**A cosmic flash of unusual energy has been recorded by scientists**

The Carpet-2 installation of the Baksan Neutrino Observatory of the Institute for Nuclear Research of the Russian Academy of Sciences (INR RAS) has recorded the highest energy photon in the history of observations of cosmic gamma-ray bursts. This should lead to revolutionary changes in either particle physics or astronomy.

A gamma-ray burst is a very energetic event that ends within a few minutes (at most, up to several hours) associated with the death of massive stars, like a supernova explosion, but even more intense and powerful. Such an event in our Galaxy was even assumed to lead to the extinction of dinosaurs, but most researchers now believe that’s not true. Although gamma-ray bursts are recorded almost every day (there are special telescopes that monitor cosmic radiation in the gamma or X-ray range), in this case we are talking about the registration of photons of the highest energy for an event that happened not in our Galaxy.

The flare was first detected by NASA's Fermi orbital observatory. This burst turned out to be the most energetic in the history of observations by this instrument since 2008 – a photon of the highest energy, 99 GeV (almost 0.1 TeV) was recorded. Then the Chinese LHAASO experiment, aimed at detecting high-energy particles, published a report that a number of photons with energies up to 18 TeV were detected from this flare. Then the Carpet-2 installation, located in the North Caucasus at the Baksan Neutrino Observatory of the INR RAS, recorded a photon with an energy of 251 TeV. Gamma-ray bursts occur in distant galaxies. If such an event happened in our Galaxy, it would have a very negative effect on all living beings.

Why is this interesting? (The discovery of Carpet-2 has already been called revolutionary, for example, in the article by Italian theorists https://arxiv.org/abs/2210.05659 that appeared recently). The distance to the gamma-ray burst, obtained with the help of spectral observations on the largest optical telescopes in the world, is about two billion light years. According to modern concepts, high-energy photons - both the 18-TeV photons observed by LHAASO and the record-breaking 251-TeV photon of Carpet-2 - cannot cover such a big distance. Interacting with the relic radiation penetrating the Universe, with the light of stars and galaxies, such photons produce electron-positron pairs. A photon with an energy of 251 TeV will not even reach the neighboring Andromeda galaxy. So, if Carpet-2 and LHAASO actually observed such a distant source, something will have to be changed in the most basic laws of particle physics. For example, it was proposed to introduce new particles – axions, which could "conserve" a photon near the source and flash it back in the magnetic field of our Galaxy. Even more radical suggestion is violation of laws of the special relativity theory, which could lead to suppression of interactions of photons at such high energies. It is not yet clear whether even such fantastic scenarios can help to explain the results of observations of the recent gamma-ray burst.

Or, maybe astronomers made a mistake and took for a distant gamma-ray burst some explosive process in our Galaxy, at distances of "only" tens of thousands light years, rather than billions. In favor of this assumption is the fact that in the sky the flare hits the region of the Milky Way, where the bulk of stars and other astrophysical objects of our Galaxy are concentrated. However, in this case, the mystery from the field of particle physics transfers into the field of astronomy – what kind of amazing object flashed in the Galaxy and how did it manage to "pretend" to be a distant gamma-ray burst? In both cases, revolutionary discoveries must happen - either in particle physics or in astronomy! The story seems to be continued and we'll probably get to know much more about it soon. Now hundreds of scientists around the world are thinking about how to explain such cosmic phenomena.

"I think we are talking about an intragalactic source, but it is not clear which one: the flash came from the region of the Milky Way, where many bright objects of our Galaxy are located at once. It could be some fantastic outburst of a magnetar. If such photons had arrived during the LHAASO observation, there would have been much more information, but the brightest photon came an hour and a half after the outburst began, when the Earth had already turned so that it was more convenient for Carpet-2 to observe them. That is why sometimes it is very useful for scientists to have relatively small installations, like Carpet-2, but separated by geographical longitude," - says Sergey Troitsky, a chief researcher at the INR RAS, corresponding member of the Russian Academy of Sciences.

"This burst has an interesting light curve. First, there was a burst of normal intensity lasting a few seconds. Nothing happened for two hundred seconds, and then an extraordinary burst of gamma-rays in the form of peaks and dips in the light curve began, and this continued for 400 more seconds. This happened before, only at lower intensities and not often. Nobody knows how to explain such a light curve. This is the flow that came in soft gamma quanta, and then a gradually decreasing flow of particles began in other ranges (the so-called afterglow), including high energies.

Both Chinese photons with an energy of 18 TeV and a Russian photon of 251 TeV are paradoxical because gamma quanta of such energies are absorbed on their way, reacting with the infrared intergalactic background. Recently some articles have appeared trying to explain the phenomenon with new physics, for example, axions. But I don't think that's really necessary. Perhaps there is a more standard explanation," - said Boris Stern, a leading researcher at the Laboratory for the Study of Rare Processes of the INR RAS.

The Carpet-2 facility is located in the ground part of the campus of the Baksan Neutrino Observatory of the Russian Academy of Sciences and detects cascades of charged particles generated as a result of interaction of high-energy radiation in the Earth's atmosphere. To determine the type of the particle that caused the cascade, a 175-square-meter muon detector is used – unlike much more numerous cosmic rays, photons cause showers in which there are few muons. The event associated with the October 9 outbreak did not give a single muon in the entire detector, so it was most likely caused by a photon. Such events are very rare, and, as the Carpet-2 team notes (and these are 22 scientists and engineers, all work at INR RAS) in the astronomical telegram about their discovery ([https://www.astronomerstelegram.org/?read=15669), the](https://www.astronomerstelegram.org/?read=15669) probability of a random coincidence of such an event with a gamma-ray burst is about one ten-thousandth.

Thus, this cosmic flash is still waiting for its researchers, theoretical physicists, who will explain what kind of source of photons with such a high energy is and how they managed to fly across half the Universe to the Elbrus region.