ОБЪЕДИНЕННЫЙ ИНСТИТУТ ЯДЕРНЫХ ИССЛЕДОВАНИЙ

Лаборатория теоретической физики

ФИЗИЧЕСКИЙ ИНСТИТУТ им. П.Н. ЛЕБЕДЕВА АН СССР

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D–976

HYPERCHARGE AND DEGENERACY IN RESPECT TO ISOTOPIC SPIN

Дубна 1962 год

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A b s t r a c t

The following new type of symmetry proposed:systems and particles with hypercharge equal to zero (hyperneutral systems) have no dependence on isotopic spin value. Application of this symmetry gives predictions of new particles, quantum numbers of these particles and relations between cross sections (for example, equality of cross sections of $\tilde{n}p$ and $\tilde{p}p$ interactions).

Some time ago one of the authors (A.M.B.) of this note considered[1] the possibility of the existence of the particle quadruplets with near masses and identical properties, differed only by the value of the isotopic spin ($T = 1$ and $T = 0$). Recently Glashow[2] analysing new experimental data on the π -meson and π -meson-hyperon resonances once more drew attention to the puzzling similarities in the properties of the particles relating to the multiplets with $T = 1$ and $T = 0$. The authors of the present note believe that these coincidences of the particle properties can not be accidental and suggest below one possible interpretation of them.

From now available experimental data it follows that to each multiplet with $T = 1$ one can put on correspondence a singlet with $T = 0$ having the same quantum numbers and a near lying mass. Among them one finds newly discovered ξ and η -mesons[3,4], earlier studied ρ and ω -mesons,[5,6] Y_1 * and Y_0 * - resonances[7,8] and at last Σ and Λ -particles. For the sake of convenience we present data, relating to these particles in the form of a table.

Table

$T = 1$				$T = 0$				
Particle	m_1 (MeV)	s	P	Particle	m_0 (MeV)	s	P	$\frac{m_0 - m_1}{m_1}$ *
π	140	0	−1	π_0^0 (?)				
ξ	575	1	−1	η	550	1	−	4,3%
ρ	750	1	−1	ω	780	1	−1	4%
Σ	1190	½		Λ	1115	½		6,3%
Y_1^*	1385	3/2		Y_0^*	1405			1,4%

As it is clear from the table the only exclusion from the discussed rule is the π -meson which for the time being has now a counterpart π_0^0 -meson. We shall return to this point later and now let us proceed considering the the table.

It is well known that generally strong interactions are strongly dependent on the isospin value of the interacting system. The striking example is the $\pi - N$ interaction. Seemingly this fact contradicts to the existence of any symmetry leading to the degeneracy of the properties of the physicol systems in respect to the isotopic spin value. However looking at the table more attentively one notices that all the particles in it have one property in common: the hypercharge Y * equal to zero.

* The hypercharge $Y = S + B$, where S is the 'strangeness', B - baryonic number.

This characteristic distinguishes them from the πN -system for which $Y = 1$ and also from $K\pi$, $K\Sigma$ $\pi\Xi$ systems. The zero value of the hypercharge for the systems, degenerated in respect to the isotopic spin might be very significant and point to a very important role, which hypecharge plays in strong interactions. The authors think that the hypercharge has a deeper physical meaning than the 'strangeness' number, the point emphasized already by Schwinger[9]. On the basis of the available data the following conclusion can be drawn which authors want to consider as a kind of a rule: hypercharge is such a characteristic of the system which switches on strong dependence of all its properties on the isotopic spin. When hypercharge equals zero, the dependence on the isotopic spin value disappears and degeneracy takes place. From this assertion first at all the near equality of the masses of the particles with $Y = 0$ relating to the different isotopic multiplets and the identity of all other quantum numbers follows. This could serve as an indication for the experimental searches in the cases when these quantum numbers (spin, parity) are not certain. In particular one should have spin $s = 1$ and negative parity for η -meson, equal parities for Σ and Λ -particles, spin $s = 3/2$ for Y_0^* -resonance. The identity of the properties must persist also for all particles (resonances) to be discovered. An interesting conclusion can be drawn in respect to $\Sigma\pi$ -system. Here a near lying resonances should be observed in the states with $T = 0$, $1,2$. The predictions of the opposite nature follow for $K\pi$, $K\Sigma$, $\pi\Xi$ -systems. In these cases there must be strong dependence of system behaviour on isospin value. The resonances should occur in the states of the particular isotopic spin. Indeed K^* -resonance is observed in the state with $T = 1/2$, and there is no indication of the near lying resonance with $T = 3/2$. Because of the close connection which exists between the masses of the bound states (positions of the resonances) and the properties of the S -matrix elements (positions of the poles) the latter must have analogous dependence on the hypercharge values. Hence one gets immediately that cross-sections for the interactions in the $\bar{N}N$ and K^-N systems must degenerate in isotopic spin (both in elastic and inelastic channels). En excellent confirmation of this statement is the equality of $\bar{p}p$ and $\bar{n}p$ cross-sections in all measured energy ranges.[10] One can easily show that this follows from the equality of the scattering amplitudes for $T = 1$ and $T = 0$ states. Another interesting consequence of this circumstance is equality of the cross-sections for annihilation $\bar{N}N$ system, on even and odd number of π -mesons. Unfortunately available data on K^-N interaction are not full enough to make such a detailed analysis.

The discussed symmetry, confirmed by a large number of facts definitely testified in favour of the π_0° -existence. The fact that π_0° sifill has not been discovered[11] may idicate only that its interaction with nucleons is weaker, than it was usually assumed. This agrees with our general rule, because nucleon carries a hypercharge and may interact with isosinglet π_0° in quite a different way than with isotriplet π -meson.

The notion of the hypercharge most naturally arises in consideration of the representations of the four-dimensional rotation group of the isotopic space.

Existence of the degeneracy in isotopic spin, removed by the presence of hypercharge, may be indicative of the very important role which this group plays in strong interactions.

The authors are thankful to Yu. D. Prokoshkin for the important remark.

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Received by Publishing Department on April, 28, 1962.