BARYON RESONANCES PRODUCED IN WEAK INTERACTIONS AND UNITARY SYMMETRY

M. P. Rekalo

Physico-technical Institute, Academy of Sciences, Ukrainian S.S.R.

Original submitted 5 February 1965.

According to the CERN neutrino experiment,[1] the cross sections of the inelastic processes such as $\nu + p \to \mu + p + n\pi$, produced by high-energy neutrinos, increase like the square of the neutrino energy. Therefore at high energies the cross sections of the inelastic processes may exceed the cross section of the elastic process $\nu + N \to N + \mu$. It is of interest in this connection to analyze theoretically the inelastic processes that can arise when a neutrino interacts with nucleons.[2] In the present communication we investigate on the basis of unitary symmetry the relations between the amplitudes for the formation of baryon resonances belonging to the irreducible representation SU(3) of dimensionality 10, upon interaction between an antineutrino and nucleons.1)

We consider first processes occurring with a proton:

$$\bar{\nu} + p \to \mu^+ + N^{*-} + \pi^+ \qquad g_1 \qquad (1a)$$

$$\bar{\nu} + p \to \mu^+ + Y_1^{*-} + K^+ \qquad g_2 \qquad (1b)$$

$$\bar{\nu} + p \to \mu^+ + Y_1^{*-} + \pi^+ \qquad g_1' \qquad (1c)$$

$$\bar{\nu} + p \to \mu^+ + \Xi^{*-} + K^+ \qquad g_2' \qquad (1d)$$

In reactions (1a) and (1b) the strangeness is unchanged ($\Delta S = 0$) and change of the hadron electric charge is $\Delta Q = -1$; in reactions (1c) and (1d) we have $\Delta S = \Delta Q = -1$. From the equation $Y = U_z + Q/2$, which relates the hypercharge Y, the third projection of U-spin, and the charge Q it follows that $\Delta U_z = 1/2$ for processes without change of strangeness and $\Delta U_z = -1/2$ for processes with change of strangeness[4]. We shall consider the consequences of the following U-spin selection rules, which hold for both types of processes:

$$\Delta U = 1/2,\ 3/2,\ 5/2.$$

If $\Delta U = 1/2$, then the amplitudes of processes (1a) - (1d) satisfy the relations

$$g_1 + \sqrt{3} \quad g_2 = 0, \qquad g_1' + g_2' = 0 \tag{2a}$$

For the case $\Delta U = 3/2$ there are no relations; on the other hand, if the selection rule $\Delta U = 5/2$ is satisfied, then

$$g_1\sqrt{3} = g_2, \quad g_1' = g_2' \tag{2b}$$

Let us consider further the reaction wherein negatively charged isobars are produced by antineutrino-nucleon interaction:

$$\begin{aligned} \bar{\nu} + n &\to \mu^+ + N^{*-} + \pi^0 \\ \bar{\nu} + n &\to \mu^+ + N^{*-} + \eta \\ \bar{\nu} + n &\to \mu^+ Y_1^{*-} + K^0 \end{aligned} \tag{3}$$

in which the strangeness does not change, and the reactions

$$\begin{aligned} \bar{\nu} + n &\to \mu^+ + N^{*-} + \bar{K}^0 \\ \bar{\nu} + n &\to \mu^+ + Y_1^{*-} + \pi^0 \\ \bar{\nu} + n &\to \mu^+ + Y_1^{*-} + \eta \\ \bar{\nu} + n &\to \mu^+ + \Xi^{*-} + K^0 \end{aligned} \tag{4}$$

in which the strangeness changes. For these processes it is convenient to introduce the amplitudes for the production of neutral mesons with $U = 1$:

$$f_1 = \left\langle \bar{\nu} n \middle| \mu^+ N^{*-} \frac{\pi^0 - \sqrt{3}\eta}{2} \right\rangle, \quad f_2 = \left\langle \bar{\nu} n \middle| \mu^+ Y^{*-} K^0 \right\rangle ; \tag{5a}$$

$$f_1' = \left\langle \bar{\nu} n \middle| \mu^+ N^{*-} \bar{K}^0 \right\rangle, \quad f_2' = \left\langle \bar{\nu} n \middle| \mu^+ Y_1^{*-} \frac{\pi^0 - \sqrt{3}\eta}{2} \right\rangle,$$

$$f'_3 = \left\langle \bar{\nu} n \middle| \mu^+ \Xi^{*-} K^0 \right\rangle. \tag{5b}$$

Then when $\Delta U = 1/2$ the following relation holds between the amplitudes (5a):

$$\sqrt{2}\, f_1 + \sqrt{3}\, f_2 = 0. \tag{6}$$

The amplitudes (5b), on the other hand, have the following structure:

$$f' = \sqrt{3}\,A_1 + \sqrt{6}\,A_3, \quad f_2' = -\sqrt{2}\,A_1 + A_3, \; f_3' = A_1 - \sqrt{8}\,A_3 \qquad (7)$$

where A_1 and A_3 are the amplitudes for the production of final hadrons with $U = 1/2$ and $3/2$. From (7) we have

$$f_1' + \sqrt{6}\,f_2' + \sqrt{3}\,f_3' = 0 \qquad (8)$$

Equations (6) and (8) go over into a set of inequalities relating the cross sections. No such relations can be obtained for the cases $\Delta U = 3/2$ or $5/2$.

In conclusion we find the corresponding relations for different values of the U-spin in the annhililation channel ($n\bar{B}^-$). Such relations hold true for peripheral mechanisms corresponding to exchange of meson states with definite values of the U-spin.

If exchange of the state with U = 1/2 takes place, then

$$\begin{aligned} &f_3' = 0, \; f_1' + \sqrt{6}\,f_2^1 = 0 && \text{if} \quad \Delta U = 1/2 \\ &f_3' = 0, \; f_1'\sqrt{2} = f_2 && \text{if} \quad \Delta U = 3/2 \end{aligned} \qquad (9)$$

For the variant $\Delta U = 5/2$ all processes of type (4) are forbidden.

If exchange is with U = 3/2, then

$$\begin{aligned} &f_1'/\sqrt{3} = -f_2'/2\sqrt{2} = f_3'/3 && \text{if} \quad \Delta U = 1/2 \\ &f_1'/2\sqrt{3} = f_2'/\sqrt{2} = f_3'/3 && \text{if} \quad \Delta U = 3/2 \\ &f_1'/3 = f_2'/2\sqrt{6} = f_3' && \text{if} \quad \Delta U = 5/2 \end{aligned} \qquad (10)$$

The author thanks A. I. Akhiezer for interest in the work.

[1] Block, Burneister, Cundy, Eiben, Franzinetti, Kerren, Hellerud, Myatt, Nikolic, Orking-Lecourois, Paty, Perkins, Ramm, Schultze, Sletten, Soop, Stump, Venus, and Yoshiki, Phys. Lett. 12, 281 (1964).

[2] Y. Yamagushi, Progr. Theor. Phys. 23, 1117 (1960); N. Dombey, Phys. Rev. 127, 653 (1962); P. Dennery, Phys. Rev. 127, 664 (1962); M. Fukawa, Progr. Theor. Phys. 28, 885 (1962); Nguyen Van Hieu, JETP 43, 1296 (1962), Soviet Phys. JETP 16, 920 (1963); N. Cabbibo and G. Da Prato, Nuovo cimiento, 25, 611 (1962); M. P. Rekalo, JETP 46, 1891 (1964), Soviet Phys. JETP

19, 1272 (1964).
[3] L. Maiani, Nuovo cimento 34, 1386 (1964).
[4] D. Horn, ibid. 33, 64 (1964).

1) The relations between the amplitudes for the production of ordinary baryons and mesons in weak interactions were considered in [3].

MELTING CURVES OF BISMUTH TELLURIDE (Bi_2Te_3) AND ANTIMONY TELLURIDE (Sb_2Te_3) AT HIGH PRESSURES

S. M. Stishov and N. A. Tikhomirova
Crystallography Institute, Academy of Sciences, U.S.S.R.
Original submitted 5 February 1965.

The tellurides of antimony and bismuth are semiconductors with layer structure of the tetradimite type. The relative "friability" of this structure suggests that at high pressures these substances can go over into denser structures. In view of the small width of the forbidden band of Bi_2Te_3 and its further decrease under pressure, it can be assumed that the expected phase transition of Bi_2Te_3, and possibly also that of Sb_2Te_3, is also a transition into the metallic state.

At present there is already some experimental evidence that Bi_2Te_3 becomes metallic under pressure[2], but the details of this transition remain unclear. We have investigated, by the thermal analysis method, the phase diagrams of Bi_2Te_3 and Sb_2Te_3 under hydrostatic pressures up to 25000 kg/cm^2. The temperature and pressure were measured accurate to $\pm$ 0.5°C and $\pm$ 75 kg/cm, respectively.

The experimental results are shown in the figure. As can be seen from the figure, the melting curves of Bi_2Te_3 and Sb_2Te_3 have maxima at 603.3°C and 16000 kg/cm^2 for the Bi_2Te_3 1) and 662.0°C and 16500 kg/cm^2 for Sb_2Te_3. In addition to the maxima, both curves exhibit kinks which obviously represent ternary points corresponding to the crossing of the melting curves and the lines of phase transition into the solid state. However, the phase transitions themselves were not registered, probably because the heats of the trans-