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GAMMA-VIBRATIONAL BANDS IN l820s AND l82*Os

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ABSTRACT

The systematics of the gamma-vibrational bands in even Os nuclei (A = 182 ~ 192) has been obtained from the study of gamma rays in ^{185,187}Re(p,2n)^{184,186}Os and ^{185,187}Re(p,4n)^{182,184}Os reactions. The gamma-vibrational energies obtained are 892 keV in ^{182}Os and 942 keV in ^{184}Os. The present results reveal a unique correlation of $\hbar\omega_\gamma$ with the moment of inertia.

†Work performed under the auspices of the U. S. Atomic Energy Commission.

The gamma-vibrational bands in neutron-deficient even Os nuclei have been studied by observing interband gamma rays in $^{185,187}Re(p,2n)^{184,186}Os$ and $^{185,187}Re(p,4n)^{182,184}Os$ reactions. The previously known gamma-vibrational band of ^{186}Os, which was studied by Emery et al.[1] from the decay of ^{186}Ir, is considerably populated up to the 5+ level in $^{187}Re(p,2n)^{186}Os$ reaction (see the spectrum in Fig. 1(a)). This information was utilized to assign gamma rays in $^{185}Re(p,2n)^{184}Os$ reaction (Fig. 1(b)). The assignment given in Fig. 1(b) seems to be suspicious, because in the strong-coupling limit the $2_\gamma \to 2_g$ line and $2_\gamma \to 0_g$ lines should agree with the $4_\gamma \to 4_g$ and $3_\gamma \to 2_g$ lines, respectively. If we regard the 840 keV peak as the $2_\gamma \to 2_g$, $4_\gamma \to 4_g$ doublet and the 936-keV peak as the $2_\gamma \to 0_g$, $3_\gamma \to 2_g$ doublet, then the 822 keV and 942 keV lines must be associated with another level at 942 keV. However, if they were so, such a level should also be populated in ^{186}Os as well as the gamma vibrational levels. Therefore we have made the assignments as shown in the Fig. 1(b), although they are still doubtful.

After having established the gamma-vibrational band in ^{184}Os, the population of the same states was examined in $^{187}Re(p,4n)^{184}Os$ reaction at E_p = 35 MeV, which showed lower population of the gamma-vibrational band compared with the ground band and relatively higher population of higher-spin gamma-vibrational states. Subsequently this information was utilized to identify gamma rays in $^{185}Re(p,4n)^{182}Os$ reaction.

The systematics of the ground and the gamma-vibrational bands has been obtained, as shown in Fig. 2. Remarkable facts are

1) The energy of gamma vibration is uniquely correlated with the moment of inertia. As the neutron number decreases, the moment of inertia

and the gamma-vibrational energy increase until they reach maxima at A = 184 (N = 108), then both start decreasing.

2) There is appreciable difference in the moment of inertia between the ground band and the gamma-vibrational band. The level spacing $\Delta_{32}^{\gamma} \equiv E(3_{\gamma}) - E(2_{\gamma})$ should be equal to $\Delta_{20}^{g} \equiv E(2_{\gamma})$ in the strong-coupling limit. The differences are presented in Table 1. The quantity, $\Delta_{32}^{\gamma} - \Delta_{20}^{g}$, is negative in ^{164}Er, ^{168}Yb, and ^{180}W according to a recent experiment by Graetzer et al.,[2] while in Os nuclei it is always positive. This quantity is roughly evaluated by perturbation as follows:

$$\frac{\Delta_{32}^{\gamma} - \Delta_{20}^{g}}{\Delta_{20}^{g}} = -\frac{4}{3}\left(\frac{E(2_g)}{E_{\beta}}\right)^2 + \frac{4}{9}\left(\frac{E(2_g)}{E_{\gamma}}\right)^2$$

The first term arises from the beta-vibration-rotation interaction. As far as only the interaction between the ground band and the K = 2 gamma-vibrational band, is taken in account, the second term should vanish. This is why in the Davydov-Chaban model this quantity is always negative. The second term appears when the interaction between the K = 2 gamma-vibrational state and the K = 0 (two-phonon) gamma-vibrational state is taken into account. Therefore the fact mentioned above may infer the presence of the two-phonon gamma-vibrational band which plays an important role in the Os region.

REFERENCES

1. G. T. Emery, et al., Phys. Rev. 129, 2597 (1963).

2. Graetzer, et al., Nucl. Phys. 76, 1 (1966).

Table I.

Nucleus	$E(2_g)$ (keV)	$E(2_\gamma)$ (keV)	$(\Delta^{\gamma}_{32}-\Delta^{g}_{20})/\Delta^{g}_{20}$ (%)	$(\Delta^{\gamma}_{42}-\Delta^{g}_{42})/\Delta^{g}_{42}$ (%)
^{182}Os	128	892	14.9	9.7
^{184}Os	122	942	17.2	7.6
^{186}Os	137	768	3.7	1.7
^{188}Os	155	633	1.3	2.8
^{190}Os	187	557	6.4	10.2
^{192}Os	206	489	-1.9	
^{158}Dy	98.7	945	1.3	1.0
^{164}Er	91.3	858	-3.6	-4.8
^{168}Yb	87.9	986	-4.4	-5.5
^{180}W	103.6	828	-9.3	-11.1

FIGURE CAPTIONS

Fig. 1(a). Gamma ray spectra in $^{187}(p,2n)^{186}$Os reaction.

Fig. 1(b). Gamma ray spectra in $^{185}(p,2n)^{184}$Os reaction.

Fig. 2. Systematics of the ground band and the gamma-vibrational bands in even Os nuclei.

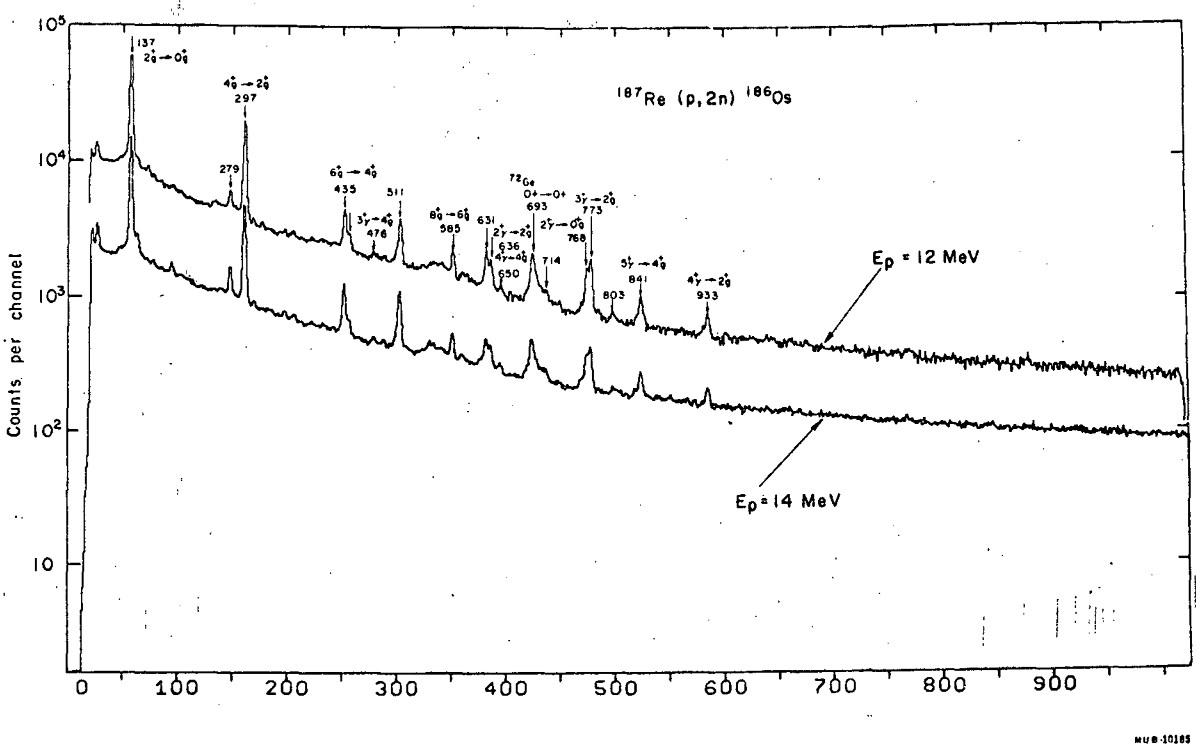
^{187}Re (p,2n) ^{186}Os
Counts per channel
E_p = 12 MeV
E_p = 14 MeV
137
$2_g^+ \to 0_g^+$
$4_g^+ \to 2_g^+$
297
279
$6_g^+ \to 4_g^+$
435
$3_\gamma^+ \to 4_g^+$
476
511
$8_g^+ \to 6_g^+$
585
631
$2_\gamma^+ \to 2_g^+$
636
$4_\gamma^+ \to 4_g^+$
650
^{72}Ge
0+ → 0+
693
$2_\gamma^+ \to 0_g^+$
768
$3_\gamma^+ \to 2_g^+$
773
714
803
$5_\gamma^+ \to 4_g^+$
841
$4_\gamma^+ \to 2_g^+$
933
MUB-10185

Fig. 1(a)

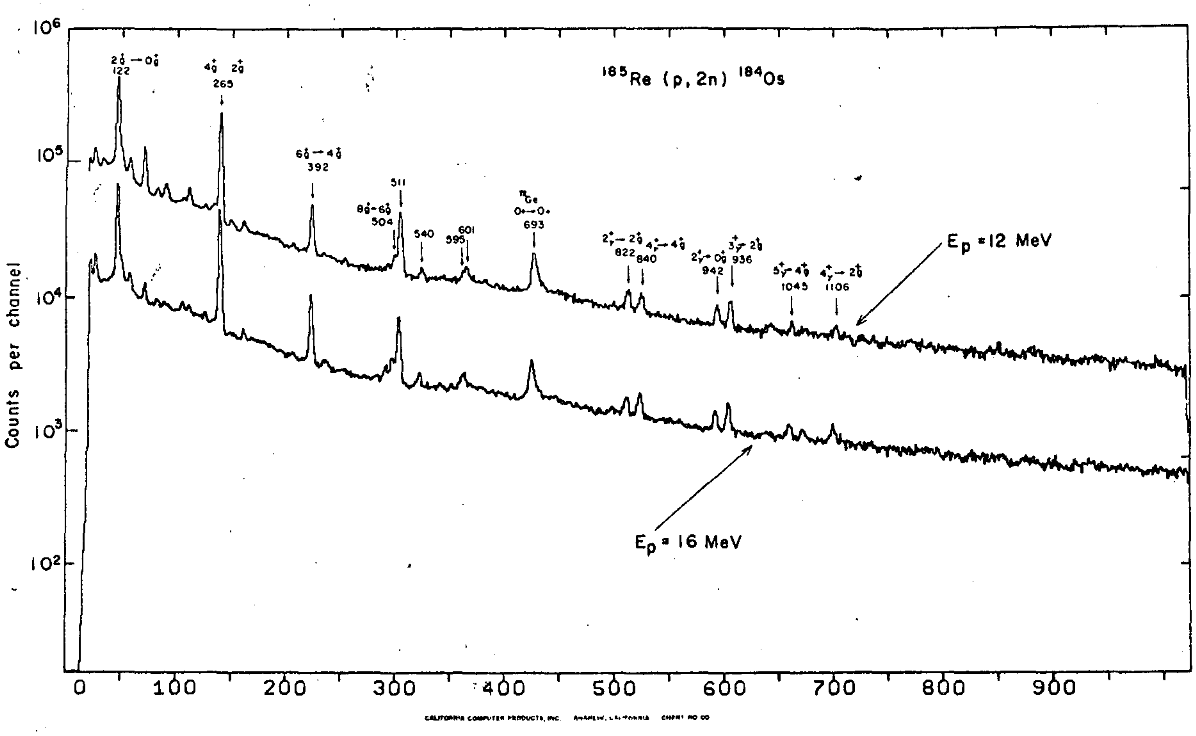
^{185}Re (p,2n) ^{184}Os
Counts per channel
E_p = 12 MeV
E_p = 16 MeV
$2_g^+ \to 0_g^+$
122
4_g^+ 2_g^+
265
$6_g^+ \to 4_g^+$
392
$8_g^+ \to 6_g^+$
504
511
540
595
601
0+ → 0+
693
$2_\gamma^+ \to 2_g^+$
822
$4_\gamma^+ \to 4_g^+$
840
$2_\gamma^+ \to 0_g^+$
942
$3_\gamma^+ \to 2_g^+$
936
$5_\gamma^+ \to 4_g^+$
1045
$4_\gamma^+ \to 2_g^+$
1106
MUB-10184

Fig. 1(b)

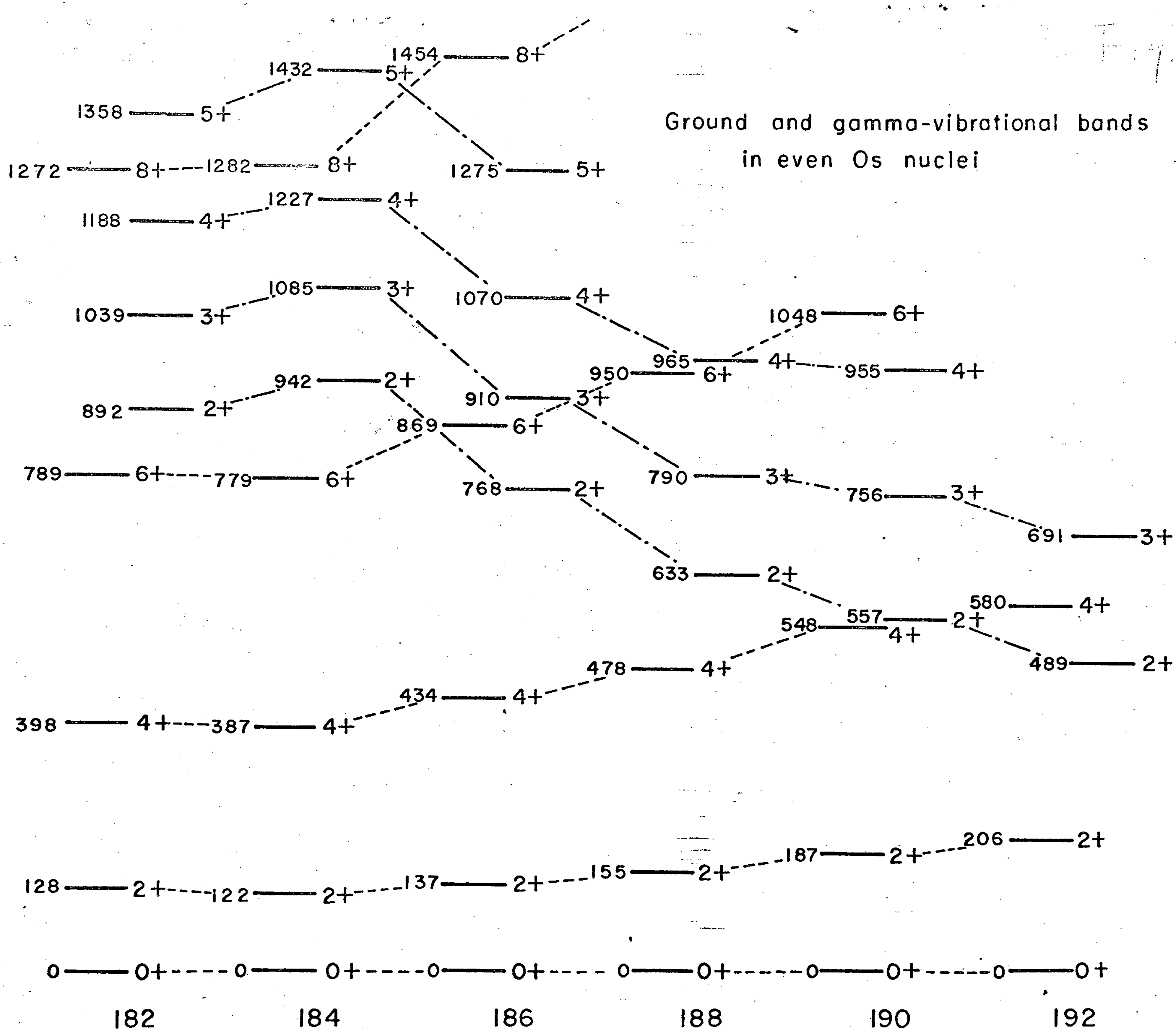
Ground and gamma-vibrational bands
in even Os nuclei
182
184
186
188
190
192

Fig. 2