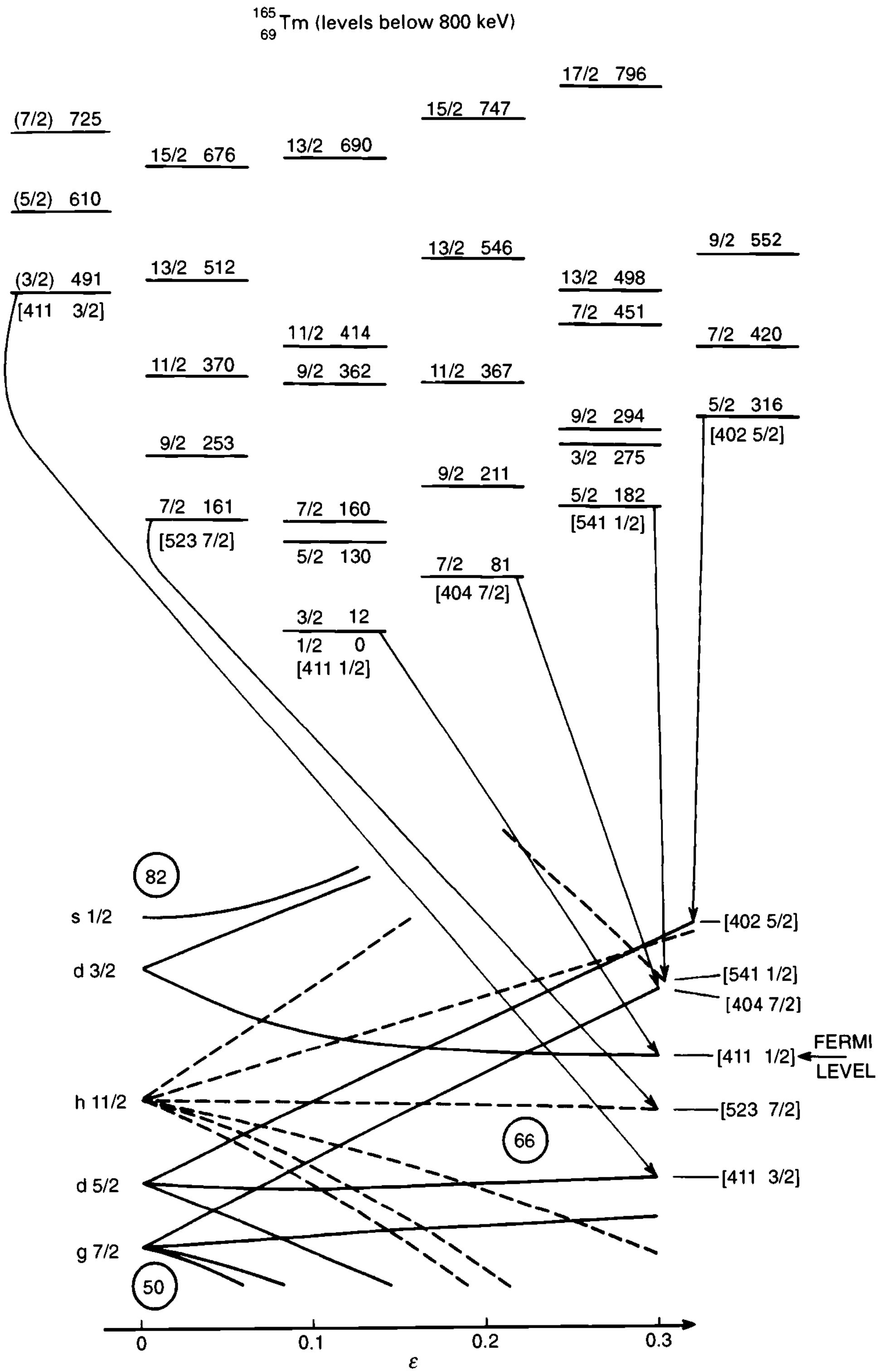

Fig. 11.4. For legend see opposite.

of this figure, the proton single-particle orbitals are exhibited as functions of the deformation coordinate, ε. For a given nucleus, the equilibrium value of ε can either be taken as an experimental quantity derivable from for example the measured quadrupole moment or it can be calculated with the methods described in chapter 9.

In the upper part of fig. 11.4, the measured low-energy spectrum of ${}^{165}_{69}Tm_{96}$ is exhibited. For this nucleus, the equilibrium value of ε is approximately equal to 0.29. The even neutrons (96 of them) are assumed to be paired off two and two in orbitals 'Ω and $-\Omega$' to angular momentum zero. Similarly, the 68 protons are assumed to fill pairwise the 34 lowest orbitals. The 69th proton is then (for the ground state) placed in the 35th orbital, marked [411 1/2]. This is thus associated with $\Omega = \frac{1}{2}$. The ground state spin is also measured to be $\frac{1}{2}$ and a rotational band with $I = \frac{1}{2}, \frac{3}{2}, \frac{5}{2}, \ldots$ based on this orbital is identified.

At 81 keV of excitation energy there is another band starting with $I = \Omega = \frac{7}{2}$ (and having positive parity). This band is obtained by promoting the odd proton from [411 1/2] and up into [404 7/2]. The excitation energy, 81 keV, is associated with the energy difference in the single-particle diagram and described by $|e_\nu - \lambda|$ in the formula above. This energy is thus counted relative to the Fermi energy λ, where λ is given by the single-particle energy of the [411 1/2] orbital. A third band, having $K = \Omega = \frac{7}{2}$ and negative parity, is observed starting at 161 keV excitation energy. This band is realised by the promotion of one of the two protons from [523 7/2] to [411 1/2], in which latter orbital a pair state of compensating spins is formed. We may then call the $\frac{7^-}{2}$ state built on [523 7/2] a 'hole' state. From fig. 11.4, it is evident that such a hole state is associated with a positive excitation energy, thus justifying the absolute sign in the $|e_\nu - \lambda|$ term of the formula above.†

The other bands of ${}^{165}Tm$ are now easily understood. They are obtained

† If pairing is also considered, the $|e_\nu - \lambda|$ term should be replaced by a $[(e_\nu - \lambda)^2 + \Delta^2]^{1/2}$ term, see chapter 14.

Fig. 11.4. (*opposite*) Calculated single-proton orbitals in the rare-earth region with the observed spectrum of ${}^{165}Tm$ above. The usual spherical subshell notation is used for $\varepsilon = 0$. For $\varepsilon \neq 0$ the standard asymptotic notation is given for each orbital $[Nn_3\Lambda\Omega]$, N being the oscillator shell quantum number, n_3 the number of modes along the intrinsic 3-axis (the symmetry axis), Λ the value of the orbital angular momentum ℓ_3 along the 3-axis and Ω the value of the total angular momentum j_3 along the same axis. The Fermi level in the case of 69 protons is indicated. The experimental states are ordered in rotational bands and the orbital of the odd particle is indicated in each case.