I. ISOSPIN: INTRODUCTION AND CONCEPTS

Protons and neutrons have almost identical mass ($\Delta m/m \cong 1.4 \times 10^{-3}$) but otherwise show an almost identical behavior in their nuclear interaction. By using a double-valued variable called **Isospin** that distinguish between the 'proton' state (describe by a projection quantum number $t_z = \frac{1}{2}$)and 'neutron' state (describe by a projection quantum number $t_z = -\frac{1}{2}$).

$$| p >=| tt_z >=| \frac{1}{2}\frac{+1}{2} > \qquad | n >=| tt_z >=| \frac{1}{2}\frac{-1}{2} >$$

Experimental evidence for the equivalent of protons and neutron in their nuclear interaction.

1) Low energy np scattering and pp scattering below $E < 5$ MeV , after correcting for Coulomb effects , is equal within a few percent in the S scattering channel.

2) Energy spectra in 'mirror' nuclei are almost identical. The small difference are both a consequence of the difference in the Coulomb interaction energy and of specific nuclear wave functions , that mean the substation $n - n \Leftrightarrow p - p; n - p \Leftrightarrow p - n$ does not modify the interaction energy. This observation implies the concept of *charge symmetry* in nuclear force, see the figure.

3) Further information on how the $n - n$, $p - n$ force relate to the $n - p$ force cannot be deduced from mirror nuclei. Consider the triplet of nuclei e.g. ${}^{30}_{14}Si_{16}, {}^{30}_{15}P_{15}$, ${}^{30}_{16}S_{14}$, it is immediately clear within a number of states $(0^+, 2^+)$ (after correcting for coulomb energies). Taken as a core ${}^{28}_{14}Si_{14}$, the data show that the residual interaction energies due to $n - n$, $n - p$, $p - p$, respectively. A number of states in ^{30}P do not find a partner in the ^{30}S, ^{30}Si nuclei. This follows from the pauli principle that excludes the realization of a number of configuration in identical nucleon system $(n - n, p - p)$ compared to the $n - p)$(non-identical nucleons) system. The pauli principle explains the large number of extra states in ^{30}P, as shown in figure.

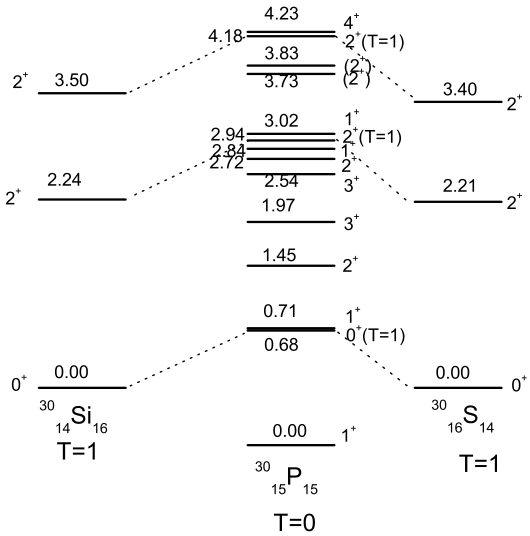

FIG. 1: The level pacing between the T=1 isospin states in the $A = 30$ ^{30}Si ,^{30}P , ^{30}S are very similar. The states in ^{30}P where isospin not given are $T = 0$ states.

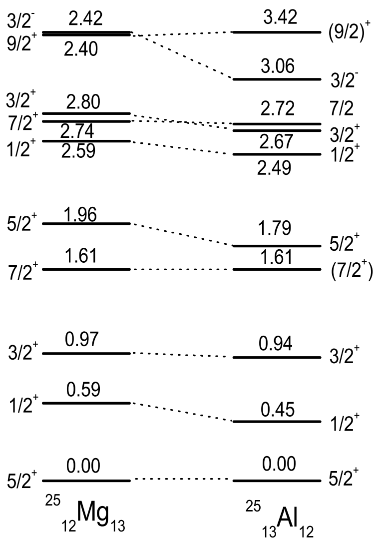

FIG. 2: Comparison of level schemes of $A = 30$ ^{25}Mg ,^{25}Al mirror nuclei shows the close similarity excitation energies.