energy with the 42^+ state very low-lying as predicted for a terminating state (Ragnarsson *et al.*, 1986). Indeed, $I^\pi = 42^+$ is identical to the maximum spin in the expected yrast configuration $\pi(h_{11/2})^4\nu(f_{7/2}h_{9/2})^4(i_{13/2})^2$. Note also the large gap associated with this neutron configuration to the far right in fig. 12.10.

Here, we have mainly discussed the nuclei with valence particles outside the ^{146}Gd core. However, starting from other closed shell nuclei similar analyses could be carried through and, as indicated above, also for holes in a closed core, an analogous formalism should be valid. The nuclei we have discussed here with $A \approx 160$ are, however, especially advantageous for several reasons. From the experimental side it is so because they are neutron deficient, which makes it easy to form high spin states from heavy ion reactions (fig. 11.11). Furthermore, nuclei with mass numbers $A = 100$–200 on the average can accommodate the highest spins as seen from fig. 12.3. From the theoretical side, the presence of several high-j shells just above the $Z = 64$ and $N = 82$ shell closures make the terminating bands especially favoured.

12.7 Shell effects at large deformation

In the preceding section, we discussed the case of a few valence nucleons outside closed shells leading to states of single-particle character at intermediate spin values. With more particles outside the core, the nucleus will stay collective to higher spins with only small shape changes. In any case, however, the centrifugal force will sooner or later become dominating as discussed within the liquid-drop model above and illustrated in figs. 12.2 and 12.3. Indeed, for nuclei with mass $A = 100$–150, the liquid-drop energy will be very soft over large regions of the deformation plane for spins $I \approx 50$–60. This means that the shell effects may play a very important role, creating minima at small but also at large and very large deformations. One example of this is seen for ^{160}Yb in fig. 12.8 where a minimum develops for $\varepsilon \approx 0.4$ and $\gamma = 20$–$30°$.

Because of the important role of the shell effects, it seems appropriate to consider their properties at large deformation in some detail. In general, one expects larger shell effects for axial symmetric shapes than for triaxial shapes. In the static harmonic oscillator approximation, this is understood from the fact that the quanta in the two perpendicular directions can be interchanged with no change in the single-particle energies. Consequently, large degeneracies occur as indicated in fig. 8.1. For example, with a two-fold spin degeneracy, the $n_z = 0$ orbitals with all quanta in the perpendicular