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摘要

Abstract:

1. The β-decay properties of the neutron-deficient nuclei ^{25}Si and ^{26}P ^{22}Al have been investigated at the GANIL/LISE3 facility Radioactive Ion Beam Line in Lanzhou (RIBLL) by means of charged-particle and γ-ray spectroscopy. The decay schemes obtained and the Garrow-Teller strength distributions are compared to shell-model calculations based on the USD interaction. $B(GT)$ values derived from the absolute measurement of the β-decay braching ratios give rise to a quenching factor of the Gamow-Teller strength of 0.6null. A precise half-life of 43.7(6)null ms was detemined for ^{26}P^{22}Al,the β-(2)p decay mode of which is described.
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1 introduction

1.1 generalities

$\star\star\star\star\, background description \,\star\star\star\star$

1. Over the last decades, β-decay properties of light unstable nuclei have been extensively investigated in order to probe their single-particle nuclear structure and to establish the proton and neutron drip lines.

2.

$\star\star\star\star\, shell model \,\star\star\star\star$

Hence, compilation of spectroscopic properites are available for many *sd* shell nuclei from which nucleon-nucleon interactions were derived. β-decay studies of nuclei having a large proton excess are therefore useful to test the validity of these models when they are applied to very unstable nuclei.

$\star\star\star\star\, reduced transition probability ft \,\star\star\star\star$

Moreover, in the standard V-A description of β-decay, a direct link between experiment results and fundamental constants of the weak interaction is given by the reduced transition probability ft of the individual allowed β-decays. This parameter,which incorporates the phase space factor f and the parital half-life $t = T_{1/2}/\mathrm{B.R.}$ ($T_{1/2}$ being the total half-life

[*] 脚注

of the decaying nucleus and B.R. the branching ratio associated with the β transition considered), can be written as follow:

$\star\star\star\star$ *equation ft* $\star\star\star\star$

$$ft = \frac{\kappa}{g_V^2 \left| \langle f|\tau|i\rangle \right|^2 + g_A^2 \left| \langle f|\sigma\tau|i\rangle \right|^2} \tag{1}$$

$\star\star\star\star$ *ft explanation* $\star\star\star\star$

where κ is a constant and where g_V and g_A are, respectively, the vector and axial-vector current coupling constants related to the Fermi and Gamow-Teller components of β-decay. τ and σ are the isospin and the spin operators, respectively.

$\star\star\star\star$ *ft meanings* $\star\star\star\star$

Hence, the comparison of the measured ft values and the computed Fermi and Gamow-Teller matrix elements appears to be a good test of nuclear wave fucntions built in the shell-model frame, stressing the role of the overlap between initial and final nuclear states as well as the configuration mixing occurring in parent and daughter states.

$\star\star\star\star$ *mirror asymmetry anomaly and quenching of the GT strength* $\star\star\star\star$

However, two systematic deviations from theoretical predictions shows the limitation of our theoretical understanding and treatment of fundamental interactions. They are reported as the *mirror asymmetry anomaly in β* and the *quenching of the Gamow-Teller strength*.

$\star\star\star\star$ *Mirror asymmetry in β decay* $\star\star\star\star$

Mirror asymmetry in β-decay: This phenomenon is related to the isospin non-conserving forces acting in the atomic nucleus. If nuclear forces were charge independent, the β^+(EC) and β^- decays of analog states belonging to mirror nuclei would be of equal strength. The deviation from this simple picture is characterized by the asymmetry parameter $\delta = (ft^+/ft^- - 1)$, where the + and - signs are associated with the decay of the proton- and the neutron- rich members of the mirror pair, respectively. Figure 1 presents an updated systematic of δ values measured for mirror nuclei with A $\leq$ 40. Thirty-nine allowed Gamow-Teller mirror transitions with log(*ft*) $\leq$ 6 pertaining to 14 pairs of a mean deviation of about 5% for these nuclei lying in the p and sd shells. The asymmetry reaches 11(1)% if only p shell nuclei are considered, which stresses the interplay between the Coulomb and the centrifugal barriers.

It was often attempted to explain the mirror asymmetry anormaly in the p shell either in terms of binding effects or by troducing the concept of " second-class currents ", which are not allowed within the frame of the standard V-A model of the weak interaction. None of the theoretical approaches ware able to reproduced the measured δ values. Shell-model calculations are currently performed to test the isospin non-conserving part of the interaciton in β-decay by studying the influence of isospin mixing effects and of radial overlap mismatches of nuclear wave functions on the Gamow-Teller matrix elements. These calculations are performed in the p shell and in the sd shell, where reliable single-particle nuclear wave functions are now available.

$\star\star\star\star$ $Gamow - Teller\ quchching$ $\star\star\star\star$

Gamow-Teller quenching: The axial-vector couping constant g_A involved in β transitions of the Gamow-Teller type is not strictly constant and it has to be renormalized in order to reproduce the ft values measured experimentally. The effective couping constant $g_{A,eff} = q \cdot g_A$ is deduced empirically from nuclear-structure experiments and shows a slight variation over a wide range of masses: $q = 0.820(15)$ in the p shell,$q = 0.77(2)$ in the sd shell(giving a quenching factor q^2 of 0.6) and $q = 0.744(15)$ in the pf shell.

Different theoretical approaches haves been used in order to derive the renormalization factor from core polarization effects (due to particle-hole excitations), isobar currents and meson exchange. Despite all these efforts, the origin of the quenching effect is not very well understood. Nevertheless, the Gamow-Teller strength function $B(GT) = (g_A/g_V)^2 \left|\sigma\tau\right|^2$, which translates the global response of the wave function to spin-isospin excitations ocuurring in the β-decay,is a useful link between experimental results and theoretical predictions and it can be used as a comparative tool.

$\star\star\star\star$ *Experimental development* $\star\star\star\star$

Experimental development: With the development of secondary radioactive beams and other experimental techiques like the combination of helium-jet transport systems with telescope detectors, a large set of neutron-deficient nuclei has been investigated since the β-decayed proton emission was first first observed forty years ago. As Q_{EC} values are increasing while nuclei become more exotic, $\beta-p$ and $\beta-\gamma$ spectroscopic studies of neutron-deficient nuclei give the opportunity to probe the Gamow-Teller strength function up to more than 10 MeV in excitation energy. Hence, the whole energy window open in β-decay can be covered both by spectroscopic studies and charge exchange reactions. Therefore, the theoretical description of nuclear structure as well as our understanding of the weak interaction can be tested far from the stability line. As an illustration,we will report in the following on the β-decay properties of two neutron-deficient light nuclei, namely ^{25}Si and ^{26}P.

1.2 Previous studies

1.2.1 Studies of ^{25}Si

1.2.2 Studies of ^{26}P

1.2.3 Present measurement

2 Experiment procedure

2.1 Fragment production and detection set-up

2.2 β-delayed proton spectroscopy

2.2.1 Energy calibration of the implantation detector

2.2.2 Proton detection efficiency

2.2.3 Absolute intensities of the observed proton groups

2.3 γ-ray spectroscopy

3 Experimental results

3.1 β-decay study of ^{25}Si

3.1.1 β-decay proton emission

3.1.2 β-delayed γ-decay

3.1.3 β-decay scheme of ^{25}Si

3.2 β-decay study of ^{26}P

3.2.1 β-delayed proton emission

3.2.2 β-delayed γ-decay

3.2.3 Measurement of the half-life of ^{26}P

3.2.4 β-decay scheme of ^{26}P

3.3 Mirror asymmetry of mass A=25,26 nuclei

4 Conclusion and perspectives