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Is there a bubble in 34Si?

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The occurrence of a central density depletion (“bubble”) has been predicted by Mean Field and Relativistic Mean Field calculations in several parts of the chart of nuclides, including in particular superheavy nuclei [1][2]. Such a drop in the central density is very rare and has not yet been observed experimentally. Bubble nuclei could constitute a useful tool to test the spin-orbit interaction, this term being linked with the derivative of the nuclear density.

In order to highlight the bubble phenomenon, an experiment was performed at NSCL in September 2012. The 34Si(-1p)33Al reaction was used to determine the proton 2s1/2 occupancy in 34Si. At the same time the 36S(-1p)35P reaction was performed. The results concerning 34Si will then be compared to those obtained for 36S, the occupancies of which are already known from a 36S(d,3He)35P experiment [3]. The S800 spectrometer was used to determine the parallel momentum distribution of the knock-out residues and then determine the orbital quantum number l of the residual nuclei. The high efficiency, high resolution gamma array GRETINA was used to tag the feeding of excited states in the knock-out residues and then determine the proton 2s1/2 occupancy of the incident nuclei.

34Si was chosen as a good candidate for a proton bubble, as the 34Si(d,p)35Si experiment performed at GANIL in 2009 revealed a significant change in the spin-orbit splitting of this nucleus [4], which suggests it has an anomalous density profile. Moreover its proton 2s1/2 occupancy has been predicted to be quite low (S=0.08), which is a key criterion for bubble occurrence, since only l=0 orbitals contribute to the central nuclear density. The 2s1/2 occupancy constitutes then a useful and more direct probe for bubble phenomena.
Motivations for studying bubble phenomena will be introduced, and the experimental setup as well as the current state of the analysis will be detailed.

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