Tidal Waves - a non-adiabatic microscopic description of the yrast states in near-spherical nuclei

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The transition energies between the yrast states of near-spherical nuclei are roughly constant, about 0.6-0.8 MeV up to spin 14, which is expected for a vibrational band. A linear relation between spin and energy is also characteristic for a region of phase transition, and a vibrational band may be interpreted as the condensation of phonons. A description in terms of multi phonon states of an adiabatically decoupled collective quadrupole mode cannot account for the irregular fluctuations of the transition energies around the mean value, which indicate a strong coupling to the single particle degrees of freedom. A non-adiabatic microscopic description for these states is presented, which takes this coupling fully into account. Semiclassically, a multi phonon state of maximal angular momentum corresponds to a wave of constant deformation running over the nuclear surface, the same as tidal waves move over the earth's oceans. The calculations can be carried by means of the selfconsistent cranking model, because the tidal wave corresponds to a static deformation in the frame rotating with it. In contrast to a rotor nucleus, angular momentum is generated at roughly constant angular velocity by increasing the deformation combined with rapidly aligning the quantized angular momenta of the nucleons at the Fermi surface. This regime requires new methods for achieving selfconsistency of the rotating mean field, which will be discussed. Good agreement with the experimental transition energies, B(E2) values and g-factors are found for the nuclides with Z=42, 44, 46,48, N=56, 58, 60, 64, 66. The calculations reproduce the irregular deviations from simple purely collective models for the quadrupole mode, which can be traced back to the response of individual nucleons and are manifest of the intimate coupling between collective in single particle motion. The tidal wave concept allows one to predict the yrast energies of exotic vibrational and transitional nuclei up to the spins that can be reached by near future experiment. It also provides predictions for the B(E2) values from COULEX experiments and γ-spectroscopy on exotic nuclei, as well as measurements of their g-factors. The coupling between single particle and collective degrees of freedom is a new source of information about the shell structure in very neutron- or proton-rich nuclei. The method can be easily applied to odd mass nuclei or band-like sequences built on high-spin isomers, for which it predicts the B(M1) values. Examples will be presented.

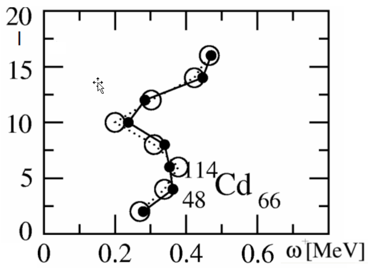

Figure 1. Angular moment I vs. frequency (half transition energy) Open circles: calc., filled: data

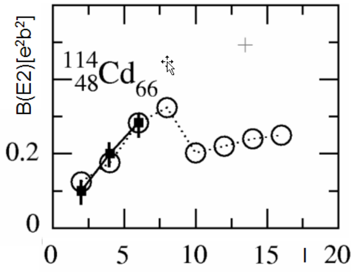

Figure 2. B(E2) values. Open circles: calculation, filled: data

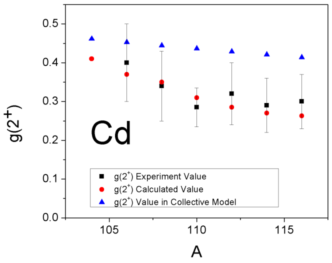

Figure 3. g-factors for Cd isotopes. Red dots: calc. black squares: data, blue triang.: Z/A

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[1] S. Frauendorf, Y.Gu. *Tidal waves as yrast states in transitional nuclei*. arXiv, Article-id: 0709.0254.