sponsible for a higher-energy resonance in the strangeness (−1) states. The method may also be applied to the process $\pi+N\rightarrow K+\Lambda$ in the region of center-of-mass system energy around 1730 Mev, since a $K+\Lambda$ resonance may exist in this energy region.[15] Since the $K+\Lambda$ state is of greater rest mass than the $\pi+N$ state, the energy-dependence and resonance-interference methods measure the same quantity, the $K+\Lambda$ orbital angular momentum of the "resonance," so that these methods cannot be combined to determine the relative intrinsic parities of the particles from associated-production data. However, the resonance-interference method may be useful in this case also as a test of any specific resonance model.

Note added in proof. Since this paper was written Tripp, Watson, and Ferro-Luzzi have obtained the result of odd $K\Sigma N$ parity by using this method [Phys. Rev. Letters 8, 175 (1962)]. The best polarization measurements are obtained for the $\Sigma^{+}+\pi^{-}$ events, and the situation is similar to that described near the end of Sec. 2, i.e., the amplitudes $\mathbf{f}_{3a}$ and $\mathbf{f}_{1b}$ are nearly in phase at 400 Mev/c and the change of sign of the polarization determines the parity.

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[15] A resonance model of the $\Lambda+K$ production data is given by A. Kanazawa, Phys. Rev. 123, 997 (1961). References to the experimental work are given.

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Lee-Yang Vector Field and Isotropy of the Universe*

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Lee and Yang suggested that, associated with heavy-particle conservation, there may exist an analog of the electromagnetic field, a field for which nucleons and antinucleons would serve as positive and negative "charges." It is shown that the null result from a recent repetition of the Eötvös experiment implies that, if it exists, the Lee-Yang interaction is at most only 10^{-7} of the gravitational interaction. This great weakness does not imply that the field does not exist. However, with the assumption of the isotropy of the average matter distribution of the universe, the Lee-Yang antisymmetric field tensor vanishes when averaged over sufficiently large volumes. This implies that, if the Lee-Yang field exists, nucleons and antinucleons are present in equal numbers in the universe, presumably gathered in matter and antimatter galaxies. However, it is found that the fact that a copious stream of γ rays is not present in the cosmic rays can be used to exclude such numbers of antimatter galaxies. It is concluded that the Lee-Yang field probably does not exist.

CONNECTED with baryon conservation, Lee and Yang[1] have suggested that there may exist a neutral, massless, gauge-invariant vector field analogous to the electromagnetic field. Nucleons and antinucleons would serve as positive and negative "charges," the sources of this field, and in motion constitute "currents." The tremendous circulating nucleon currents in the galaxy could result in the generation of the Lee-Yang analog of the magnetic field. The Lee-Yang analog of the electric field would lead to a repulsion between matter, tending to reduce the gravitational acceleration. It is evident that if it exists, the Lee-Yang interaction is weak, or matter would fall up, not down.

As shown by Lee and Yang, the null result of the Eötvös experiment[2] imposes a severe restriction upon the strength of the Lee-Yang field. The Eötvös experiment demonstrated with an accuracy of about 5 parts in 10^9 that gravitational accelerations are independent of the atomic weight of the falling body. More recently[3] it has been shown that the accelerations toward the sun of copper and lead are equal to an accuracy of one part in 10^{10}.

Consider the force exerted on an atom by the sun through the Lee-Yang analog of an electric field. This force is proportional to A, the nucleon number of the atom, and is independent of the motions of the nucleons inside the nucleus. Hence, the Lee-Yang force is independent of the binding energy of the nucleus, but this implies that the resulting acceleration of the atom depends upon the mass (and binding energy).

It is easily shown that the fractional difference in acceleration, toward the sun, of two different substances of different atomic weight is

$$\frac{\delta g}{g}\cong\gamma\left\langle\frac{A}{M}\right\rangle_s\left[\left(\frac{A}{M}\right)_2-\left(\frac{A}{M}\right)_1\right],\tag{1}$$

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[1] T. D. Lee and C. N. Yang, Phys. Rev. 98, 1501 (1955).

[2] R. v. Eötvös, D. Pekar, and E. Fekete, Ann. phys. 68, 11 (1922).

[3] R. H. Dicke, P. Roll, D. Currott, and R. Krotkov (to be published).

where A/M is the ratio of the nucleon number to atomic weight, $\langle A/M\rangle_s$ refering to the appropriate average over the sun. γ is the strength of the Lee-Yang interaction, relative to gravitation. Assuming that for copper and lead

$$|\delta g/g| < 10^{-10}, \tag{2}$$

and inserting the values

$$\langle A/M\rangle_s \sim 1, \quad (A/M)_{\mathrm{Cu}} = 0.9993, \quad (A/M)_{\mathrm{Pb}} = 1.003, \tag{3}$$

gives

$$\gamma < 10^{-7}. \tag{4}$$

Thus, the Lee-Yang interaction, if it exists, is at most only 10^{-7} of the strength of the gravitational interaction.

While it might be argued that the great weakness of the Lee-Yang interaction implies that it is nonexistent, this argument is believed to have little merit. It is interesting therefore that a symmetry argument, independent of the strength of the interaction, can be used to cast doubt upon the existence of this field.

Making the usual assumption of uniformity and isotropy of the universe, when averaged over sufficiently large volumes, it is possible to conclude that gauge-invariant vector fields in general, and the Lee-Yang field in particular, vanish when averaged over large volumes. This conclusion is based on a symmetry condition, is therefore independent of the strength of the coupling to the field, but is also valid only to the extent that the assumption of the isotropy of the universe is valid. It should be remembered that we see only a part of the universe, and that imperfectly. The assumption of uniformity and isotropy always involves an element of faith.

This symmetry argument is easily given. Expressed in co-moving coordinates (time orthogonal), matter is assumed to be, when averaged over large volumes, isotropically distributed about any space point. The average vector field, derived from this average matter distribution, must then exhibit this same symmetry. All components of any three-vector in this coordinate system must vanish, for there is no preferred direction in this space. In particular, electric and magnetic fields and all components of the analogous-antisymmetric Lee-Yang field tensor must vanish. Although, the symmetry argument is based upon the use of a particular coordinate system, its conclusion is generally valid, for the vanishing of all the components of a tensor in one coordinate system implies its vanishing in any coordinate system. Because of the "Maxwell equations" of the Lee-Yang field,

$$J^i = F^{ij}{}_{,j} = [1/(-g)^{\frac{1}{2}}][(-g)^{\frac{1}{2}}F^{ij}]_{,j}. \tag{5}$$

J^i the nucleon four-current, vanishes if $F^{ij}=0$. This in turn implies that, taken over sufficiently large volumes, the nucleon number density of space is zero. Thus nucleons and antinucleons must be present in equal numbers.

The structure and history of the galaxy is such that it is inconceivable that nucleons and antinucleons should be present in comparable numbers in the same galaxy. It must be presumed that if the Lee-Yang field exists, and the symmetry argument is valid, the universe must be populated with both nucleon and antinucleon galaxies. Such a universe has been suggested previously.[4] It is difficult to see how such a separation of matter into nucleon and antinucleon galaxies could occur. Furthermore, a universe populated by a mixture of matter and antimatter galaxies, should contain many energetic photons, having their origin in the annihilation of a part of the gas masses of colliding galaxies. The expected collision rate is sufficiently great that, under these assumptions and contrary to what is observed,[5] a large γ-ray flux should appear in the cosmic radiation. The past annihilation of only one part in a million of the matter content of the universe would lead to an expected photon flux in the cosmic radiation of roughly $\frac{1}{3}$ of a photon per second per square centimeter, several orders of magnitude too great.

To summarize, one can conclude, on the basis of the symmetry argument, one of three things:

(1) The universe is populated with matter and antimatter galaxies.
(2) The assumption of uniformity of the universe is invalid.
(3) The Lee-Yang vector field does not exist.

As the possibilities (1) and (2) seem unpromising, it seems very likely that the Lee-Yang field does not exist. It should be remarked that the above symmetry argument is without substance for the short-range vector field proposed recently by Schwinger[6] as a replacement for the Lee-Yang field.

[4] P. Morrison, Am. J. Phys. **26**, 358 (1958), and M. Goldhaber, Science **124**, 218 (1956) have given discussions which are relevant.
[5] T. L. Cline, Phys. Rev. Letters **7**, 109 (1961).
[6] J. Schwinger, Phys. Rev. **125**, 397 (1962).