▼ In order to obtain an unambiguous test of $\mathscr{T}$ symmetry, the target nucleus must have a finite spin, since for spin zero, the relation $P=A$ can also be obtained from $\mathscr{P}$ conservation. In fact, a reflection in the collision plane gives a phase $(-1)^{m_s}$ for each particle in a reaction; hence, for target spin 0, $\mathscr{P}$ conservation implies $(-1)^{m_s-m'_s}=+1$, which for $s=\frac{1}{2}$ allows only the nonflip processes $m_s=m'_s$. With this restriction, the above relation (1-44) follows from the relation (1-45) and is therefore a consequence of rotational symmetry.

Thus, for ^{7}Li, in which the spin angular momentum is mainly concentrated on a single proton, only the contribution of this particle to the scattering provides a test of $\mathscr{T}$ symmetry, if $\mathscr{P}$ symmetry is assumed. The data in Fig. 1-6 therefore only provide weak limits on the ratio of the $\mathscr{T}$ violating to $\mathscr{T}$ invariant nuclear fields. The polarization-asymmetry relation has also been tested in other scattering processes, including $p-p$ scattering (see, for instance, Hillman *et al.*, ▲ *loc. cit.*, Fig. 1-6).

1-3 ISOBARIC INVARIANCE

1-3a Isospin Symmetry

Isospin of nucleons

A fundamental feature of nuclear structure is associated with the presence of two kinds of nucleons, the neutron and the proton. The near equality of the mass of these two particles ($\Delta M/M=1.4\times10^{-3}$; see Table 1-1, p. 4) immediately suggests a deep similarity between them (Heisenberg, 1932), and the more detailed study of their role in nuclear processes has revealed a basic symmetry between neutron and proton in all nuclear interactions. The symmetry in the interaction was first recognized as a result of the analysis of the low-energy *np* and *pp* scattering (Breit *et al.*, 1936). At low energies ($E<5$ MeV), the *np* system interacts mainly in the ^1S and ^3S channels, but the exclusion principle restricts the *pp* system to the ^1S channel. A detailed analysis of the observed scattering reveals that the *np* interaction in the ^1S channel is equal to the *pp* interaction (with the Coulomb force subtracted) to within a few percent. (For references, see the discussion in Sec. 2-5a.) The existence of a general symmetry between *np*, *nn*, and *pp* interactions is strikingly borne out by the comparison of the spectra of different isobars (nuclei having the same total number of nucleons, but different numbers of neutrons and protons). Examples will be discussed at the end of the present section.

Thus, we are led to consider the hypothesis that the nuclear forces are independent of the charge of the nucleon. Because of the exclusion principle, the charge independence symmetry refers only to the channels with antisymmetric space-spin wave functions, that is, singlet spin ($S=0$) and even orbital angular