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▶ To cite this version:

Dinh-Lien Pham. Investigation of the quadrupole deformation of 11B by means of 30 Mev polarized proton inelastic scattering. Journal de Physique Lettres, 1976, 37 (4), pp.67-68. 10.1051/jphyslet:0197600370406700 . jpa-00231239

HAL Id: jpa-00231239
https://hal.science/jpa-00231239

Submitted on 4 Feb 2008

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Classification
Physics Abstracts
4.370

INVESTIGATION OF THE QUADRUPOLE DEFORMATION OF ^{11}B BY MEANS OF 30 MeV POLARIZED PROTON INELASTIC SCATTERING

DINH-LIEN PHAM

Institut des Sciences Nucléaires, BP 257, 38044 Grenoble Cedex, France

(*Reçu le 6 février 1976, accepté le 16 février 1976*)

Résumé. — Les sections efficaces et pouvoirs d'analyse de la diffusion inélastique ^{11}B(**p**, p′) à E_p = 30,3 MeV ont été analysés dans le formalisme des équations couplées. Ces calculs suggèrent la valeur positive de la déformation quadrupolaire β_2 du ^{11}B (prolate) et donnent le résultat suivant $\beta_2 = +\ 0{,}52$.

Abstract. — The cross-sections and resolving powers of the ^{11}B(**p**, p′) inelastic scattering at E_p = 30.3 MeV are analyzed in the coupled-channels formalism. These calculations suggest a positive value for the quadrupole deformation β_2 of ^{11}B (prolate) and give the result $\beta_2 = +\ 0.52$.

In the understanding of 1p shell nuclei, the investigation of their deformation plays an important role. For the ^{11}B nucleus, Hartree-Fock calculations [1] do not give a prolate lower minimum compatible with the positive electric quadrupole moment obtained from experiments. For this nucleus a strong-coupling rotational model [2] has given a better result although a quantitative disagreement with the experimentally determined electric quadrupole moment still remains [3].

The above discrepancies have suggested that we need much more investigations about the quadruple deformation of the ^{11}B nucleus by means of inelastic scattering. In particular a recent investigation of the quadrupole deformation of ^{11}B by inelastic helion (^{3}He) scattering at $E_{^3\mathrm{He}}$ = 74 MeV [4] has shown, with analysis using the coupled-channels (CC) method, the possible existence of oblate-prolate effects of ^{11}B in this reaction. It would therefore appear necessary to determine the quadrupole deformation of ^{11}B by means of polarized proton inelastic scattering.

In view of the determination of the sign and the value for the quadrupole deformation β_2 of ^{11}B, we have analyzed, in the coupled-channels (CC) formalism with the rotational model using the code ECIS 75 [5], the experimental data for the cross-sections and resolving powers in the ^{11}B(**p**, p) and ^{11}B(**p**, p′) scattering to the lower two members of the $K^\pi = \frac{3}{2}^-$ band of ^{11}B, i.e. the $\frac{3}{2}^-$ ground state and the $\frac{5}{2}^-$ second-excited state (E_x = 4.46 MeV) at E_p = 30.3 MeV [6]. The optical parameters used as initial values for the optical model search procedure were taken from the analysis performed by Karban *et al.* [6] and are listed in table I. In the CC formalism, the nuclear radius is defined by

$$R = R_i(1 + \beta_2\, Y_{20} + \cdots)$$

where the β's are the deformation parameters determined by the experiment, the Y's are spherical harmonics and R_i corresponds to the various optical potential radii. The interaction potential arises from the deformation of the Coulomb potential, the complex central potential and the spin-orbit potential. The deformed spin-orbit potential was of the full Thomas form [7]. In the CC calculations, the states explicitly coupled are the lower two members of a

TABLE I

Optical model parameters used in the analysis of the ^{11}B(**p**, p)^{11}B *scattering*

V_0 (MeV)	r_0 (fm)	a_0 (fm)	W_V (MeV)	W_D (MeV)	r_I (fm)	a_I (fm)	V_{s0} (MeV)	r_{s0} (fm)	a_{s0} (fm)	r_C (fm)
45.18	1.09	0.59	0	3.38	1.30	1.01	7.78	0.98	0.57	1.09

Article published online by EDP Sciences and available at http://dx.doi.org/10.1051/jphyslet:0197600370406700

$K = \frac{3}{2}^-$ rotational band in ^{11}B. The results are presented in figure 1 and the corresponding parameters listed in table II.

The two values $\beta_2 = +0.43$ and $\beta_2 = -0.50$ obtained from reference [4] by analyzing only the cross-sections of the $^{11}B(^3He, ^3He')$ inelastic scattering at $E_{^3He} = 74$ MeV with the CC method give equally low χ^2 values. But it should be mentioned [4] that $\beta_2 = +0.43$ agrees quite well with the experimental value of $+0.0372$ b [3] for the electric quadrupole moment. The results we have obtained by analyzing simultaneously the cross-sections and resolving powers of the $^{11}B(\mathbf{p}, p')$ inelastic scattering at $E_p = 30.3$ MeV using the CC calculations suggest also a positive value for the quadrupole deformation β_2 of ^{11}B (prolate) and give the result $\beta_2 = +0.52$.

We are grateful to Dr. R. de Swiniarski for valuable discussions and his interest in this work.

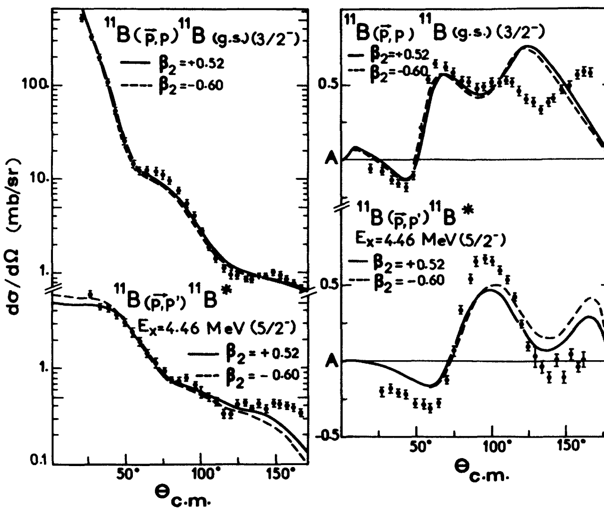

FIG. 1. — Experimental results of the $^{11}B(\mathbf{p}, p')^{11}B^*$ scattering compared to the results of the coupled-channels calculations corresponding to the two parameter sets of table II.

TABLE II

Coupled-channel parameters used in the analysis of the $^{11}B(\mathbf{p}, p')^{11}B^*$ *inelastic scattering*

β_2	V_0 (MeV)	r_0 (fm)	a_0 (fm)	W_V (MeV)	W_D (MeV)	r_I (fm)	a_I (fm)	V_{s0} (MeV)	r_{s0} (fm)	a_{s0} (fm)	r_C (fm)	χ^2
+ 0.52	46.65	1.09	0.59	0	3.22	1.30	1.01	8.38	0.98	0.57	1.09	34.83×10^2
− 0.60	46.98	1.09	0.59	0	3.34	1.30	1.01	8.34	0.98	0.57	1.09	38.48×10^2

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