Highly excited high spin states in ^{22}Ne

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The main aim of this work is to study the high spin states of some highly excited levels in ^{22}Ne and to investigate their nature. The data on the presence of highly excited high-spin states in ^{22}Ne which decay by α-particles were obtained previously using the $^{18}O+^{12}C$ reaction (see [1] and references therein). However, in spite of a number of theoretical predictions for the properties of the ^{22}Ne quasimolecular bands [2], mainly experimental data are available only for the low lying levels which decay by γ-rays [3,4]. The scarce information on high-spin states in ^{22}Ne is in strong contrast with the data on ^{20}Ne, where many high-spin states were interpreted as members of ten rotational bands [5].

We used the $^{14}C(^{12}C, \alpha_1)^{22}Ne^* \rightarrow \alpha_2 + ^{18}O$ reaction to populate high spin states in ^{22}Ne. If α_1 detected at zero degrees, then the α_1- α_2 angular correlations provide for a reliable way to make spin-parity assignment. The angular correlation function, W(θ), will be

$$W(\theta) \sim (2J + 1)/4\pi[P_J(\cos\theta)]^2$$

where θ is the angle of the second α-particle, J is the spin of the level in neon and P_J is the ordinary Legendre polynomials.

Experiment

The experiment was carried out using the K-130 Cyclotron of the University of Jyvaskyla, Finland and a 44 MeV ^{12}C beam. The target was a self-supporting carbon foil with a thickness of 280 μg/cm2 (80% of ^{14}C). A schematic of the experimental arrangement is shown in fig. 1. The primary α-particle was detected using two 10 mm^2 silicon detectors of 380 μm thickness placed at $\pm 3^0$ (below and above the horizontal plane) behind a 15 μm platinum foil used to absorb the elastically scattered ^{12}C ions. The α-particles were separated from other light products by pulse-shape discrimination techniques [6]. The α-particles from the decay of states in ^{22}Ne were detected in dE − E detector telescopes. Each telescope consisted of a position-sensitive gas proportional counter used as the dE detector combined with 10 silicon PIN diodes as E detectors. The total active area of the dE − E detectors is 18 cm2. The thickness of the fully depleted PIN diodes was 380 μm. The dE gas proportional counter has a single resistive wire and measures the energy loss of the particles and the X-coordinate of the points of penetration. The counter was filled with Ar+10% CH4 gas mixture (pressure 250 Torr). A continuous renewing of the gas in the counter volume was provided. The length of the detectors (100 mm) spanned 40º in the laboratory system. The angles at the center of each diode were measured with the precision of better than ±0.5º. The (α-α) double coincidence events were analyzed to generate the α_2 angular distributions for the decays to the ground state of ^{18}O. The decay channel was selected using a two-dimensional plot $E\alpha_2$ versus $E\alpha_1$ at each α_2 angle as given by the position sensitivity of the α_2 detector.

Results

The measured angular correlation functions together with a fit by squared Legendre polynomials are shown in Fig. 1. Results of the analysis are summarized in Table I.

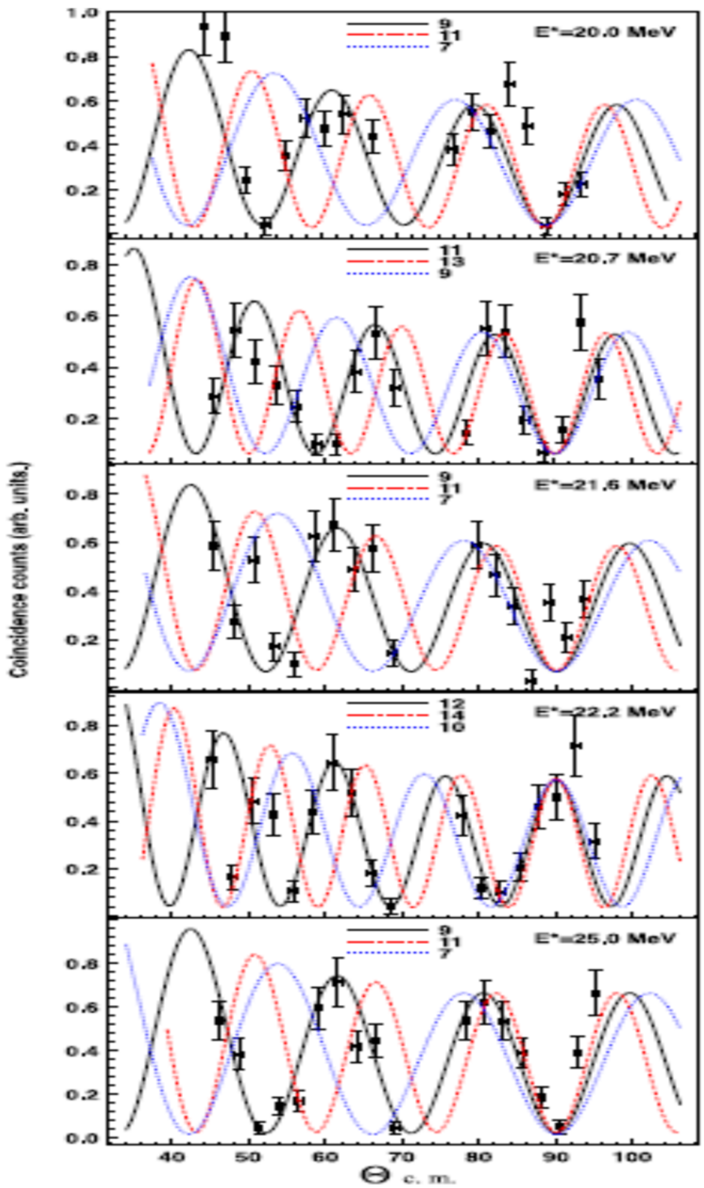

FIG. 1. Double angular correlations for the α decay of the 20.0MeV.

Table I. ^{22}Ne levels. Energy, spin and parity information from this and other work.

Present work	Adopted levels
17.0 MeV (unres. group)	17.05 MeV 7^- [23]
18.45 MeV Γ ~330 keV	18.42 MeV [22]
19.13 MeV (unres. group)	19.28 MeV 7^- [9]
20.0 MeV 9^- Γ ~270 keV	19.89 (10^+) [12]
20.7 MeV 11^- Γ ~340 keV	20.85 MeV 9^- [9]
21.6 MeV 9^- Γ ~350 keV	21.84 9^- [9]
22.2 MeV 12^+ Γ ~250 keV	(22.2) MeV [22]
22.9 MeV Γ ~290 keV	
24.0 MeV (unres. group)	24.14 MeV [24]
25.0 MeV 9^- Γ ~350 keV	
25.9 MeV (unres. group)	
27.0 MeV (unres. group)	26.89 MeV [24]

A very characteristic back bending observed for the high spin states with the positive parity in ^{22}Ne and the comparison with ^{20}Ne (Fig.2) evidences that new 12^+ level is the yrast level in ^{22}Ne.

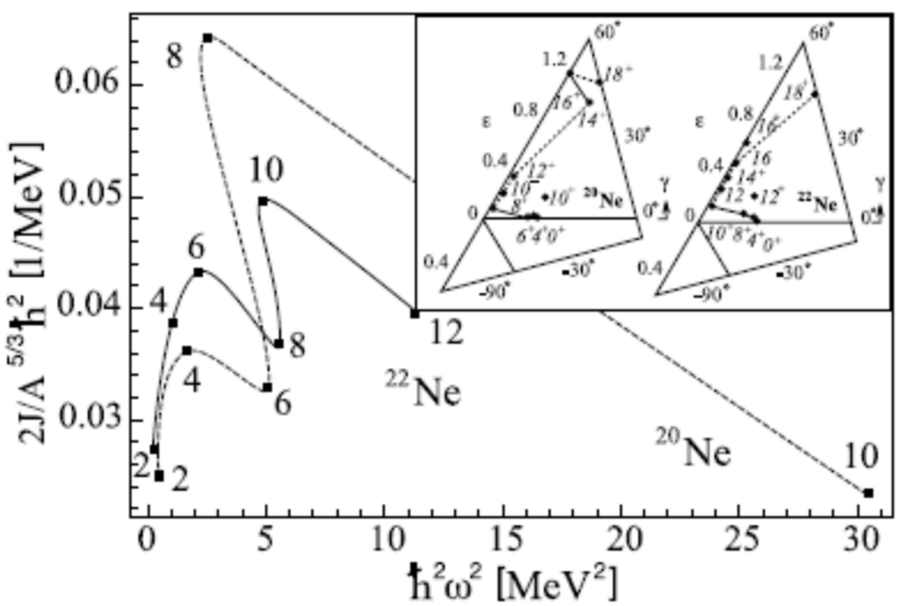

FIG. 2. Effective moment of inertia versus of the square of the rotational frequency for the ^{20}Ne and ^{22}Ne yrast lines. The inset compares the yrast-spin trajectories for these nuclei as was obtained in [10].

Summary

The spins of five highly excited states in ^{22}Ne were determined by measuring double α-α angular correlations ^{14}C(^{12}C,α_1)^{22}Ne* → α_2+^{18}O reaction. The 22.2 MeV (12^+) state is assigned to the yrast line of ^{22}Ne in good agreement with theoretical prediction based on the Nilsson-Strutinsky formalism. The states at 20.7MeV (11^-) and 21.6MeV (9^-) were considered as members of the α-cluster rotational bands supporting the cluster model predictions.

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