OG. 1.2.04

A STUDY OF THE PRIMARY MASS COMPOSITION IN THE "KNEE" REGION USING X-RAY EMULSION CHAMBERS

T.S. Yuldashbaev, O. Bezrukova, Kh. Nuritdinov, A.N. Nosov
Physical-Technical Institute of Academy of Science, 700084, Tashkent, Uzbekistan

Abstract

Large scale X-ray emulsion chambers (XREC) can be used as an alternative method of Primary Mass Composition (PMC) determination. In the paper presents the results of data analysis of "Pamir" XREC experiment. Different sensitive selection criteria of gamma-families are used for PMC determination at the energy region Eo=3-30 PeV.

1. Introduction

The nature of the knee in Primary Cosmic Rays (PCR) energies spectrum at $E_0 > 3 \cdot 10^{15}$ eV is not cleared up to now. At present, there are some interpretations of this phenomenon are proposed. In connection with PCR mass composition determination in the region above $E_0 > 3$ PeV is very important for the understanding of knee problem. According to the diffusion model of cosmic rays propagation, with increasing of particles energies at the $E_0 > 3$ PeV, grows the diffusion coefficient and PCR accumulation decreases [1]. In that case PCR mass composition should be a considerably enriched by heavy nucleus. On the other hand, Hillas model [2] predicts the protons dominant composition after knee region.

In the paper presents the results of Primaries Mass Composition (PMC) analysis performed on the basis of X-ray emulsion chambers (XREC) “Pamir” experiment data. Large scale XREC are an alternative method of the PMC investigation. Since the minimal registration energy of secondaries E_{min} above 4 TeV, these data, concerning to fragmentation region of incident particles, are more sensetive to mechanism of primary hA strong interactions and PMC.

2. Method

In this paper on the basis of Quark-Gluon String (MCO) strong interaction model [3] a number of gamma-families characteristics χ_n , d, sensitived to PCR composition are considered. These characteristics were used for the elaboration of the selection criteria of gamma-families originated from primary pA (P-families) and AA (A-families) interactions. In the model close to "normal" chemical composition of PCR enriched by heavy nucleus at the energies above 1 PeV according to Table is assumed. In table presents also PMC for the same as a MCO strong interaction HMCO-model with heavy composition.

Table 1
The chemical composition of primary cosmic rays in the models

	MCO		HMCO	
E_0, PeV	1	10	1	10
P	0,36	0,28	0,12	0,06
He	0,20	0,18	0,25	0,23
CNO	0,11	0,13	0,26	0,28
VH	0,11	0,12	0,15	0,16
Fe	0,22	0,27	0,22	0,27

It were considered the following family characteristics:

- $\chi_t = \Sigma E_\gamma / E_t$, where $\Sigma E\gamma$ - visible family energy, $E_t = \Sigma E_i R_i$ - transverse energy flux of the particles with energies E_i situated on the distance R_i = 1-30 cm from family centre.

- $d = n_\gamma / n_{in}$, where n_γ - number of observed, n_{in} - number of initial family particles, obtained after using decascading procedure.

Fig.1 presents the distributions of these characteristics normalized on the average values $<\chi_t>$ and <d>. As can see from Fig.1, considerable differences of the characteristic distributions for P- (open points) and A-families (black points) are observed. Experimental data (cross points) are placed between these values.

Also, it was considered the following selection criteria parameters: "efficiency" $\eta = N^{cr}/N$, background rejection coefficient $J = N_b/N_b^{cr}$ and background events fraction $\Pi_b = N_b^{cr} / (N^{cr} + N_b^{cr})$, where N^{cr}, N_b^{cr} - number of selected and background events satisfied to criteria; N, N_b - number of initial selected and background events registered by the XREC.

According to obtained results, for the A-families normalized selection criteria $\chi_t < <\chi_t>$, $d < <d>$, week dependence of the parameters on the wide set models are observed. At the region $E_0 > 10$ PeV the criteria parameters are equal to following values: $\eta = 0.75 \pm 0.04$, $J = 2.1 \pm 0.2$, Π_A = 0,20-0.30. That is enable us to estimate the fraction of A-families Δ_A registered by XREC at the observation level.

3. Results

It the paper Pamir experimental data consisted of N_0 = 699 families with energies ΣE_γ = 100 - 700 TeV, $n_\gamma \geq 4$ and minimal energies of particles $E_\gamma^{min} > 4$ TeV are considered.

Fig.2 presents the dependence of fraction of events Δ_χ satisfied to criteria $\chi_t < <\chi_t>$ on E_t for the MCO and HMCO models and experiment. HMCO is the same MCO strong interaction model, with more heavy that “normal” PCR composition (see Table). As can see from Fig.2 experimental data contradict to HMCO model supposed “heavy” PCR composition and reproduced by the MCO model. For the values Δ obtained by using criteria $d < <d>$, similar dependencies on E_t in the MCO and HMCO models are also observed. Therefore, obtained data are in agreement with “normal” PCR composition enriched by heavy nucleus at the energy region above 10 PeV.

References

1. Ptuskin V.S., Rogovaya S.I., et al. 1993, Astron. Astrophys. 268, 726S
2. Hillas A.M. 1979 Prac. 16th Int. Conf. on Cosmic Rays (Kyoto) vol.8, p.7
3. Muchamedshin R.A., Izv. 2AS., Ser.phys, 1997, v61, n.3, p 434

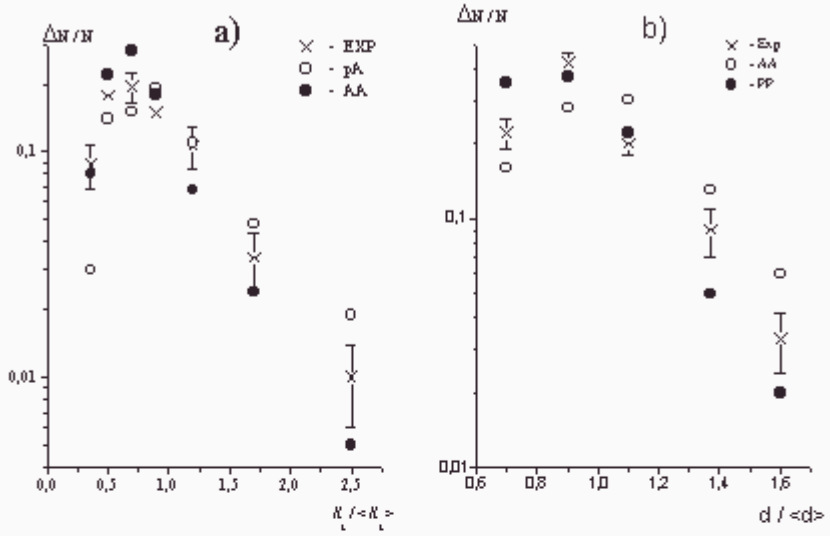

Figure 1. The distributions of the normalized values n_t and d in the models and experiment.

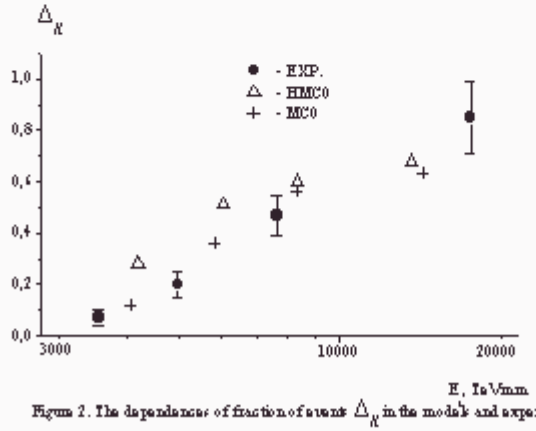

Figure 2. The dependences of fraction of events Δ_n in the models and experiment.