Spin assignment of the 7.57 MeV state in the unbound nucleus ^{16}Ne*

J. Marganiec[1,2,3], *F. Wamers*[1,2,3], *T. Aumann*[1,3], *L.V. Chulkov*[1,4], *B. Jonson*[5], *T. Nilsson*[5], *H. Simon*[3], *and the R^{3}B collaboration*

[1]TU Darmstadt, Germany; [2]EMMI, GSI Darmstadt, Germany; [3]GSI Darmstadt, Germany; [4]NRC Kurchatov Institute, Moscow, Russia; [5]Chalmers Tekniska Högskola, Göteborg, Sweden

Two-proton decay of the unbound nucleus ^{16}Ne, produced in one-neutron knock-out from a 500 MeV/u ^{17}Ne beam, has been studied at GSI. The beam was directed towards carbon (370 mg/cm^2) or polyethylene (213 mg/cm^2) targets. The reaction products were identified by means of position, energy loss, and Time-of-Flight measurements, using the R^{3}B-LAND setup. Coincidences between ^{14}O and two protons provided the momentum four vectors, which were transformed into the projectile rest-mass frame, where two different sets of non-relativistic Jacobi coordinates (T- and Y-system) were used in the analysis [1].

The internal kinetic energy (the relative energy) E_{fpp} in the three-body system ^{14}O+p+p (see Fig. 1), and the fractional energies in the fragment-proton (ϵ_{fp}) and the proton-proton (ϵ_{pp}) subsystems were reconstructed. The correlation functions normalized to unity, for the fractional-energy distributions $W(\epsilon_{fp})$ and $W(\epsilon_{pp})$ and the angular distributions $W(\cos\theta_{fp})$ and $W(\cos\theta_{pp})$, were constructed and analyzed. The required efficiency and acceptance corrections have been estimated using the Monte Carlo simulations (see Ref. [2] for details).

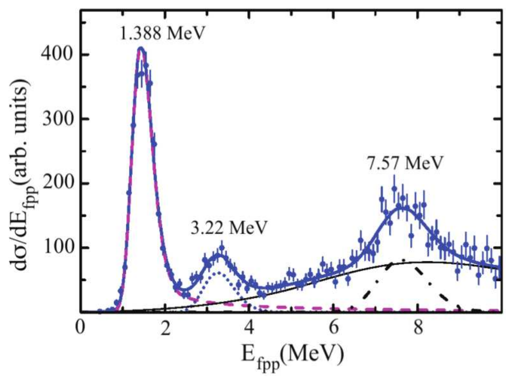

Figure 1: ^{14}O+p+p relative energy spectrum.

Correlations between the decay products from the excited state at the resonance energy $7.57(6)$ MeV are shown in Fig. 2. The two peaks visible in $W(\epsilon_{fp})$ and $W(\cos\theta_{pp})$ have been associated with transition to the state at $E_{rel} = 2.8$ MeV in ^{15}F. The results of the calculations for the assumed initial spin value $I^{\pi} = 2^{+}$ and channel spin $j = 5/2$ are shown in Fig. 2 as dashed lines. The physical background contributions are shown in Fig. 2 as dotted lines. The sum of these two contributions (solid lines) perfectly reproduces the experimental data (see Ref. [2] for details).

* Work supported by NAVI, GSI-TU Darmstadt cooperation, HIC for FAIR, EMMI and BMBF. (B.J.) is a Helmholtz International Fellow.

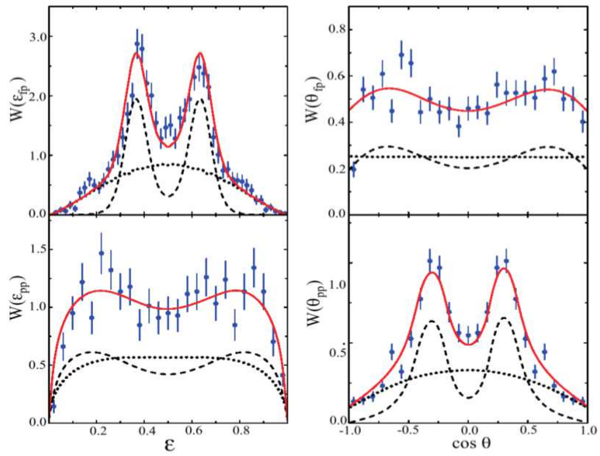

Figure 2: Three-body correlations between the decay products of the $E_{rel} = 7.57$ MeV.

In this case, the initial 2^+ state emits a proton from the $d_{5/2}$ shell feeding the ^{14}O+p in a $d_{5/2}$ shell configuration in ^{15}F. This 2^+ state is unstable and emits two protons. Its width is surprisingly narrow. This suggests that its structure can be more complicated than a ^{14}O+p+p state. This state is also situated above the four proton emission threshold, what indicates a possible many-body structure. And the ^{12}C+4p configuration with four protons in the (sd) shell, could be the cause of such a narrow width of this state [3]. A special case of such a structure could consist of an excited core together with two protons, ^{14}O(2^+)+2p [4]. The theoretical predictions for the position of the second 2^+ state in ^{16}Ne are $E^* = 4.2$ MeV [5] or $E^* = 3.6$ MeV [6], both close to the known position of the second 2^+ state in the mirror nucleus ^{16}C [7]. From this mirror nucleus (the third 2^+ state of ^{16}C is at $E^* = 6.11$ MeV [8]), the investigated state is assumed to be the third 2^+ state in ^{16}Ne.

References

[1] L.V. Grigorenko *et al.*, Phys. Lett. **B 677**, 30 (2009)

[2] J. Marganiec *et al.*, Eur. Phys. J. **A 51**:9 (2015)

[3] H.T. Fortune, R. Sherr, Phys. Rev. **C 87**, 057308 (2013)

[4] I. Mukha *et al.*, Phys. Rev. **C 82**, 054315 (2010)

[5] N.K. Timofeyuk, P. Descouvemont, Phys. Rev. **C 81**, 051301 (2010)

[6] H.T. Fortune, R. Sherr, Phys. Rev. **C 82**, 027310 (2010)

[7] M. Petri *et al.*, Phys. Rev. **C 86**, 044329 (2012)

[8] Y. Satou *et al.*, Phys. Lett. **B 728**, 462 (2014)

DOI:10.15120/GR-2015-1-MU-NUSTAR-NR-02