Study of particle-hole states in ^{208}Pb with the Q3D magnetic spectrograph

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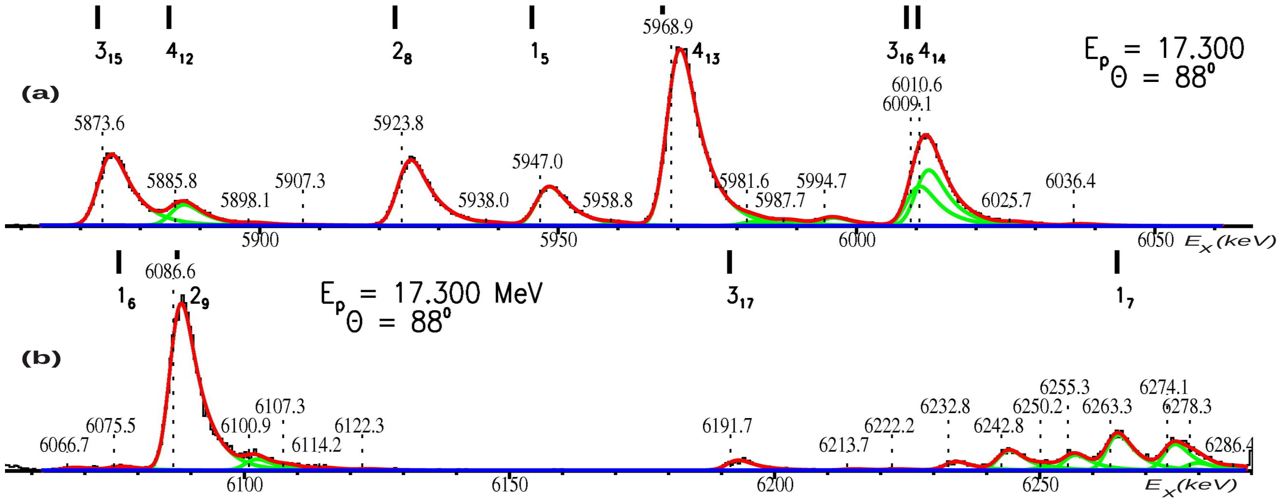

Figure 1: Spectrum of ^{208}Pb(p,p') taken near the $g_{7/2}$ IAR in ^{209}Bi for $E_x = 5.8$ - 6.3 MeV (from Ref. [6].)

The Q3D magnetic spectrograph at the MLL (Garching) has been used to study the structure of states in the doubly magic nucleus ^{208}Pb. Experiments on the ^{207}Pb(d,p) and ^{208}Pb(d,d') reactions were accompagnied by Pb(d,p) experiments with various isotopic mixtures of ^{206}Pb, ^{207}Pb, ^{208}Pb. The main source of information derives from the study of the ^{208}Pb(p,p') reaction via the seven known isobaric analog resonances (IAR) in ^{209}Bi equivalent to neutron pickup reactions on seven different target states in ^{209}Pb.

The most annoying experimental problem is the knockout reaction of atomic electrons [1]. Whereas the M-electrons with binding energies of $E_B = 2.48$, 2.59, 3.07, 3.55, 3.85 keV finally limit the resolution, the L-electrons with $E_B = 13.1$, 15.2, 15.9 keV produce satellites with a typical fraction of 0.1 - 1% of the main peak. Only by comparing spectra taken for at least three out of the nine reactions mentioned above, or spectra taken at different scattering angles, the satellites produced by the L-electrons (and K- electrons with $E_B = 88$ keV) can be discriminiated from main peaks of nuclear states in ^{208}Pb.

A typical resolution of 3 keV was achieved. The peak shape, however, is asymmetric due to the knockout reaction of atomic electrons, see Fig. 1. Excitation energies for about 200 states at $2.5 < E_x < 8.1$ MeV are determined with a mean uncertainty of 0.5 keV. For states strongly excited by at least three out of the nine reactions mentioned above, an uncertainty of 20 eV is achieved.

Several doublets with a distance of 0.2 - 1.5 keV between the states are resolved [2-7].

The shell model predicts 70 states with negative parity below $E_x = 6.3$ MeV and 50 positive parity states below $E_x = 6.1$ MeV. The states with spins 0^-, 4^-, 5^-, 6^-, 7^-, and 8^- consist by more than 90% of an equal number of particle-hole configurations [6]. These ensembles of states may be considered as a complete system; thus the strength of particle-hole configurations can be deduced which are undetectable by experiment. For each of these spins, the next particle-hole configuration is predicted to have excitation energies much larger than the mean matrix element of the residual interaction (about 50 keV [7]). Indeed all spectra taken near 6 MeV show a gap of about 200 keV where no such state is observed. Fig. 1 shows an example; here at $6.02 < E_x < 6.20$ MeV only states with positive parity or spins 1^-, 2^-, or 3^- show up.

The ^{208}Pb(d,d') reaction offers the opportunity to discern all states in ^{208}Pb. Namely, the cross sections for different states (except for several yrast states) differ much less than for the other reactions; the ^{207}Pb(d,p) reaction and the resonant ^{208}Pb(p,p') reaction are highly selective.

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