Large Amplitude Qn-Qp Collectivity in N-Rich Oxygen Isotopes *

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The dominance of neutron-proton attraction is one of the main characteristic of the effective interaction between nucleons. This can be related to isospin symmetry and a cooperation between the T=0 and T=1 channels. As a result, most isovector collective modes have a much higher excitation energy than their isoscalar counterparts.

In view of the experimental opportunities which are presently opening, it is of particular interest to analyze in what measure this situation is modified in nuclei far away from stability. Here we will focus on the neutron-rich side of the valley of stability where it is expected that the excess of neutrons and the fact that their distributions extends much beyond that of protons (neutron skins, halos) open possibilities of new collectivity and n-p decoupling. For instance, the so-called “pigmy” low energy dipole resonance has already been abundantly studied. On the other hand, (isoscalar) quadrupole mode dominates standard nuclear low energy large amplitude collective dynamics. It is thus of interest to study how it can be affected by a neutron excess. With the present work we start such an exploration with the case of the oxygen isotopes.

Our analysis starts with constrained Hartree-Fock-Bogoliubov (HFB) calculations performed with the Skyrme SLy4 interaction and a density-dependent zero-range pairing interaction [1]. We consider successively i) the usual single constraint on the total axial quadrupole moment generating a deformation energy curve and ii) two independent neutron and proton quadrupole constraints generating a deformation energy surface. The corresponding HFB wave-functions are then projected on the exact number of particle (N,Z) and on the total spin. In this way, we have determined 0^+ and 2^+ collective energy curves or surfaces. This amounts to a transformation from the intrinsic to the laboratory frame. Fig. 1 gives the contour lines of the 0^+ energy surface of ^{20}O as an example. The deformation valley stretches first mostly along the neutron quadrupole direction (Q_n axis) reflecting the expected resistance to deformation of the magic proton number. Thus, at the projected mean-field level, this oxygen isotope displays a decoupling of neutron and proton deformations. Further, after a reorganization of the proton core which destroys the magic structure (2p-2h configuration), the deformation valley bends up in the direction of larger Q_p's. Similar 0^+ and 2^+ energy surfaces have been calculated for ^{22}O and ^{24}O. They display the same global features albeit enhanced with increasing values of the neutron number.

As a last step, we compute the collective dynamics by means of a global configuration mixing performed within the Generator Coordinate Method (GCM) [2]. In this way, we gain, access to absolute and excitation energies for the low spin states, as well as multipole moments and B(E2) values.

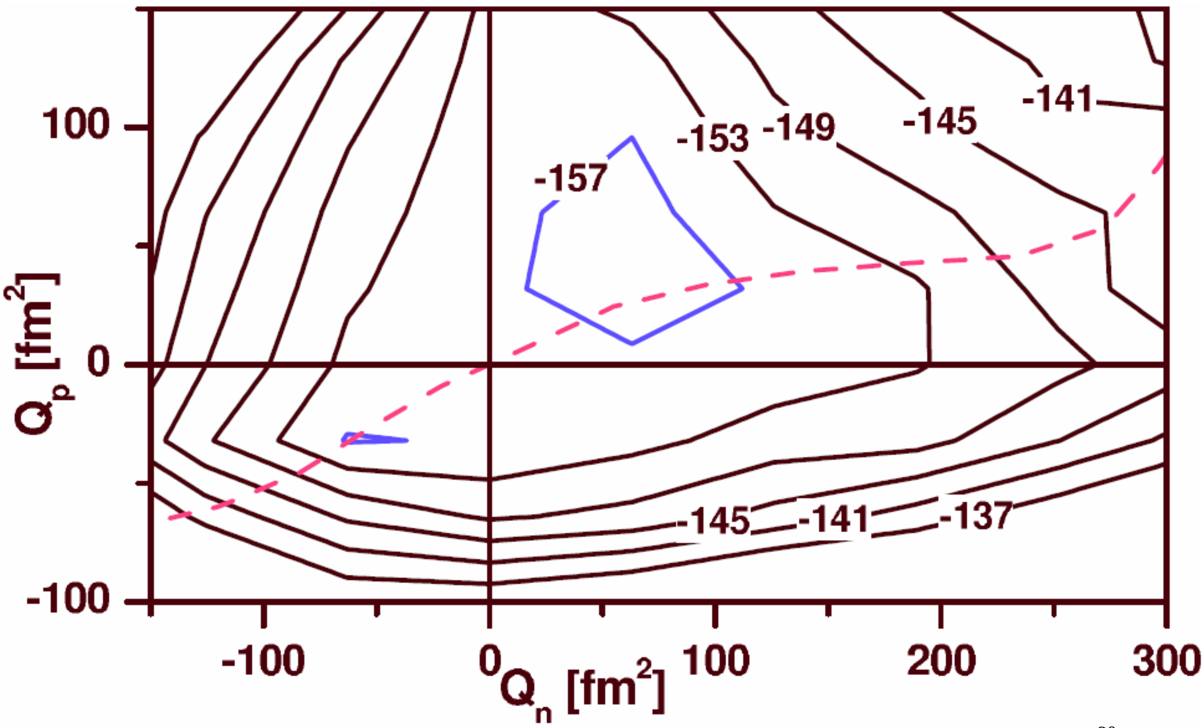

Figure 1: Contour lines of the Q_n - Q_p deformation energy surface for the 0^+ configuration of ^{20}O. The curves are labelled by the absolute energy in MeV. The dashed line shows the deformation path associated to the standard isoscalar quadrupole constraint (Q_n+Q_p).

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