In the definition of the shell energy, all quantities should be evaluated at the same spin I_0, i.e. the smoothed single-particle energy sum should be calculated at an ω-value giving a smoothed spin $\widetilde{\Sigma m_i} = I_0$. Thus, the ω-values in the discrete sum and in the smoothed sum are generally different and it becomes difficult to get any feeling for the variation of E_{sh} from an inspection of a single-particle diagram. However, it can be shown that the quantity

$$E_{\text{quasi-sh}}(\omega) = \Sigma e_i^\omega - \widetilde{\Sigma e_i^\omega}$$

with all quantities calculated at the same ω is numerically very similar to E_{sh}. An elementary discussion of this is given in Ragnarsson *et al.* (1978). The quantity $E_{\text{quasi-sh}}$ is defined exactly analogous to the static shell energy discussed in chapter 9. Thus, ω enters very much as a deformation parameter and we can take over all our experience from the static case; specifically that gaps in the single-particle spectrum give a favoured (negative) shell energy while a large level density leads to a positive shell energy, i.e. an unfavoured configuration.

12.6 Competition between collective and single-particle degrees of freedom in medium-heavy nuclei

We will now turn to heavier nuclei where, as seen in fig. 11.2, the moment of inertia extracted from the measured 2^+ to 0^+ energy spacing is less than 50% of the calculated rigid body value. We have already pointed out that the low value is due to the pairing correlations (the pairing correlations are less important in a light nucleus like ^{20}Ne). With increasing spin, the experimental moment of inertia becomes larger (fig. 11.13) and for the deformed rare-earth nuclei, it comes close to the rigid body value in the $I = 20$–30 region. This suggests that the pairing correlations are rather unimportant at these spins and the same conclusion is also reached from more fundamental theoretical considerations. The cranking model in the form in which we applied it to ^{20}Ne, with independent particles in a rotating potential, should then be applicable to heavy nuclei at high enough spins, let's say $I \geq 30$. For such high spins, the approximation of identifying the total spin with the projection on the rotation axis should also be quite accurate. The result from ^{20}Ne that the model seems to describe the spectrum quite reasonably all the way down to $I = 0$ or at least $I = 2$ is in some ways surprising. Indeed, the application of a rotating independent particle model to the $I = 0, 2, \ldots$ states of ^{20}Ne can hardly be justified theoretically.

Calculated potential energy surfaces for ^{160}Yb at different spin values