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NEW ISOTOPES ^{23}F, ^{24}F, ^{25}Ne AND ^{26}Ne, PRODUCED IN NUCLEAR REACTIONS WITH HEAVY IONS

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As we have already reported [1], the nuclear reactions with heavy ions represent a very effective way of getting new neutron-rich isotopes of light elements. In the work reported here we have obtained in such a way four new isotopes, namely ^{23}F , ^{24}F , ^{25}Ne and ^{26}Ne .

High energy proton experiments of Poskanzer et al. [2] have shown the particle stability of ^{11}Li , ^{12}Be and ^{15}B . The heaviest among the known isotopes of three successive elements are ^{18}C , ^{20}N and ^{22}O [1]. Theoretical estimates [3,4,5] suggest that for $Z \leq 6$ the observed extremly-neutron-rich isotopes lie close to the boundary line of the particle stability, while for $Z > 6$ this boundary corresponds to a much larger neutron excesses than those of heaviest isotopes discovered so far. In view of these estimates the experimental proof of the particle stability of the successive isotopes of F and Ne is a step towards reaching the boundary of the particle stability for these elements as well.

Our experiment was performed on the 300-cm heavy ion cyclotron at Dubna. A metallic ^{232}Th target 4.4 mg/cm^2 thick was bombarded with the 174 MeV ^{22}Ne ions. The reaction products were identified by means of the magnetic spectrometer combined with the $\Delta E/dx$, E techniques.

The reaction products emitted from the target at the 40° angle with respect to the incident beam passes the magnetic spectrometer and were detected in a particle telescope placed in the focal plane in the spectrometer. The telescope consisted of two surface barrier silicon detectors: a 46.6 μm thick ΔE detector and a 0.6 mm thick $E-\Delta E$ detector. The pulses from both detectors were sent to the two - dimensional, 64 x 64 channel pulse - height analyzer.

By making the reaction products go through the magnetic spectrometer we could change the continuous energy spectra along the practically unresolvable lines $MZ^2 \cong$ const. into a set of the well separable maxima with coordinates:

$$\Delta E = \int_{R(E_0)-d}^{R(E_0)} \frac{dE(Z,M)}{dx} dx$$

$$E - \Delta E = E_0 - \Delta E = \frac{1}{2}(eBR)^2 \frac{Z_i^2}{M} - \Delta E .$$

Here $R(E_0)$ and $R(E_0)-d$ are the ranges of the (Z,M) reaction product in silicon for energy E_0 determined by the chosen magnetic rigidity BR and for energy $E_0 - \Delta E$, respectively. Z_{ic} is the charge of the ion when it is passing the spectrometer.

For more detailed information concerning the experimental method used we refer to the paper previously published /1/.

The search for new neutron-rich isotopes of fluorine and neon was performed for the values of BR corresponding to $Z_1 = Z-1$. For the chosen value of BR the only source of the background in the experimental method used would be the isotopes of the Z+1 element passing the spectrometer with the charge lower by 3e than that correspondibg to the total ionization. We have found however that this effect is practically undetectable.

The results obtained with the magnetic rigidity $BR/B_{el}R$ = 1.159 corresponding to the maximum yield of the heaviest isotopes of F and Ne are shown in fig.1. Here $B_{el}R$ is the magnetic rigidity value for the elastically scattered ^{22}Ne ions. The numbers of counts given in fig.1 were obtained by summing the counts in a few adjacent ΔE -channels along the line Z =const. on which the peaks corresponding to the isotopes of the Z-element should be situated. The arrows point to the predicted positions for different isotopes.

Fig.2 shows the results obtained for another value of BR, namely for $BR/B_{el}R$ =1.138.

The results quoted above show that apart from a number of known isotopes four new isotopes: ^{23}F (720 events), ^{24}F (25 events), ^{25}Ne (400 events) and ^{26}Ne (26 events) were obtained and identified unambiguously.

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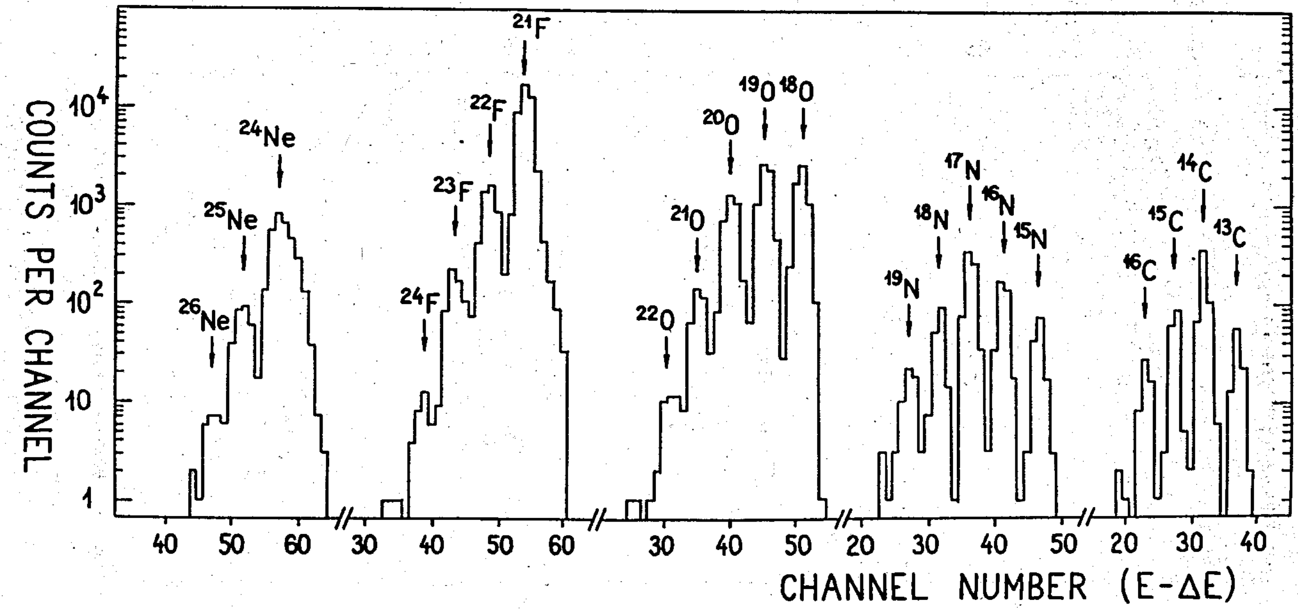

Fig.1. Yields of neon, fluorine, oxygen, nitrogen and carbon isotopes from the $^{22}Ne + ^{232}Th$ reaction at $E_{\ell ab}$ = 174 MeV; $BR/B_{e\ell}R$ = 1.159; the ^{22}Ne flux through the target I = = 9.25 10^{15} particles.

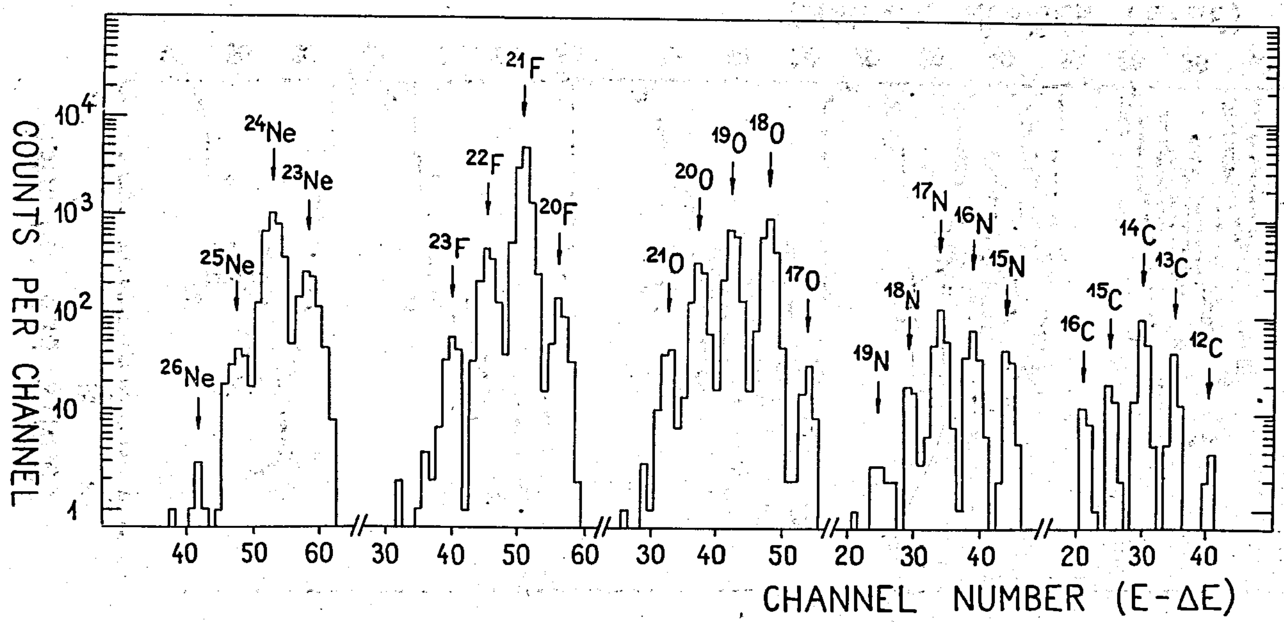

Fig.2. Yields of neon, fluorine, oxygen, nitrogen and carbon isotopes from the $^{22}Ne+^{232}Th$ reaction at E_{lab} =174 MeV; $BR/B_{el}R$ = 1.138; the ^{22}Ne flux through the target I = 2.29 10^{15} particles.