I. S. Shapiro. *Bound and Resonant States of the Nucleon-Antinucleon System.* The possibility of the existence of comparatively long-lived quasinuclear states of the $N\bar{N}$ system was demonstrated theoretically in 1969–1970 (L. N. Bogdanova, O. D. Dal'karov *et al.*; see references in the reviews[1–3]). The same authors later studied the processes of formation of $N\bar{N}$ systems in the interaction of antiprotons ($\bar{p}$) with deuterium, as well as electromagnetic transitions from the states of the $\bar{p}p$ atom to levels of the quasinuclear $N\bar{N}$ system with emission of hard (average energy on the order of 100 MeV) discrete-spectrum γ radiation.

Beginning in 1971–1972, experimental data indicating the existence of $N\bar{N}$ quasinuclear systems began to appear. These data can be divided into three groups: observation of the aforementioned hard γ-radiation accompanying annihilation of $N\bar{N}$ to pions, anomalies in the annihilation of slow $\bar{p}$ in hydrogen and deuterium (d), and direct observation of heavy mesons that have a mass of about two nucleon masses and are strongly bound to the $N\bar{N}$ channel, i.e., having a rather large (on the order of 10% or more) partial decay width (real or virtual in the case of bound states).

The object of the present paper is to give a brief review of the present state of the problem (with emphasis on the available experimental facts). It can be summarized as follows.

1. *γ radiation accompanying annihilation of antiprotons.* This radiation (with an average energy of ~100 MeV) was observed on annihilation of $\bar{p}d$ in experiments performed by Kalogeropulos' group on the accelerator at the Brookhaven National Laboratory. Its intensity was found to be very high (0.73 ± 0.08) quanta per annihilation act (the probable intensity is theoretically in the range from 10^2 to 2/3). This result has not yet been confirmed. Data obtained with bubble chambers on the γ-radiation spectrum indicate the presence of a discrete structure (with some lines having intensities on the other of 10% at a width of 10 MeV).[4,5] The statistical material on them is not extensive (about $4.4 \cdot 10^3$ events). On the other hand, the results of scintillation-spectrometer experiments in which large numbers of γ quanta were registered (on the order of 10^5) and in which the discreteness of the lines is not evident (at the 3.3% level for lines with natural widths much smaller than 10 MeV), are hard to interpret because of the inadequate resolution of the instrument (which, for example, does not reproduce the known spectrum of γ radiation from neutral-pion decay; see[5,6]). The experiments now being performed in various laboratories will probably yield more definite data in the very near future.

2. *Anomalies in the annihilation of slow $\bar{p}$.* Very strong annihilation is observed from triplet P-states of $\bar{p}p$ and $\bar{p}d$ atoms (about 40 and 70% of all annihilations, respectively), as well as deviation from the $1/v$ law for slow $\bar{p}$ (see[1–3,5]). These facts become understandable in the scheme of quasinuclear $N\bar{N}$ states and would be difficult to explain if such states did not exist.

3. *Direct observation of heavy "quasinuclear" $N\bar{N}$ mesons.* Resonant $N\bar{N}$ states make their appearance in the variation of the total cross sections of the $\bar{p}p$ and $\bar{p}d$ interactions with energy, and also in the large-angle $\bar{p}p$ elastic-scattering ("backscattering") cross sections. Bound states can be observed in $\bar{p}d \to X + p$ annihilations either in the spectrum of the deficient or effective mass X or in the energy spectrum p (the rather narrow $N\bar{N}$ resonant states can also be investigated in the same way). Various experimental groups (see[3,5,7]) have used these methods to observe bound and resonant $N\bar{N}$ states with the following masses and widths (MeV, widths indicated in parentheses): 1794 (7), 1873 (10), 1900 (20), 1932 (9), 1940 (60), 2000 (200), 2150 (95), and 2335 (110). The 2000 resonance observed in the process $\bar{p}p \to K^0 K^{\pm} \pi^{\mp}$ may be the "h-meson" observed in the $2\pi^0$ channel at the Institute of High-Energy Physics and in the K^+K^- channel at CERN (see references in the review[7]). If this interpretation is correct, almost the entire width of the "h meson" should be due to the elastic channel. It has not yet been possible fully to establish the quantum numbers of the observed quasinuclear mesons: the isospins and G parities are known, but the available data do not permit a definite decision as regards the spins and P parities.

The theoretically expected spectrum of quasinuclear $N\bar{N}$ states runs to about 20 levels (unlike the NN system, which has only a single discrete-spectrum state, the deuteron).

If future studies confirm the existence of quasinuclear $N\bar{N}$ states and establish their energy spectrum and quantum characteristics, we shall have acquired an important source of information on the nuclear forces, since there is a direct relation between the $N\bar{N}$ and NN two-particle interactions (a similar relation exists between the forces in the electron–electron and electron-positron systems). It can be said that nuclear physics has acquired its own "hydrogen atom"—a two-particle or "almost two-particle") system with a rich spectrum of states, in place of the single-level deuteron that is presently at its disposal. On the other hand, the formation of $N\bar{N}$ (and $Y\bar{N}$ or $Y\bar{Y}$, where $\bar{Y}$ is the hyperon) quasinuclear states may prove essential for explanation of various phenomena in high-energy-particle interactions (see[3]). If this is the case, "low-energy" nuclear physics and elementary-particle physics will be related much more strongly and directly in some of their aspects than had hitherto been imagined. For example, nuclear forces of the same physical nature should explain both the states of the lightest nuclei (the deuteron, tritium, helium) and the spectrum of heavy mesons (with masses in the 2 GeV range).

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