Study of the lowest states in ^{9}He as a test of unusual nuclear structure beyond the neutron dripline

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Examining nuclear matter under extreme conditions makes the most demanding test of our understanding of nuclear structure. A well known opportunity is provided by the study of nuclei which are far from the valley of stability. Indeed, it looks like we encounter cases of very light neutron rich nuclei: ^{9}He, ^{10}He, and ^{7}H, which challenge our current knowledge of nuclear structure. A controversy between different experimental results and predictions for ^{7}H and ^{10}He is broadly discussed (see [1, 2] and references therein). However, the most evident contradiction between the theoretical predictions and experimental results is for ^{9}He.

The structure of ^{9}He, with its 2 protons and 7 neutrons could be expected to be simple: two protons fill the *s* shell, while six neutrons fill the p3/2 sub shell and the extra neutron should be in the $p_{1/2}$ shell. The most sophysticated modern calculations ([3,4] and references therein) support this "naive" view on the ^{9}He structure. This means that the reduced neutron decay width for the $1/2^-$ state should be close to the Wigner limit and the state should be rather broad (all calculations predict the ^{9}He to be unstable to a neutron decay to ^{8}He). However several high resolution measurements of spectra of products of complicated binary or quasi binary reactions induced by heavy ions by a group in the Hahn-Meitner Institute [5, 6] brought interesting data with rather small uncertainties. They found the $1/2^-$ state of ^{9}He at 1.27 ± 0.10 MeV above the ^{8}He + n threshold with $\Gamma = 0.10 \pm 0.06$ MeV. The width appeared to be more than ten times smaller than could be expected [4]. The narrow width of the $½^-$ state could be considered as a direct evidence for its complicated, non shell model structure, and also could be a sign of an unusual structure appearing at the neutron dripline. Several groups tried to obtain detailed information on the lowest states in ^{9}He (including using the ^{8}He(d,p) reaction[7]), but low counting statistics or unadequate energy resolution did not give a possibility to test results [5,6].

We began an experimental study of the lowest states in ^{9}He using the ^{9}Be(^{18}O,^{18}Ne)^{9}He reaction. In contrast to other similar investigations we used coincidence between ^{18}Ne and the products of the ^{9}He decay, ^{8}He and ^{6}He. This should provide for the assignment of the correct excitation energy to the reaction products because there are excited states in ^{18}Ne which are stable to a nucleon decay, and improve the signal/background ratio. The experiment was made using ^{18}O beam of 12 MeV/A from the K150 cyclotron. Heavy ions were detected using MDM spectrometer [8] in the angular interval $5^\circ \pm 2^\circ$. The detection system of the MDM spectrometer [8] provided for the needed angular (± 0.3°) and energy resolution (~200 keV). The charged products of ^{9}He decay: ^{8}He, ^{6}He or ^{4}He were detected by Si detectors placed in the scattering chamber of the MDM spectrometer (a scheme of the setup is given in Fig.1). The identification of the mass of He isotopes was made using the reaction kinematics and by time of flight between heavy ions detected by MDM and the products of ^{9}He decay. As tests of the setup and the experimental parameters we used reactions of the ^{18}O+^{9}Be elastic scattering and the ^{9}Be(^{18}O,^{19}Ne)^{8}He reaction. In particular, the test reactions provided for spread of times of flight of ions of different energies through the MDM. This spread of ions covered the whole interval of the energy interval of the ^{18}O ions appeared to be less than 2ns.

The results of the test experiment are currently under analyzed.

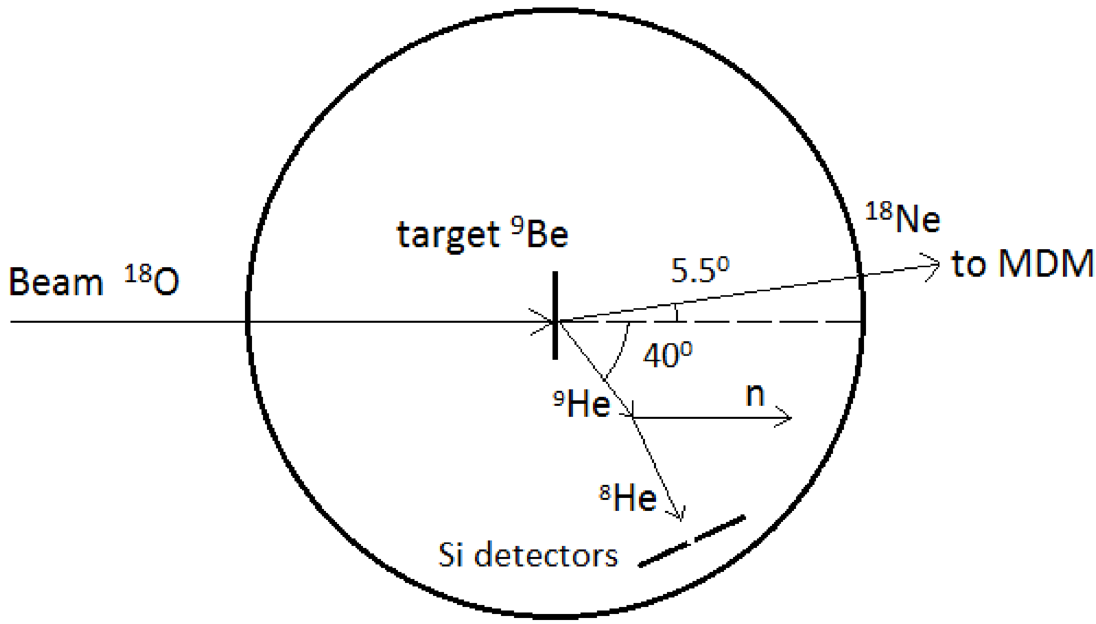

FIG. 1. Scheme of setup of the experiment.

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