ON THE ISSUE OF DETECTION DARK MATTER PARTICLES

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. Analyzing the spectra of ultrahigh-energy cosmic rays (photons), confirmation of the existence of new particles - X17 and X38 bosons, with masses of 17 MeV and 38 MeV, respectively, has been found. These particles are not Standard Model particles. They were discovered earlier in experiments on accelerators. These experiments need independent confirmation, which was analyzed in our previous works within the framework of a thermodynamic model. In the present work, using the thermodynamic approach, an independent confirmation of the existence of these particles, which are candidates for the role of dark matter particles, is obtained..

Using the black body formula, it is possible to describe both the spectra of strange particles and the spectra of new particles X17 and X38 with the found temperature already for a "cold" electromagnetic plasma, when compared with experimental data for soft photons.

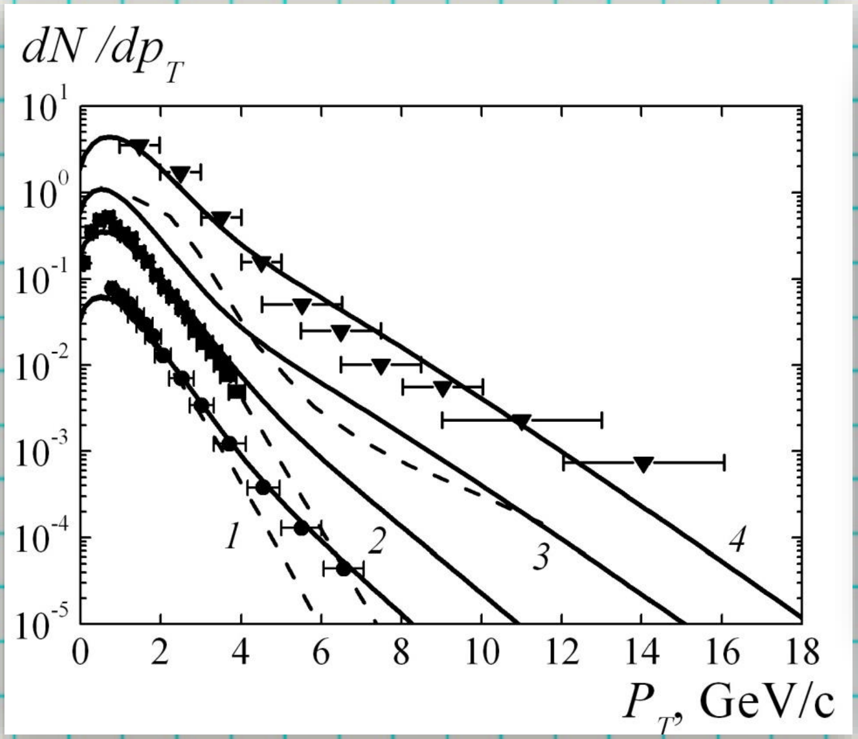
"... важно сконцентрировать имеющиеся ресурсы на основных прорывных направлениях..." В.В. Путин

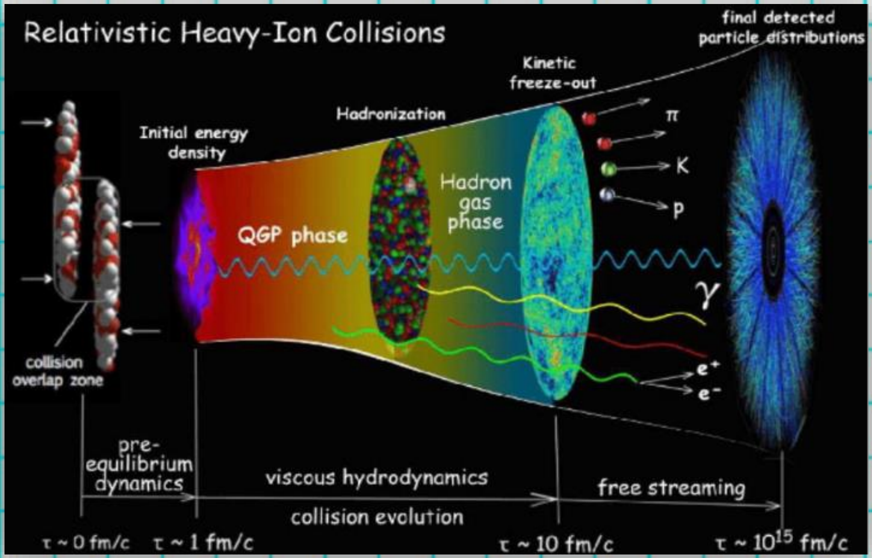
In [1-3], we have shown the manifestation of new X17 and X38 particles with masses of 17 MeV and 38 MeV from the spectra of soft photons in collisions of protons and nuclei at high energies. They were discovered earlier in the experiments of the Hungarian ATOMKI group (boson X17) and in collisions of protons and high-energy nuclei at the International Nuclear Centers CERN (Switzerland) (boson X17) and JINR (Dubna) (boson X38). These new particles can be considered dark matter particles. Recall that the visible part of the mass of the Universe is only 5% in the Universe. The obtained indications of the existence of these new particles need independent confirmation.

- ✓ *That is, such an interpretation of the spectrum of soft photons (its hardening) can serve as another evidence in favor of the existence of a new particle, the X17 boson. On the same Figure 1 also shows the contribution of photons from the decay of another new particle, the X38 boson with a mass of 38 MeV (dash-dotted line), predicted in experiments carried out in Dubna [5]. However, its contribution appears only at the tail of the spectrum and is weakly visible in the figure. Note that such a hardening of the photon spectrum is not obtained due to the contribution of photons from the hot spot. Since in this case its contribution is 10 times less than the total cross section, and the photon mass is zero, the hardening of the photon spectrum in the energy region of 20 MeV due to the higher hot spot temperature is still negligibly small.*

LHC

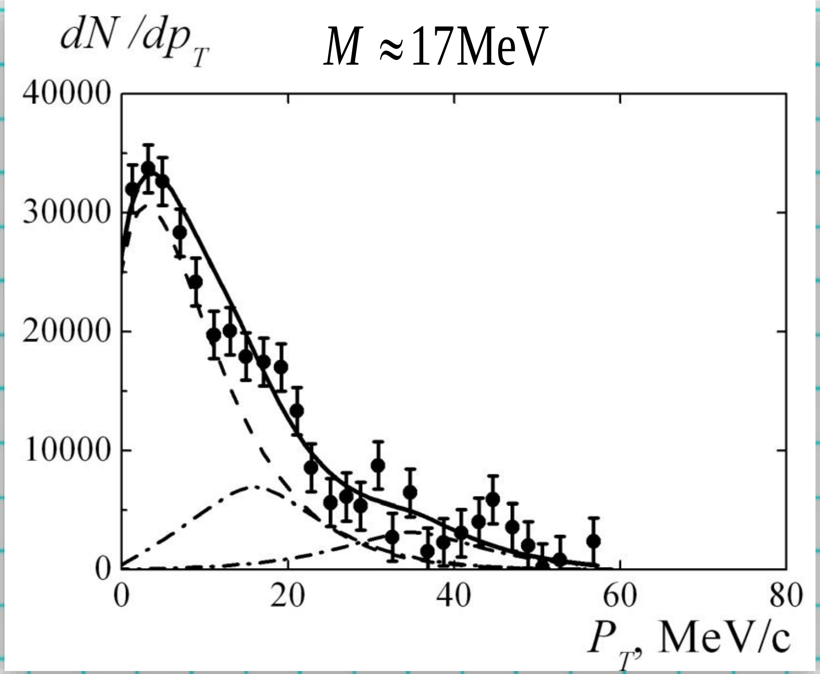
$$\frac{dN}{dp_T} = CTp_T \exp\left(-\frac{\sqrt{m^2+p_T^2}-m}{T}\right) \quad T = \left(\frac{E_0}{g_Q V_R}10^9\right)^{1/4} \quad g_Q = (2\times 8 + \frac{7}{8}2\times 2\times 3\times 3) = 47$$





Dark matter for soft photons

$\mathrm{p} + \mathrm{p} \rightarrow 2\gamma + \mathrm{X}$ $\quad M^2 = 2\pi\rho n \quad$ $\mathrm{p} + \mathrm{C} \rightarrow 2\gamma + \mathrm{X}$



On Figure 1 shows the experimental spectrum of soft photons (points [4]), as well as the calculation with allowance for the X17 boson (solid line) and without it (dashed line), the dash-dotted line is the contribution from the X17 boson. It can be seen from the figure that, without taking into account the contribution from the X17 boson, the calculation underestimates the experimental data, and taking this contribution into account reproduces them

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DISCUSSION

- The X17 boson predicted in Refs [6, 7] may manifest itself in the spectrum of soft photons. This was reported in Wong's papers [8, 9] as well as in our papers [1-3]. Wong [8] proposed an interpretation of this boson as a result of combining QCD and QED. In this case, the union is performed for two-dimensional $QCD_2 \times QED_2$ in the tube model
- In [1], we proposed a modified tube model. In this case, as well as Wong [8], we consider both the hadronic tube at the coupling constant $\alpha = \alpha_s$ and the electromagnetic tube at $\alpha = \alpha_e = 1/137$.The tube radii are determined from the minimum energy per unit length, and the strong interaction constant is $\alpha_s \approx 0.5$ .According to the model of a tube stretched between two quarks [1], one can find the masses of the resulting hadrons, and in the case of an electromagnetic tube, the mass of the X17 boson. In this case, according to [10, 11], the energy density of the tube consists of two terms:

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$$\rho = A + G \qquad (1)$$

- The first term A is determined by the field strength E. If the field were distributed uniformly, then the energy per unit length of the tube of radius r would be distributed into the hemisphere, equal to

$$A = E^2 \frac{2\pi}{4\pi} \pi r^2 = \frac{1}{2} E^2 \pi r^2 \qquad (2)$$

But, since in the direction of the length of the tube it is necessary to sum only the solid angles multiplied by $\cos\theta$, the projections of the unit vector onto the direction of the tube, then the solid angle

$$\Omega = \int_0^{\pi/2} \cos\theta \sin\theta d\theta \int_0^{2\pi} d\varphi = \pi \qquad (3)$$

but not 2π. That's why

$$A = E^2 \frac{\Omega}{4\pi} \pi r^2 = \frac{1}{4} E^2 \pi r^2, \qquad (4)$$

where the intensity vector E flux is $\Phi = \int_0^{\pi/2} E \cos\theta d\theta \int_0^{r} 2\pi r dr = E\pi r^2$, and intensity

$$E = \frac{\Phi}{\pi r^2} = \frac{g}{\pi r^2}$$

and the coupling constant $\alpha = \frac{g^2}{4\pi}$, r is the radius of the tube.

Hence $$A = \frac{\alpha}{r^2} \qquad (5)$$

The second term is expressed in terms of the bag constant $B = 0.17$ GeV/fm^3 [12]:

$$G = B\pi r^2 \frac{\alpha}{\alpha_s} \qquad (6)$$

where we introduced the ratio of the constant α to the strong interaction constant α_S. Here fm=5 GeV^{-1}

- For an oscillating rectilinear string-tube, we obtain [10] the mass :
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$$M^2 = 2\pi\rho n \qquad (7)$$

- where *n* is the quantum number. For the hadron tube at *n=1*, we obtain
- $M \approx 152$ MeV for the π^0 -meson. But if the bag constant is chosen equal to 0.13 GeV/fm^3, then for the π^0- meson we obtain a $M \approx 140$ MeV value that is closer to the experimental one. For an electromagnetic tube with the same tube radius, we obtain the mass of the neutral **X17 boson 17 MeV**. According to the formula $M^2 = 2\pi\rho m$, resonances can also be obtained, where *m* is a multiple folded string with rotation. So you can get the mass ρ - meson, and for the electromagnetic string we get the mass of the **X38 boson 34 MeV** at $m = 4$, obtained in Wong's work in a different way.
- Note that these results were obtained in our approach using formulas different from Wong's. In his work [8], Wong proposes to interpret the **X17 boson as a dark matter particle, since it is neutral, not a baryon**, and can be a composite particle of large-mass astrophysical objects.

Ultrahigh energy cosmic ray

- In this paper, it is proposed to check the manifestation of these new particles in the spectra of cosmic rays of ultrahigh energies of the order of 10^{19} eV. Indeed, bursts in the spectrum of cosmic rays in the energy region of 10^{11} GeV were obtained in [13, 14], which are interpreted in [15] as a manifestation of a dark photon. This dark photon has a mass different from zero, but very small, less than 10^{-6} eV.
- We propose an interpretation of these bursts as a contribution from the decay of new X17 and X38 particles in the framework of our approach [1-3]. Indeed, the contribution from the decay of the X boson into photons can be approximately represented as
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$$\frac{dN}{dE} \sim p \exp\left(-\frac{\sqrt{m^2 + (p - p_0)^2} - m}{T} G \right) , \qquad (8)$$

- where m is the mass of the X-boson, p is the momentum, T is the temperature, G is the effective Lorentz factor, taking into account the motion of X bosons in cosmic rays, p_0 is the position of the burst.
- In order to determine the temperature T and the factor ***G,*** we use an approximation of the cosmic radiation spectrum before the burst
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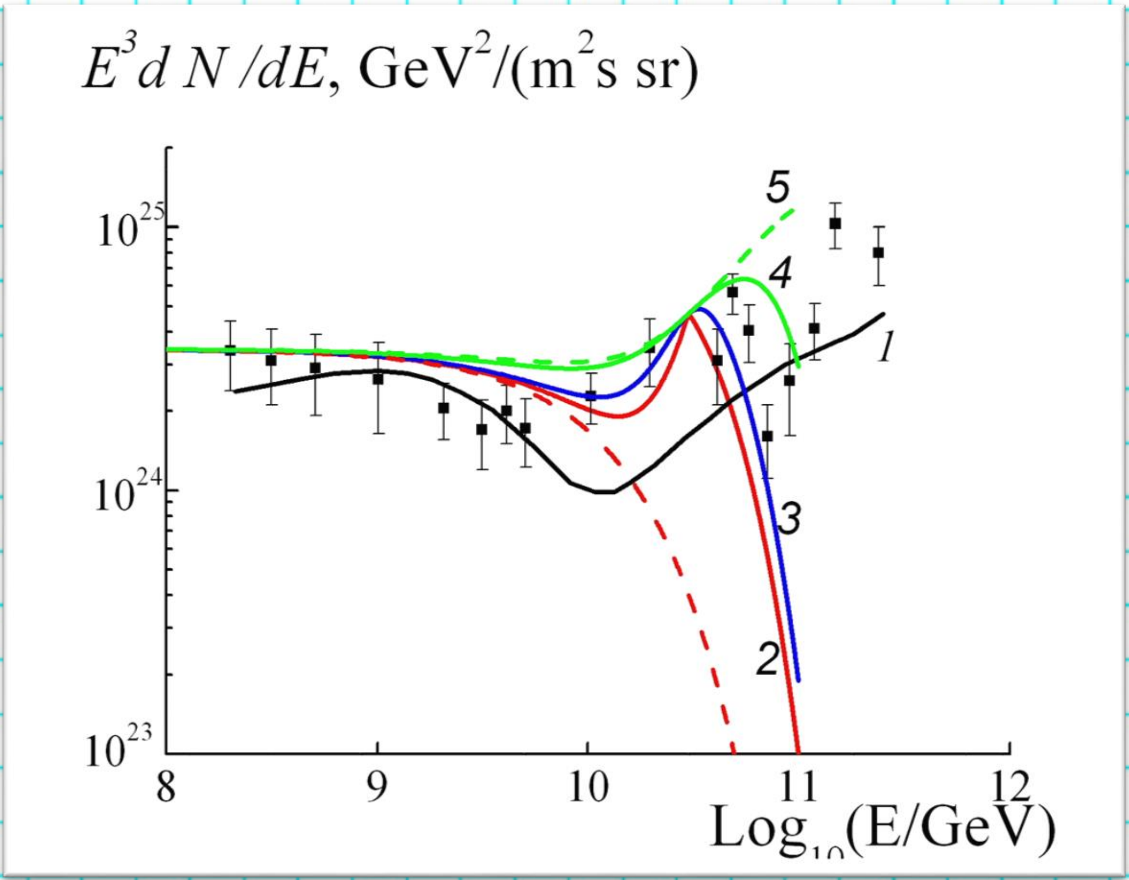
$$\frac{dN}{dE} \sim \exp\left(-\frac{p}{T} G \right) \qquad (9)$$

- which is known and approximately proportional to E^{-3} . From here we find G, assuming that the temperature $T \approx 14$ MeV is about 10 times less than the temperature of hadrons 140 MeV, since we are interested in electromagnetic interactions. The same is true and of our X-bosons. Included in formula (8) is found from the definition of the peak maximum.
- Approximately $p - p_0 \approx T / G$ relative to the tail of the spectrum (9) for small m . As a result, we compared this with experimental data. We compared the experimental points from [13, 14] and the data from [15] for an ultralight dark photon



- **Figure2.** Spectrum of ultrahigh-energy cosmic rays. Experimental points from [13, 14]. The solid curve *1* is the spectrum from a dark photon from [15]. Solid curve *2* is our spectrum of photons from the X17 boson decay in accordance with formula (8), dashed curve without taking into account the boson decay according to formula (9), Solid curve *3* corresponds to a mass of 1000 MeV, curve *4* corresponds to a mass of 10 GeV, dashed curve *5* corresponds to mass 100 GeV
- Curve *1* from
- **P, Tantirangsri, D. Samart, C. Pongkitivanichkul. ArXiv 2301.11122 v1[hep-ph].**
- **Points from**
- **M. Takeda, N. Hayashida, K. Honda et al. Phys.Rev. Lett. 81, 1163 (1998).**
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CONCLUSION

- Thus, we are convinced that one more confirmation of the existence of X17 and X38 bosons with masses of 17 MeV and 38 MeV has been obtained in the light of experimental data from cosmic rays for ultrahigh energies that are not achievable with modern accelerators. Heavy particles of large mass also do not contradict these experimental data.
- The proposed thermodynamic method has a wide range of applications. It can be used to describe the emission of photons in applications in optics, space research, and other fields.

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THANK YOU !