scattering angle θ and the mass of X.

Straightforward calculation [3] leads to the conclusion that in the case (3) the X particles of given mass M created at definite E and θ are completely polarized with the three-vector $\vec{e}$ of the polarization lying in the plane of production. The expression for the polarization vector in this plane depends in general on the ratio of the unknown functions a and b. However, the particles emitted at $\theta \simeq 0$ or $\theta \simeq 180^{\circ}$ are polarized in the direction of their momentum. Still, the fraction of cases satisfying these conditions may be rather too small.

The case (4) is, therefore, more interesting because then the X particles are always completely polarized in the direction perpendicular to the plane of production independently of the value of c. Thus we see that in this case all the X particles for which the plane of production can be determined are in definite and known polarization states. This fact can be used for several purposes. First it can be used for a better and more convincing assignment of spins and parities to the new mesons by making the analysis of their subsequent decays more conclusive and transparent. E. g. we may look for definite anisotropics in the distribution of the decay products in processes

$$X \to 2\pi\,, \quad X \to 3\pi \tag{5}$$

with respect to the plane of production in the case (4), or with respect to the direction of momentum for X particles emitted at $\theta \simeq 0$ or 180° in the case (3). Second, by a suitable choice of spinless particles we can achieve complete polarization of the vector or pseudovector mesons in the direction perpendicular to the plane of production. We can obtain such a beam of completely polarized vector mesons from the reaction

$$\pi + \alpha \to X + \alpha \tag{6}$$

or

$$K^- + \alpha \to {}_{\Lambda}H^4 + X^0\,, \tag{7}$$

provided that the relative parity of K^- and the hyperfragment ${}_{\Lambda}H^4$ is odd as it has been recently suggested [4].

A vector meson polarized in the z direction would then exhibit a $\cos^2\theta$ distribution of decay products in $X \to 2\pi$ processes. In the three-pionic decays of a polarized vector meson there should be no decays in which the polarization vector lies in the plane of decay.

For pseudovector mesons the decays into 2π are forbidden unless parity is not conserved. In 3π decays of polarized pseudovector mesons there should be no decays in which the decay plane is perpendicular to the polarization vector.

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ON HIGH ENERGY COSMIC PHOTONS ORIGINATING IN INTERGALACTIC SPACE

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In recent reports [1] it has been suggested that extensive air showers containing few muons could be attributed to those initiated by ultra-high energy photons and their detection has been attempted by various means. In connection with this the author would like to call attention to a possibility that neutral pions produced by the collisions of ultra-high energy cosmic rays with intergalactic light may provide an important source of such photons.

The pion production by the collision of a proton with star light becomes possible at energy higher than 10^{17} eV per nucleon. Let the omnidirectional intensity of such nuclear particles be J_n, the cross section for the photon production be σ and the density of photons at a distance r be $n(r)$, in which the multiplicity of photons is included in σ. The intensity of the photons is then given by

$$J_{\gamma} = J_n\, \sigma \int n(r)\, dr\,. \tag{1}$$

If pions are produced in a way analogous to the case of a nucleon-nucleon collision, the energy of pions produced is smaller by a factor of about one hundred than the energy of an incident nucleon. Hence the energy of cosmic photons in question may be greater than about 10^{15} eV; photons of such energies are effective to produce detectable extensive air showers.

The sun in the solar system, stars in the Galactic disk and stars in numerous galaxies are considered as sources of light responsible for high energy cosmic photons. The contribution of sun light has been discussed in connection with the break-up of heavy nuclei by photo-nuclear reactions [2]. In the same way the yield of neutral pions can be calculated by putting $\sigma \simeq 5 \times 10^{-29}$ cm^2 and their multiplicity $\simeq 10$. Thus we have $J_\gamma/J_n \simeq 3 \times 10^{-5}$ for photons coming from the direction of the sun. The density of photons in the Galactic disk is about 1 cm^{-3}, although its exact value in and beyond the Galactic nucleus is not known yet. Within this uncertainty $J_\gamma/J_n \simeq 10^{-4}$ may be expected. However, the contribution from the collisions with interstellar matter is greater by a factor of one hundred or more; note that we are comparing the intensities of protons and photons with different energies. Currently one refers to the latter value for the expcted intensity of cosmic photons, extrapolating the pion production process known at energies below 10^{14} eV. One has, however, to take into account an indication that the pion production mechanism is different at higher energies [3].

In comparison with the above case, the contribution of star-light to the generation of cosmic photons in the Galactic halo and the intergalactic space is relatively important, because the matter density therein is very small. For example, the contributions from matter and light may be comparable for cosmic photons produced in the halo. In the intergalactic space in which the gas density seems to be as low as 10^{-4} cm^{-3}, the contribution of light is predominant over that of matter. Since even such a small density of matter would give a considerable intensity of cosmic photons, if the cosmic ray intensity in the intergalactic space were as large as that in the Galaxy [4], the contribution of light must be very important for the present problem. Assuming that a significant part of very-high-energy cosmic rays of interest are of extragalactic origin, we expect

$$J_\gamma/J_n \simeq \sigma n R \ , \tag{2}$$

where R is the absorption mean free path of cosmic photons and the light density within R is assumed as constant. If R is taken as 10^8 light years [5] and $n \simeq 0.3$ cm^{-3}, we have $J_\gamma/J_n \simeq 3 \times 10^{-2}$. This is comparable to the cosmic photon intensity due to the collisions with Galactic matter, provided that J_n in the intergalactic space is essentially equal to that in the Galaxy.

Here arises a problem whether or not the cosmic ray intensity in the intergalactic space is comparable to the one we observe. This is of great importance for the question of the origin of cosmic rays. Therefore, the observation of cosmic photons with very high energies will provide a crucial test on the extragalatic origin, in addition to the detection of the largest extensive air showers [6].

Finally, we add a comment on heavy primaries of very high energies. If they were of extragalactic origin, those with energies higher than 10^{16} eV per nucleon would suffer from the collision with the intergalactic light so that a considerable part of them could be eliminated [5]. Consequently, the extragalactic component of the heavy primaries of isotropic distribution would be suppressed, so that the possible anisotropy [7] of the Galactic component could be enhanced. Since this is not the case for protons, protons would be more isotropic than heavy nuclei.

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