A microscopic investigation of the low-lying 0^+ states in deformed nuclei [a]

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Recent high resolution (p,t) experiments have established the existence of a large number of low-lying excited 0^+ levels in several deformed nuclei [1,2].
In order to account for such a large abundance and to gain a deep understanding of the properties of these states, we have adopted the quasiparticle-phonon model (QPM) using an interaction of general separable form [3,4]. We have computed the $E0$ and $E2$ transition strengths to probe the quadrupole collectivity, as well as the two-nucleon transfer spectroscopic factors. These latter quantities are directly extracted from the experiments and represent a unique probe for pairing correlations.
The QPM analysis of the $E2$ and $E0$ transitions has lead to the conclusion that quadrupole collectivity is weak in all 0^+ states of all nuclei. Almost all 0^+ are one-phonon states built out of pairing correlated configurations. These, however, add coherently only in one 0^+. Such a pairing collective state is the only one predicted to be strongly populated in (p,t) two-nucleon transfer reactions, in agreement with experiments. Experimentally, in fact, the (p,t) reaction populates mostly only one out of the many 0^+ levels. ^{168}Er represents an exception. In this nucleus, in fact, the (p,t) strength is almost evenly distributed among weakly excited states. Such a fragmentation is a pure anharmonic effect due to the mixing between different phonon configurations.
The analysis of the QPM wave functions suggests that these 0^+ arise from pairing vibrations associated to fluctuations of the pairing field in the ground state.
The QPM has been adopted also for investigating the structure of the huge number of 2^+ states detected in ^{168}Er [5]. The calculation not only accounts for all the observed levels but reproduces well the magnitude and distribution of the (p,d) strength collected by these states.
The results obtained has encouraged us to carry out a systematic study of the 0^+ states throughout the whole rare earth region in parallel with experimental investigations. This analysis is in progress.

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