

Resonances in elastic alpha-particle scattering as evidence of clustering at high excitation in ^{34}S and ^{40}Ca

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The main goals of the present $^{30}\text{Si} + \alpha$ and $^{36}\text{Ar} + \alpha$ experiments were to find excitation functions for several angles in a large energy interval in highly excited ^{34}S and ^{40}Ca , to make approximate parameter assignments for the observed resonances and to compare the results to nearby nuclei. Data were collected using the time-saving Thick Target Inverse Kinematics (TTIK) technique [1,2]. The data were analyzed using a simplified R -matrix formalism [3–5], in the same manner as in [6] and similar to that of [7].

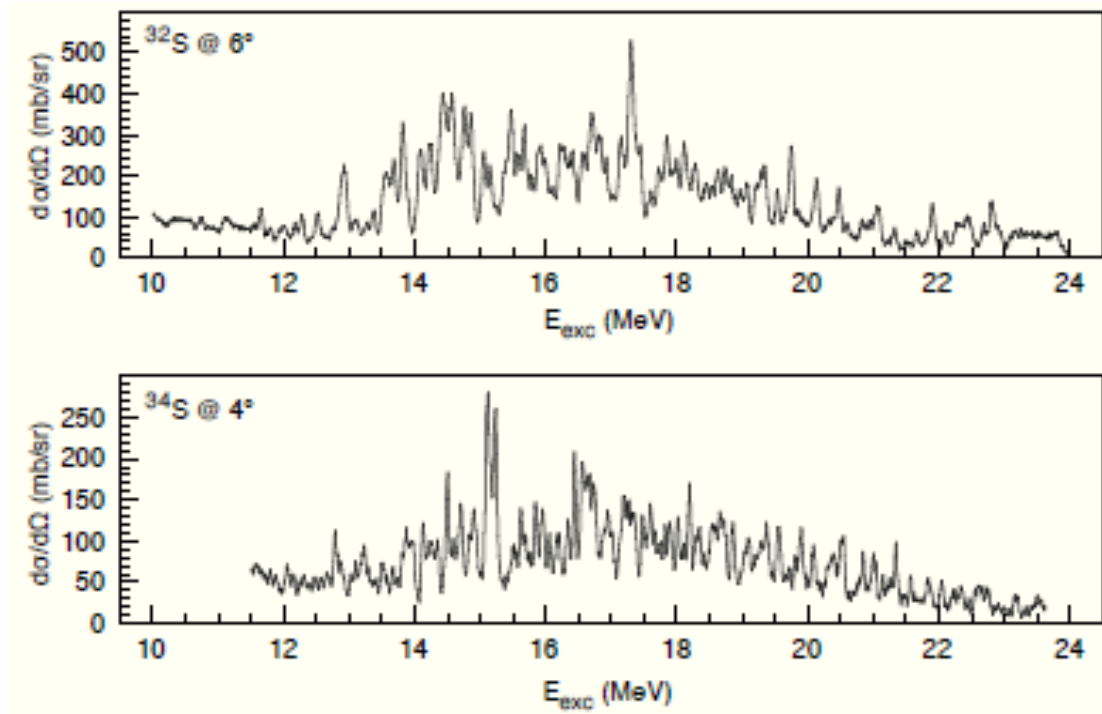


FIG. 1. The excitation function of ^{32}S from [6] (top), compared to the present data for ^{34}S (bottom).

The data collected for $^{30}\text{Si} + \alpha \rightarrow ^{34}\text{S}$ are shown in Fig.1 in comparison with the previous data for $^{28}\text{Si} + \alpha \rightarrow ^{32}\text{S}$ [6] and the data collected for $^{36}\text{Ar} + \alpha \rightarrow ^{40}\text{Ca}$ are shown in Fig. 2 at several angles. The elastic cross-sections are similar for ^{32}S and ^{40}Ca , but much lower in ^{34}S . This might in part be explained by the difference in threshold energies for α -decay, neutron decay and proton decay. Especially, the neutron partial widths should be larger in ^{34}S providing for a decrease in the probability to observe the α -decay. The density of resonances is clearly larger and their average width clearly smaller in ^{40}Ca compared to the sulphur isotopes, perhaps connected to its tightly bound doubly magic structure.

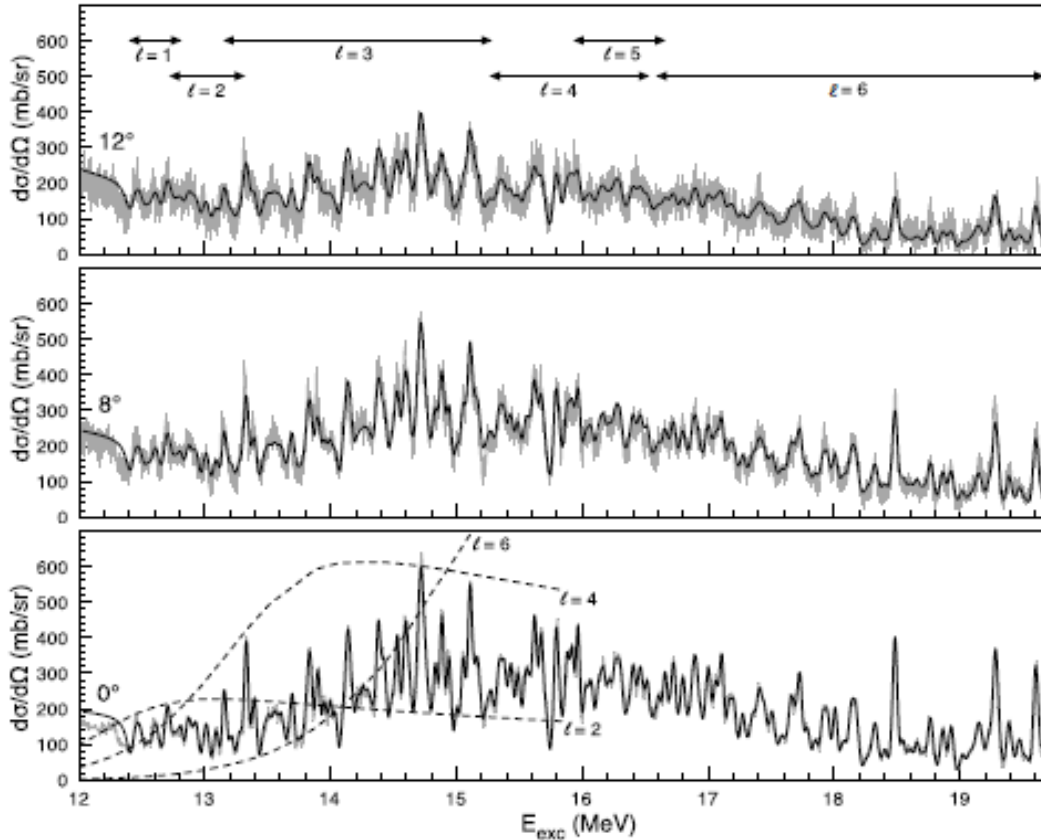


FIG. 2. Excitation functions including uncertainties for the $^{36}\text{Ar} + \alpha$ scattering measured by detectors at 0° , 8° , and 12° respectively. The black lines show the fits to the data. The regions where different spin groups are found are indicated with arrows in the top panel. In the bottom panel the dashed lines indicate the maximum theoretical cross-section for strong resonances of selected spins, detected with a resolution of 30 keV.

Fig. 3 shows resonances found in ^{32}S (from [6]), ^{34}S , ^{36}Ar [7] and ^{40}Ca plotted according to their respective excitation energy and spin. An average for each spin value has been obtained by weighting each level by its reduced width, illustrated by the diamonds in the figure. In all four cases a clear linear behavior is seen, indicative of quantum mechanical rotation. The moments of inertia can be extracted and for all four nuclei they lie between the values of a rotating “molecular” core + α -particle and a single α -particle orbiting an inert core.

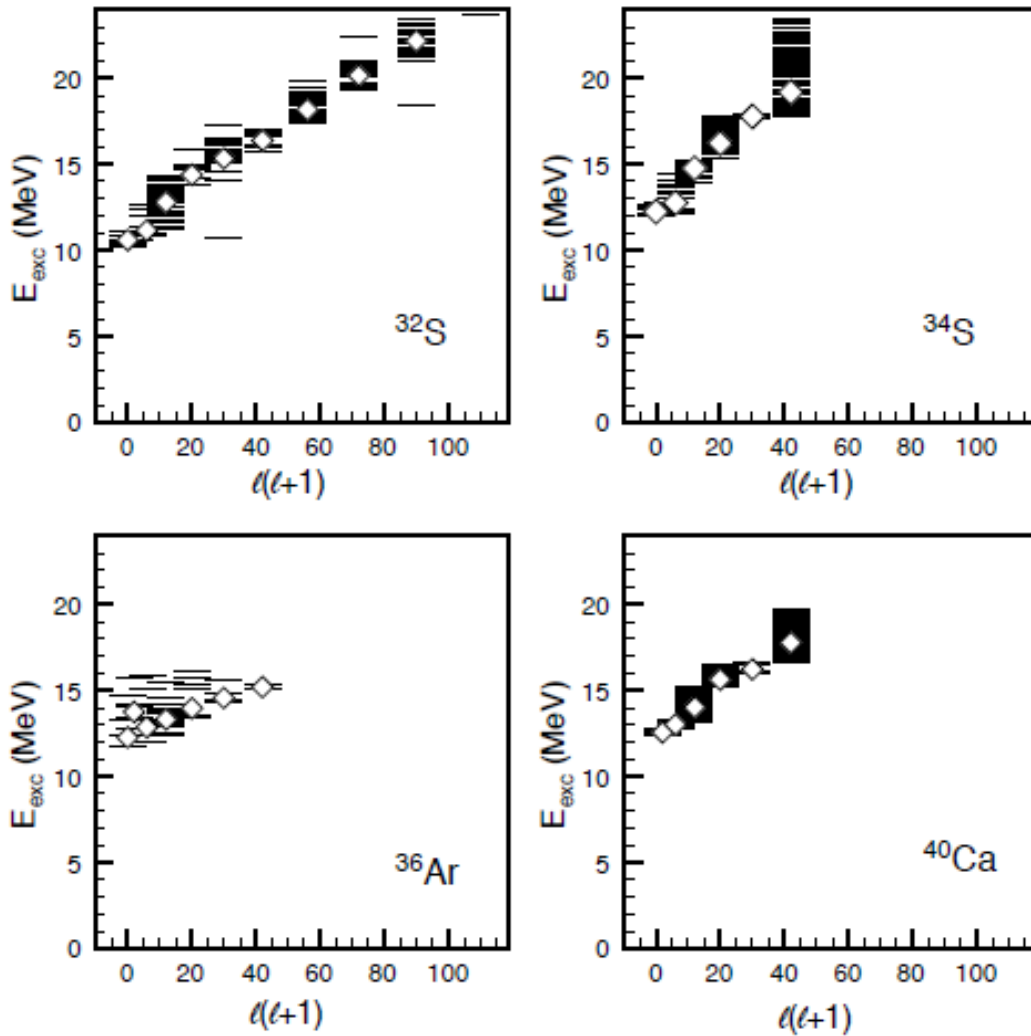


FIG. 3. The $l(l+1)$ versus E_{exc} plot of resonances in ^{32}S (from [21]), ^{34}S , ^{36}Ar [23] and ^{40}Ca . The diamonds represent the weighted average energy for the levels of the same spin.

This work shows the importance of the α clusterization for the medium light nuclei even at high excitation energy.

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