Magnetic excitations beyond the dipole in nuclei with neutron excess

G. Co' and V. De Donno [1 2] and M. Anguiano and A. M. Lallena [3]

[1]Dipartimento di Fisica, Università del Salento, Italy

[2]Istituto Nazionale di Fisica Nucleare sez. di Lecce, Italy

[3]Departamento de Fisíca Atómica, Molecular y Nuclear, Universidad de Granada, Granada, Spain

In our recent work we have analyzed the magnetic excitations in nuclei with neutron excess in the continuum RPA (CRPA) framework that uses finite range interactions with tensor channel [1]. Whereas the 1^+ case shows a clear behaviour, the study of the excitations beyond the dipole is more complicate because more complex structures emerge. We have conducted our investigation in various oxygen and calcium isotopes where the s.p. levels below the Fermi surface are fully occupied, and those above are empty. We present here only results obtained for oxygen isotopes, we have found similar behaviours for calcium ones. We show calculations implemented with the traditional D1S [2] interaction and with the D1ST force that we have recently constructed by adding a finite-range tensor-isospin term to the former parameterization [3].

We have analyzed the 2^- and 3^+ modes that are composed by p-h excitations with intrinsic different characteristics. The 2^- mode is composed by p-h transitions between different major shells. On the contrary, in the 3^+ mode p-h excitations within the same major shell are allowed. We have investigated whether this difference produces remarkable effects on observables.

As an example of the comparison between the results obtained in discrete RPA (DRPA) and CRPA calculations we show in Fig. 1 the 2^- excitation of the oxygen isotopes. For all the isotopes considered we observe a good agreement between the position of the peaks in discrete and continuum results. In ^{16}O the DRPA calculation produces a sharp peak at 12.10 MeV, which is below the continuum threshold. This peak is dominated by the s.p. transitions $[(1d_{5/2})(1p_{1/2})^{-1}]$ of both protons and neutrons, whose unperturbed excitation energies are 10.27 MeV and 10.05 MeV respectively. The figure shows that the size of the $B(\mathcal{M}2)\uparrow$ strength for the ^{16}O and ^{28}O is comparable with that of the other two isotopes, contrary to what we found for the 1^+ excitation.

More interesting is the effect of the tensor force: in Fig. 2 the CRPA results, are now compared with those obtained by using the D1ST force. We observe that the strengths are concentrated in three different regions. A first one between 10 and 15 MeV, a second one between 16 and 20 MeV, and a third one around 25 MeV.

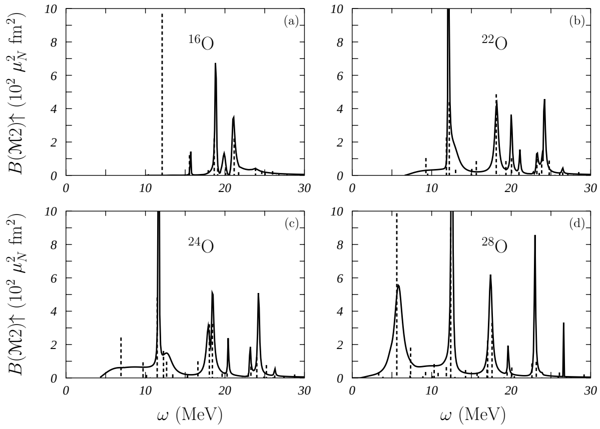

Figure 1. $B(\mathcal{M}2)\uparrow$ values obtained with the D1S interaction for oxygen isotopes with CRPA (full lines) and DRPA (vertical dashed lines) calculations.

The excitations between 10 and 15 MeV are dominated by the $[(1d_{5/2})(1p_{1/2})^{-1}]$ proton transitions. The calculations with and without tensor predict almost identical excitation energies for these resonances in the ^{16}O and ^{28}O nuclei, while for the ^{22}O and ^{24}O nuclei the resonances of the calculations with D1ST have larger energies than those obtained with D1S. This is a consequence of the Otsuka effect [4,5] of the tensor force on the s.p. energies. This effect appears in nuclei where not all the spin-orbit partner levels of a certain type of nucleons (protons or neutrons) are occupied and affects the s.p. energies of the nucleons of the other type.

The investigation done for the 2^- excitation has been repeated for the 3^+ mode. In Fig. 3 we compare the RPA results obtained with the D1S (full lines) and the D1ST (dashed lines) interactions for the ^{22}O and ^{24}O isotopes. For the other two oxygen isotopes under investigation the results obtained with and without tensor almost overlap, as observed for the 2^- cases.

The difference between the positions of the peaks obtained with and without tensor is due

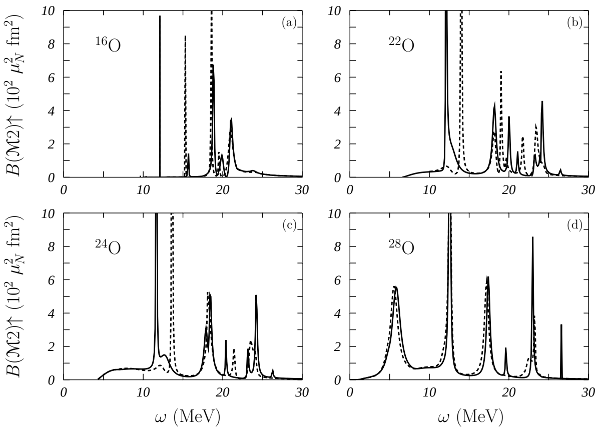

Figure 2. $B(\mathcal{M}2)\uparrow$ values for oxygen isotopes as a function of the excitation energy. The full and the dashed curves show the CRPA results obtained, respectively, with the D1S and D1ST interactions.

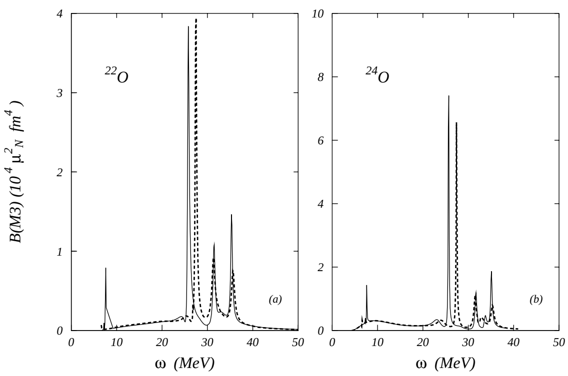

Figure 3. $B(\mathcal{M}3)\uparrow$ values for the ^{22}O and ^{24}O isotopes obtained by CRPA calculations with the D1S and D1ST interactions indicated, respectively, by the full and dashed curves.

mainly to the Otsuka effect.

REFERENCES

1. G. Co', V. De Donno, M. Anguiano and A.M. Lallena, submitted to Phys. Rev. C.
2. J. F. Berger, M. Girod, D. Gogny, Comp. Phys. Commun. 63 (1991) 365.
3. M. Anguiano, G. Co', V. De Donno, A. M. Lallena, Phys. Rev. C 83 (2011) 064306.
4. T. Otsuka *et al.*, Phys. Rev. Lett. 95 (2005) 232502.
5. T. Otsuka, T. Matsuo, D. Abe, Phys. Rev. Lett. 97 (2006) 162501.