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DOI

[10.1103/PhysRevLett.58.2383](https://doi.org/10.1103/PhysRevLett.58.2383)

Publication date

1987

Published in

Physical Review Letters

[Link to publication](#)

Citation for published version (APA):

Woude, A. V. D., Borghols, W. T. A., Brandenburg, S., & Sharma, M. M. (1987). Comment on "Compression Modulus of Nuclear Matter and Charge-Distribution Differences". *Physical Review Letters*, 58(22), 2383-2383. <https://doi.org/10.1103/PhysRevLett.58.2383>

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Comment on "Compression Modulus of Nuclear Matter and Charge-Distribution Differences"

In a recent Letter Co' and Speth¹ argue that the extraction of the compression modulus of infinite nuclear matter K_{NM} from the excitation energy E_x of the isoscalar giant monopole resonance (GMR) is highly model dependent, because the scalar-isoscalar part f_0 of the particle-hole interaction depends strongly on the density. The compression modulus of nuclear matter K_{NM} relates to the inner part of the nucleus, whereas the breathing mode has a large contribution from the nuclear surface. Thus, dependent on the density dependence of f_0 , different values of K_{NM} can reproduce the excitation energy of the GMR if the datum of only one nucleus like ²⁰⁸Pb is used. Co' and Speth also argue that presently the only reliable way to extract a value for K_{NM} is from the charge differences between the various Pb isotopes since these data relate to the inner part of the nucleus. Their analysis indicates that K_{NM} should be larger than the "commonly accepted" value² $K_{\text{NM}} = 210 \pm 30$ MeV with a preference for $K \approx 350$ MeV.

The purpose of the present Comment is to point out that in fact there is an independent and reliable method to relate K_{NM} to $E_x(\text{GMR})$, which takes surface effects explicitly into account. It employs the semiphenomenological relation between the nuclear compressibilities K_A^S in the scaling approximation and K_{NM} ²⁻⁴:

$$K_A^S = K_{\text{NM}} + K_S' A^{-1/3} + K_\delta' [(N-Z)/A]^2 + K_C Z^2/A^{1/3},$$

where K_C is the electrostatic contribution to the compressibility which can be calculated.³ In this expression there are three unknown parameters, K_{NM} , K_S' , and K_δ' , which can be determined by the use of the $E_x(\text{GMR})$ values of a series of nuclei with different surface-to-bulk contributions. Thus the surface effect on the breathing mode is explicitly taken into account. Because of the weak A dependence of the surface term the extraction of a value of K_{NM} in a three-parameter fit using this relation has been hampered in the past by the apparent lack of $E0$ strength in most nuclei with $A \leq 120$.⁴ This fact always left open the possibility that in addition to the strength concentration which was identified with the GMR, more $E0$ strength at higher excitation energies would be present, shifting the centroid of the GMR to higher excitation energies and thus K_A^S to higher values. On the other hand, with use only of the data for $A \geq 120$ nuclei, the available A range was too limited to determine accurately the values of K_{NM} and K_S' separately, because of the inevitable correlation between these two quantities in this limited mass range. This experimental problem has recently been solved by

TABLE I. Results of a three-parameter fit to the data for nuclei in which more than 50% of the $E0$ EWSR was identified.

Reference	K_{NM} (MeV)	K_S' (MeV)	K_δ' (MeV)	Input data
5	270 ± 13	-607 ± 43	-540 ± 145	a
6	253 ± 12	-488 ± 56	-285 ± 443	b
8	273 ± 12	-551 ± 50	-302 ± 118	c

^a ²⁸Si, ^{64,66}Zn, ^{112,116,118,120,124}Sn, ¹⁴²Nd, ¹⁴⁴Sm, ¹⁹⁷Au, and ²⁰⁸Pb.

^b ²⁴Mg, ²⁸Si, and 25 nuclei with $A > 90$ for which $> 50\%$ of the $E0$ EWSR has been observed (Refs. 5 and 6).

^c Kernfysisch Versneller Instituut data for ²⁴Mg (Ref. 7), ^{112,114,116,120,124}Sn (Ref. 8), ^{144,148}Sm (Ref. 8), and ²⁰⁸Pb (Ref. 6).

the discovery of an appreciable amount of concentrated $E0$ strength in ²⁸Si⁵ and ²⁴Mg^{6,7}. For ²⁴Mg about 90% of the isoscalar $E0$ energy-weighted sum rule (EWSR) could be identified. Table I shows the results of a three-parameter fit to the data for nuclei in which more than 50% of the $E0$ EWSR was identified. A value of $K_{\text{NM}} = 265 \pm 20$ MeV is the result of this method of analyzing the breath-mode excitation energy. This value is relatively independent of the curvature contribution³ $K_\rho A^{-2/3}$. Our analysis showed that K_{NM} increases from 265 MeV for $K_\rho = 0$ to 290 MeV for $K_\rho = 375$ MeV.

The K_{NM} value obtained from this analysis is smaller than the value of $K_{\text{NM}} \approx 350$ MeV preferred by the authors of Ref. 1. It would be interesting to see whether a value of $K_{\text{NM}} = 270$ MeV is also compatible with the experimentally observed charge differences between ²⁰⁶Pb and ²⁰⁸Pb and between ²⁰⁷Pb and ²⁰⁸Pb.

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Received 29 September 1986

PACS numbers: 21.65.+f, 24.30.Cz

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