WIGNER X RESOLVED AND PHOTO-REACTION CROSS-SECTION PREDICTIONS: IMPROVEMENTS FOR ASTROPHYSICAL CALCULATIONS

Abstract

by

Ian Bentley

Nuclear potential energy surfaces are generated using a mixed micro-macro model. This is done in an automated procedure called AutoTAC which is used to find equilibrium deformation parameters corresponding to an energy minimum. This information will be used as a starting point for nuclear structure calculations with implications for astrophysical significance.

IBM parameter fits based on energy ratios and transition probabilities can be used to determine the ground state probability distribution from experimentally measured input. An alternative approach involves mapping Fermionic potential energy surfaces on to Bosonic space. This can give a predictive low-lying excitation spectra as well as the probability distribution of the ground state. The probability distributions can be combined with the dipole strength function calculated using QRPA. The Instantaneous Shape Sampling (ISS) procedure involves adding many weighted strength functions, which is particularly important for the photo-absorption cross-section of transitional nuclei.

The linear coefficient in symmetry energy term of nuclei is also called the Wigner X. The

experimental determination of the Wigner X involves removing the Coulomb energy by use of mirror nuclei with corrections for deformation based on additional experimental information. Energy differences are calculated using groups of three nuclei along an isobaric chain in steps of T_z=2, in order to avoid even-odd staggering effects, starting at N~Z. The resulting energy dependence is of the form T(T+X) and appears to involve fluctuations about X=1 and X=4. For the strong pairing limit of isovector pairing the dependence should be of the form T(T+1), which reflects the spontaneous breaking of the isorotational symmetry by the isovector pair field. Calculations using an isovector monopole pairing interaction are solved exactly by means of diagonalization for small 6 and 7 level systems. The equilibrium deformation parameters calculated in AutoTAC are used as input.

The Wigner X observable is particularly sensitive to the deformation. In mid-shell regions, theoretically determined deformations are fairly constant and small, whereas experimental values are large and varied. In closed shell regions, where the theoretical deformations appear to be more accurate, the model does an excellent job of reproducing the observable. It is shown that allowing for slight adjustments of the experimentally determined deformation parameters will reproduce the large amplitude fluctuations seen experimentally for A~80. The pairing calculations also allow for comparisons with the energy difference between the even-even and odd-odd mass parabolas to be determined, using the same procedure. The results indicate that the same pairing mechanisms that mediate the pairing gap are also responsible for the Wigner X.