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

Woude, A. van der; Borghols, W.T.A.; Brandenburg, S.; Sharma, M.M.

Published in:
Physical Review Letters

DOI:
10.1103/PhysRevLett.58.2383

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In a recent Letter Co' and Speth[1] argue that the extraction of the compression modulus of infinite nuclear matter $K_{\rm NM}$ 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 $K_{\rm NM}$ 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 $K_{\rm NM}$ can reproduce the excitation energy of the GMR if the datum of only one nucleus like ^{208}Pb is used. Co' and Speth also argue that presently the only reliable way to extract a value for $K_{\rm NM}$ 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 $K_{\rm NM}$ should be larger than the "commonly accepted" value[2] $K_{\rm NM}=210\pm30$ MeV with a preference for $K\simeq350$ MeV.

The purpose of the present Comment is to point out that in fact there is an independent and reliable method to relate $K_{\rm NM}$ to E_x(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 $K_{\rm NM}$[2-4]:

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

where K_C is the electrostatic contribution to the compressibility which can be calculated.[3] In this expression there are three unknown parameters, $K_{\rm NM}$, K_S', and K_δ', which can be determined by the use of the E_x(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 $K_{\rm NM}$ 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 $A\leq120$.[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 $A\geq120$ nuclei, the available A range was too limited to determine accurately the values of $K_{\rm NM}$ 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 the discovery of an appreciable amount of concentrated $E0$ strength in ^{28}Si[5] and ^{24}Mg[6,7]: For ^{24}Mg 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 $K_{\rm NM}=265\pm20$ MeV is the result of this method of analyzing the breath-mode excitation energy. This value is relatively independent of the curvature contribution[3] $K_\rho A^{-2/3}$: Our analysis showed that $K_{\rm NM}$ increases from 265 MeV for $K_\rho=0$ to 290 MeV for $K_\rho=375$ MeV.

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	$K_{\rm NM}$ (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] ^{28}Si, ^{64,66}Zn, ^{112,116,118,120,124}Sn, ^{142}Nd, ^{144}Sm, ^{197}Au, and ^{208}Pb.
[b] ^{24}Mg, ^{28}Si, 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 ^{24}Mg (Ref. 7), ^{112,114,116,120,124}Sn (Ref. 8), ^{144,148}Sm (Ref. 8), and ^{208}Pb (Ref. 6).

The $K_{\rm NM}$ value obtained from this analysis is smaller than the value of $K_{\rm NM}\simeq350$ MeV preferred by the authors of Ref. 1. It would be interesting to see whether a value of $K_{\rm NM}=270$ MeV is also compatible with the experimentally observed charge differences between ^{206}Pb and ^{208}Pb and between ^{207}Pb and ^{208}Pb.

A. van der Woude, W. T. A. Borghols, S. Brandenburg, and M. M. Sharma
Kernfysisch Versneller Instituut
9747 AA Groningen, The Netherlands

M. N. Harakeh
Natuurkundig Laboratorium
Universiteit van Amsterdam
1081 VV Amsterdam, The Netherlands

Received 29 September 1986
PACS numbers: 21.65.+f, 24.30.Cz

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