Thomas-Ehrman shifts

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The Thomas-Ehrman shift (TES) is a very important characteristic of the mirror asymmetries related to the structure of nuclei with weakly-bound protons. The TES is especially large when the participating states are unbound against proton emission and when the occupation of the s-shell is large. This is demonstrated in Table 1, where TES for neon isotopes with core+2p structure and their respective mirror nuclei are given. TES is defined as the difference between the excitation energy differences between mirror states with spins I_1 and I_2:

$$\mathrm{TES}(I_1, I_2) = [\mathrm{E}(I_1) - \mathrm{E}(I_2)]_\mathrm{p} - [\mathrm{E}(I_1) - \mathrm{E}(I_2)]_\mathrm{n}. \quad (1)$$

Table 1: Thomas-Ehrman shifts for neon isotopes with core+2p structure and their mirror nuclei. S_{2p} is the two-proton separation energy and $P(s^2)$ the amount of s^2 in the wave function [1, 2]. Uncertainties smaller than 1 keV are not indicated.

Isotope	S_{2p} (MeV)	$P(s^2)$	Mirror	TES (MeV)
^{18}Ne $2^+;\ 0^+$	4.523	19%	^{18}O	-0.095
^{17}Ne $3/2^-;\ 1/2^-$	0.973(27)	24%	^{17}N	-0.086(8)
^{16}Ne $2^+;\ 0^+$	-1.388(15)	46%	^{16}C	0.070(46)
^{15}Ne $5/2^-;\ 3/2^-$	-2.552(66)	63%	^{15}B	0.573(78)

Attempts to describe the TES for the nuclei ^{17}Ne and ^{16}Ne were made in Refs. [3, 4] within a three-body model, with inert core plus two protons. The conclusion given in Ref. [3] was: *"The computed three-body Thomas-Ehrman shifts are then meaningful although relatively inaccurate"*.

The progress in the spectroscopy of exotic nuclei has given access to isospin multiplets in their ground and excited states. Investigation of isospin symmetry in the isobaric analog states and the properties of the Isobaric Multiplet Mass Equation (IMME) was recently made in Refs. [5, 6]. We have made an IMME analysis using the known masses and excited states of the $A = 16$ quintet. Table 2 gives the result of a least-square fit to the masses of the 0^+ and 2^+ states for $T = 2$ isobaric $A = 16$ multiplet.

Usually the Thomas-Ehrman shift is given as the difference in energies of excited states in mirror nuclei. Here we propose a broader understanding of the TES by analysing

Table 2: Coefficients in the Isobaric Multiplet Mass Equation obtained from a fit to experimental data.

State	a (keV)	b (keV)	c (keV)	$\chi^2_{min}/1$
0^+	17982(3)	-2572(4)	213(2)	3.29
2^+	19771(8)	-2598(10)	220(4)	3.68

the dependence of the positions of excited states on the isospin projection. With the IMME coefficients we may calculate TES for members of the $T = 2$, $A = 16$ multiplet and deduce the energies of the unknown excited 0^+ and 2^+ states in ^{16}F (Fig. 1). We thus predict the 0^+ state at $E^* = 10.087(10)$ MeV and the 2^+ state at $E^* = 11.908(14)$ MeV, which is in good agreement with the estimate made by Fortune [7].

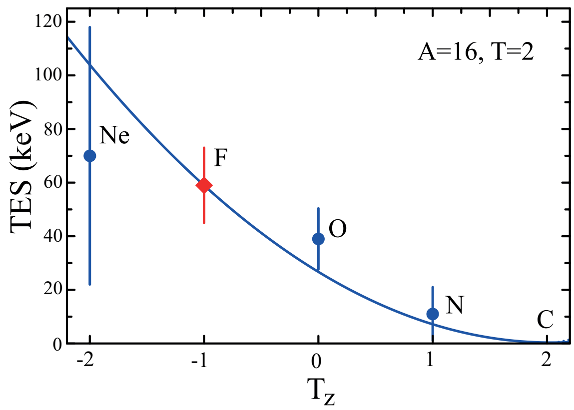

Figure 1: Thomas-Ehrman shift between 2^+ and 0^+ states for members of the isobaric quintet ($A = 16, T = 2$) as a function of the isospin projection.

References

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