(p,2p) AND (p,np) REACTIONS ON ^{23}Na, ^{29,30}Si, ^{31}P AND ^{39}K AT 1 GeV

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This investigation completes the experimental study of quasielastic scattering of 1 *GeV* protons on (2*s*-1*d*)-shell nuclei. Earlier, the analogous experiments have been performed on ^{24,25,26}Mg, ^{27}Al, ^{28}Si, ^{32,34}S and ^{40}Ca [1 — 4]. Wide range of the investigated nuclei ($16 \leq A \leq 40$) enables us to determine in details the evolution of both isovector and isoscalar components of nuclear potentials as well as single particle wave functions of $1d_{5/2}$-, $2s_{1/2}$-, $1d_{3/2}$-shell nucleons. The experimental results are shown in the figure, where the proton and neutron hole-states spectra are demomstrated. Most of them were measured for the first time. It is seen from the figure that the fine structure in the E_N-spectra is observed even at the first stage of the d-shell formation. Adequate theoretical description of this splitting presumes an axially-symmetrical deformation of the self-consistent nuclear potentials. For ^{23}Na the deformation parameters of proton and neutron components of nuclear potential equal to $\beta_{2p} \approx \beta_{2n} \approx +0.25$ which leads to the splitting of $1d_{5/2}$-shell on two substates with different momentum projections on the axis of symmetry ($\Omega^{\pi} = 1/2^{-}$ and $\Omega^{\pi} = 3/2^{-}$) (fig.). Further filling of the subshell $\Omega^{\pi} = 3/2^{-}$ in the magnesium isotopes [1,2] does not change the deforuation significantly which indicates on an approximate balance of the spin-orbital and the deformation forces. In ^{27}Al nucleus the deformation decreases significantly [1] and in ^{28,29,30}Si it becomes negative ($\beta_{2p} \approx \beta_{2n} \approx -0.25 - 0.30$). In this configuration the spin-orbit interaction dominates, therefore $1p_{1/2}$- and $2S_{1/2}$ -levels in the E_N-spectra are isolated (fig.). Filling of $2S_{1/2}$-shell in ^{31}P leads to another change of the sign of the deformation parameters. The values of β_{2p}, β_{2n} remain positive up to ^{39}K nucleus where the effect of the shell splitting is very small if it exists at all (fig.).

The theoretical analysis of the experimental data in the framework of the partially self-consistent nuclear model [5] allowed us to obtain the parameters of the proton and neutron components of the nuclear potentials, the realistic wave functions of the nucleon single-particle states, the nuclear ground state wave functions, and also various parameters of the nuclear structure as averaged values of corresponding operators. Together with the experimentally obtained values of the separation energies E_N, this information enables to verify existing microscopic nuclear models (e.g. Hartree-Fock model) and can be a basis in future theoretical investigations of nuclear matter.

References

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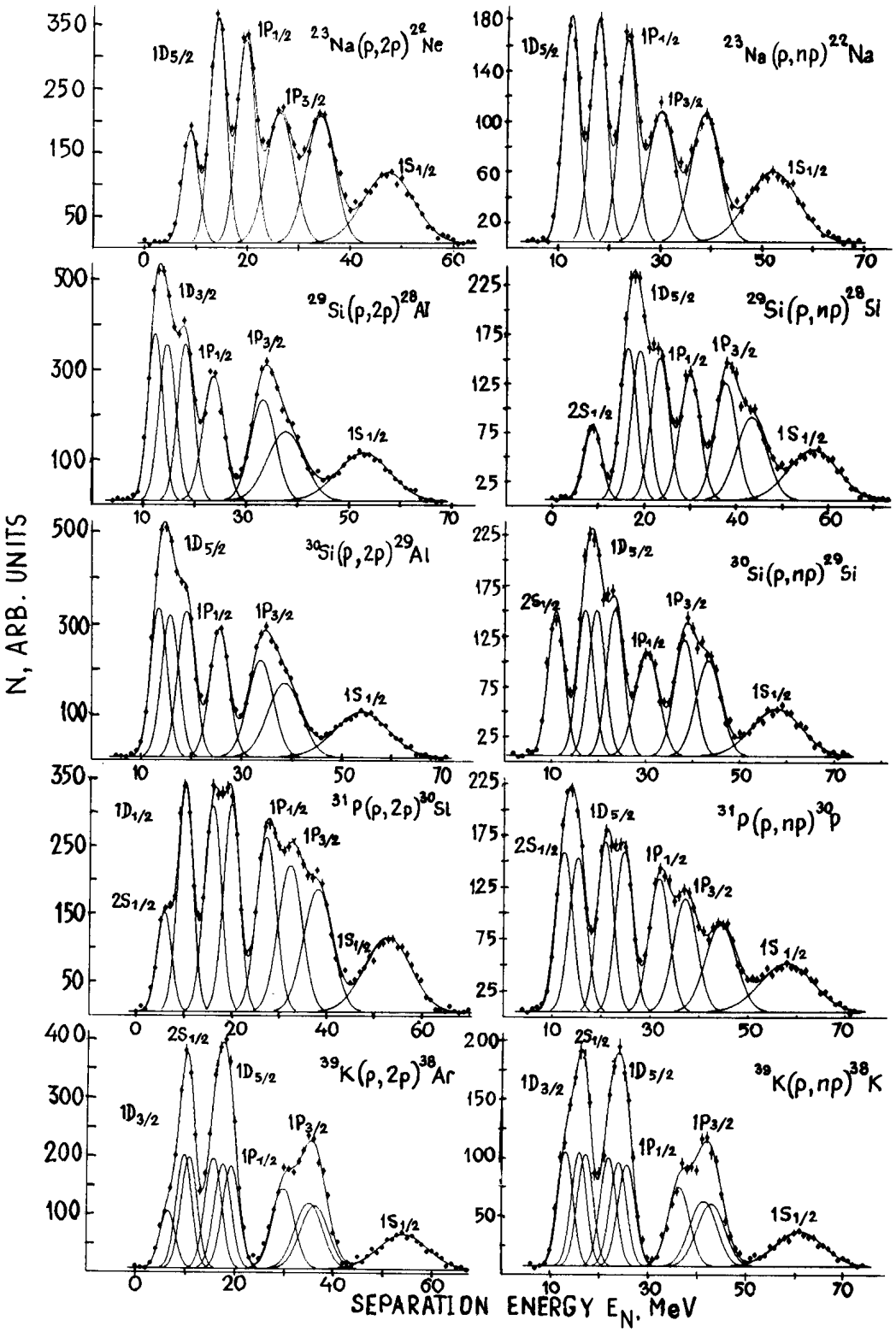
N, ARB. UNITS
SEPARATION ENERGY E_N, MeV
$^{23}Na(p,2p)^{22}Ne$
$^{23}Na(p,np)^{22}Na$
$^{29}Si(p,2p)^{28}Al$
$^{29}Si(p,np)^{28}Si$
$^{30}Si(p,2p)^{29}Al$
$^{30}Si(p,np)^{29}Si$
$^{31}P(p,2p)^{30}Si$
$^{31}P(p,np)^{30}P$
$^{39}K(p,2p)^{38}Ar$
$^{39}K(p,np)^{38}K$
1D5/2
1P1/2
1P3/2
1S1/2
1D3/2
2S1/2
1D1/2

Fig.