Phys. Rev. D 68, 052007 (2003).
[9] V.Kopenkin, Report on research activity to FAPESP (Fundacao de Amparo a Pesquisa do Estado de Sao Paulo), 1996.
[10] V.Kopenkin et al., Phys. Rev. D 65, 072004 (2002).
[11] V.Kopenkin and Y.Fujimoto, Phys. Rev. D 71, 023001 (2005).

Table 1. Exotic cosmic ray signal in emulsion chambers

Experiment	Event (feature)	Exotic hypothesis	Mundane explanation
Chacaltaya emulsion chamber [1]	Centauro-I Small shower multiplicity in the upper chamber Large multiplicity in the lower chamber	New hadron interaction mechanism New particle New phenomena	The upper and lower families are not products of the same interaction, Specific features of the detector setup [8]
Chacaltaya emulsion chamber [2]	Centauro species (Chiron, mini-clusters, etc.)	New mechanism of interaction and particle production	Fluctuations within standard hadronic physics, Estimation of the detector response [10]
Pamir emulsion chamber [3,4]	Long mean free path Short mean free path	New particle New mechanism New state of matter	Estimation of the detector response [10]
Sanriku Balloon emulsion chamber [5]	ET-track (Unusual penetrating particle with almost horizontal arrival direction)	New particle New mechanism	Specific feature of the balloon flight (the chamber might not have been flat) [5]
Balloon Trans-Siberian flight 1975 [6]	Peculiar superfamily (High multiplicity central jet, Ring like structure, Alignment of showers in the center, Halo)	New mechanism of interaction and particle production	A heavy primary origin particle [11]
Pamir x-ray emulsion chamber	Structure-less event SDX6987 [7]	A variety of possibilities	A heavy primary origin particle [7]