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

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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_{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 ^{208}Pb 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" value[2] $K_{\mathrm{NM}}=210\pm30$ 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_{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_{NM}[2-4]:

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

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(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 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 $K_{\mathrm{NM}}=265\pm20$ 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_{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_{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_{NM} value obtained from this analysis is smaller than the value of $K_{\mathrm{NM}}\simeq350$ MeV preferred by the authors of Ref. 1. It would be interesting to see whether a value of $K_{\mathrm{NM}}=270$ MeV is also compatible with the experimentally observed charge differences between ^{206}Pb and ^{208}Pb and between ^{207}Pb and ^{208}Pb.

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[1] G. Co' and J. Speth, Phys. Rev. Lett. **57**, 547 (1986).
[2] J. P. Blaizot, Phys. Rep. **64**, 171 (1980).
[3] J. Treiner *et al.*, Nucl. Phys. **A371**, 253 (1981).
[4] M. Buenerd, J. Phys. (Paris), Colloq. **45**, C4-115 (1984).
[5] Y.- W. Lui *et al.*, Phys. Rev. C **31**, 1643 (1985).
[6] S. Brandenburg *et al.*, to be published, and Ph.D. thesis, Rijksuniversiteit Groningen, 1985 (unpublished).
[7] H. J. Lu *et al.*, Phys. Rev. C **33**, 1116 (1986).
[8] M. M. Sharma *et al.*, private communication.

