Structure Studies of ^{15}C Using the ^{9}Be(^{7}Li,p) Reaction

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As proposed already in 1997 by von Oertzen [1], neutron-rich carbon isotopes may form molecular structures at high excitation energies through the clustering into three α-particles (trimers) with the extra neutrons as valence particles, which provide the binding. These structures correspond to the extension of the molecular structures in ^{11}Be and ^{12}Be by one more α-particle.

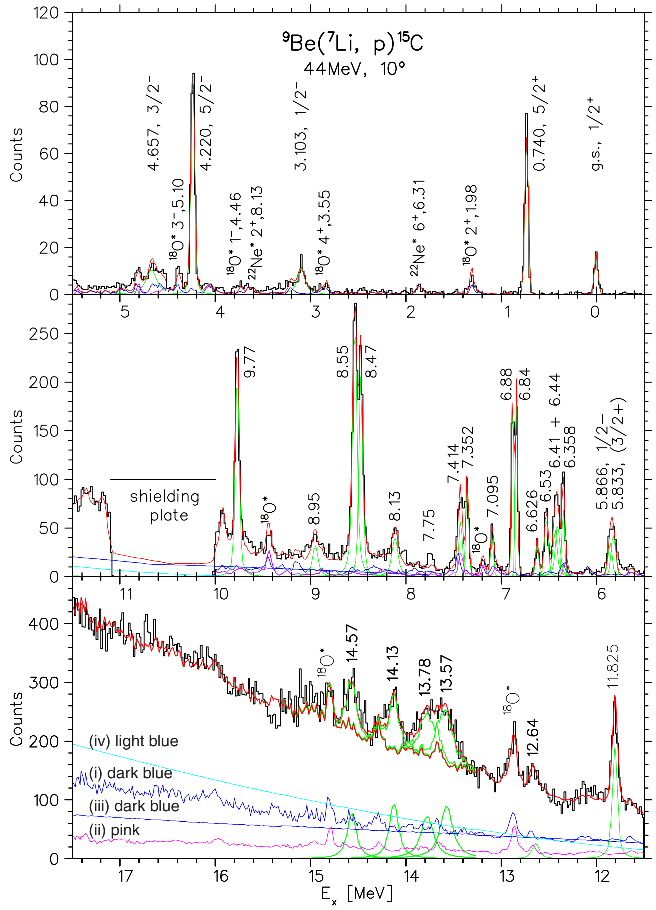

Fig. 1: Spectrum of ^{15}C-states obtained in the ^{9}Be(^{7}Li,p) reaction at $E_{\rm Lab} = 44$ MeV and $\Theta_{\rm Lab} = 10°$.

We have measured the ^{9}Be(^{7}Li,p) reaction at the Q3D magnetic spectrograph of the Munich Tandem Laboratory to study the structure of ^{15}C and, in particular, search for new high-lying states with possible molecular structure. States are known in ^{15}C up to 11.8 MeV, but molecular structures are expected rather at about 15 MeV excitation energy [1]. Fig. 1 shows the spectrum obtained at 10° with 5 settings of the magnetic field to cover the range of excitation energies from the ground state to 17.5 MeV. All the known states of ^{15}C could be identified in the spectrum (except between 9.8 MeV and 11.2 MeV, where a shielding plate was inserted against the elastic line). In addition to the known states five new states were observed at the excitation energies 12.64 MeV, 13.57 MeV, 13.78 MeV, 14.13 MeV and 14.57 MeV with widths between 50 and 150 keV. In this region of excitation energy different background contributions of four kinds exist: the (^{7}Li,p) reaction on the contaminations (i) ^{16}O (dark blue fluctuating line) and (ii) ^{12}C (pink line), and (iii) the three-body (dark blue continuous line) and (iv) four-body (light blue line) phase space distributions. Above 14.6 MeV no significant peak is observed up to the end of the spectrum (17.5 MeV), although there is much more energy available due to the positive Q-value of +9.093 MeV.

The four new states between 13.57 MeV and 14.57 MeV fall close to the expected region of molecular states and may be candidates for this structure. A molecular band with a K = 1/2 or 3/2 band head at 13.57 MeV fits the observed excitation energies. States in the region of 5.8 - 12 MeV show a dependence of cross sections on spins J, which is typical for a rotational band. Fig. 2 shows the tentative spin assignments for the states, which may form a rotational band built on the known $1/2^-$ state at 5.866 MeV (a neutron hole state in the 1p1/2 shell). The present results are preliminary and the analysis is continued.

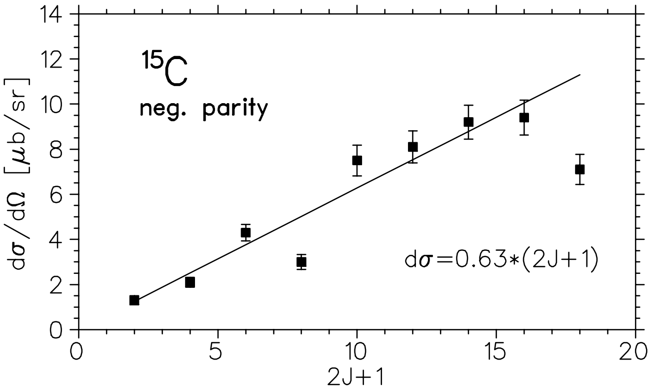

Fig. 2: Tentative spin assignments for states, which may form a rotational band built on the $1/2^-$ state at 5.866 MeV. The cross sections show a dependence on the spins J proportional to 2J+1 (except for $7/2^-$ and $17/2^-$).

References

[1] W. von Oertzen, Z. Phys. A **375**, 355 (1997).