LETTERS TO THE EDITOR

INTERPRETATION OF 5^- LEVELS IN EVEN-EVEN NUCLEI

In a recent note by one of us[1] 5^- levels in even-even nuclei were interpreted as possibly belonging to $\lambda = 5$ modes of collective vibration. The evidence in support of this interpretation consisted of the following :

1. The excitation energy of these levels varied very little with mass number suggesting some sort of core excitation.

2. No 5^- level was definitively known for $A < 90$ consistent with the breakdown of collective motion characterised by a given number of nodes when the corresponding wavelength at the nuclear surface becomes comparable with or less than the internucleon distance.

Recently Broek[2] has observed levels in Ni and Zn isotopes and suggests that these may arise from coupling of 2^+ and 3^- states. In view of this it is interesting to re-examine our table on 5^- levels and see if a re-interpretation on the lines of Broek is possible.

In Table I are assembled 5^- levels which have been known with some certainty. Column I indicates the even-even nuclei considered in the present analysis. In columns II, III and V are shown the excitation energies of 2^+, 3^- and 5^- states obtained from various references. Column IV is the sum-energy of 2^+ and 3^- states designated by $[E(2^+) + E(3^-)]$. The last columns, VI and VII, indicate the values of $AE(3^-)$ and $AE(5^-)$, where A is the mass number of that particular nucleus.

Now, if the 5^- level results from the coupling of (one phonon) 2^+ and 3^- (octupole) states, then one should expect that,

$$[E(2^+) + E(3^-)] = E(5^-).$$

Further one should observe as a result of angular momentum coupling other states namely 1^-, 2^-, 3^- and 4^- besides the 5^- level.

The following conclusions can be drawn from Table I :

Columns IV and V indicate that the expected fit for $[E(2^+) + E(3^-)]$ and $E(5^-)$ is not found.

Further only in four cases Cd^{108}, Cd^{110}, Xe^{130} and W^{182} the two energies come within a difference of 0·2 Mev. Of these only Xe^{130} has the $E(5^-)$ within the predicted energy limit of $[E(2^+) + E(3^-)]$ set by Broek.[2]

Column V also shows that the excitation energy $E(5^-)$ is far less than the sum-energy of 2^+ and 3^- states. By the way of argument one may suspect the existence of some other groups, different from 5^- levels, which has excitation energies in the vicinity of $[E(2^+) + E(3^-)]$. Thus the 5^- level has a different excitation mechanism and the possibility of arising from two phonon quintet is less.

The similarities exhibited by the excitation energies of 3^- and 5^- levels and the quantities of $AE(3^-)$ and $AE(5^-)$ having values 200-300 (within certain limits) with the insensitive character to the closed shells, suggest that the same type of excitation mechanism is involved in both 3^- and 5^- states. Then the interpretation of 3^- states as the octupole vibrations of even-

TABLE I

I Nucleus	II [a] $E(2^+)$ Mev	III [b] $E(3^-)$ Mev	IV $E(3^-)+E(2^+)$	V [c] $E(5^-)$ Mev	VI $AE(3^-)$	VII $AE(5^-)$
Zr^{90}	..	2·18	2·2	4·38	2·32	198·0	208·7
Cd^{108}	..	0·630	2·19	2·82	2·54	236·4	274·3
Cd^{110}	..	0·656	2·056	2·712	2·92	226·2	321·2
Sn^{118}	..	1·22	2·28	3·5	2·29	269·0	270·2
Sn^{120}	..	1·18	2·38	3·56	2·29	285·6	274·8
Xe^{130}	..	0·528	1·998	2·526	2·34	259·8	304·2
W^{182}	..	0·100	1·374	1·474	1·62	250·1	294·8
Pb^{202}	..	0·961	..	..	2·04	..	412·1
Pb^{206}	..	0·803	2·525	3·328	2·8	520·2	570·9
Pb^{208}	..	..	2·614	..	3·2	543·8	665·6
					3·71		771·8
Po^{210}	..	1·181	..	..	2·91	..	611·0

(*a*) Strominger, D. and Hollander, J. M., *Decay Schemes*, Berkeley, California, June 1958.
(*b*) Hausen, O. and Nathan, O , *Nucl. Phys.*, 1963, **42**, 197.
(*c*) Ramaswamy, M. K., *Curr. Sci.*, 1963, **32**, 63.

even core gives some evidence to our interpretation of 5^- states as due to collective vibrations.

Now turning to the other expectation, we find that so far no quintet of 1^-, 2^-, 3^-, 4^- and 5^- is observed in the level schemes of all the cases considered in the present analysis.

The table also shows that no 5^- level is observed for $A < 90$ consistent with our proposed systematics for the 5^- levels.

The failure to observe the collective 5^- levels may be attributed to the fact that these levels may be obscured by the transitions in the neighbouring low-lying states.

Thus one can interpret 5^- levels as collective vibrations of $\lambda = 5$ mode.

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Dharwar, *October* 22, 1963.

1. Ramaswamy, M. K., *Curr. Sci.*, **1963, 32, 63.**
2. Broek, H. W., *Phys. Rev.*, **1963, 130, 1914.**