

Monday Discussions Session



Recent advances on proton-neutron pairing, session II
2-6 September 2019

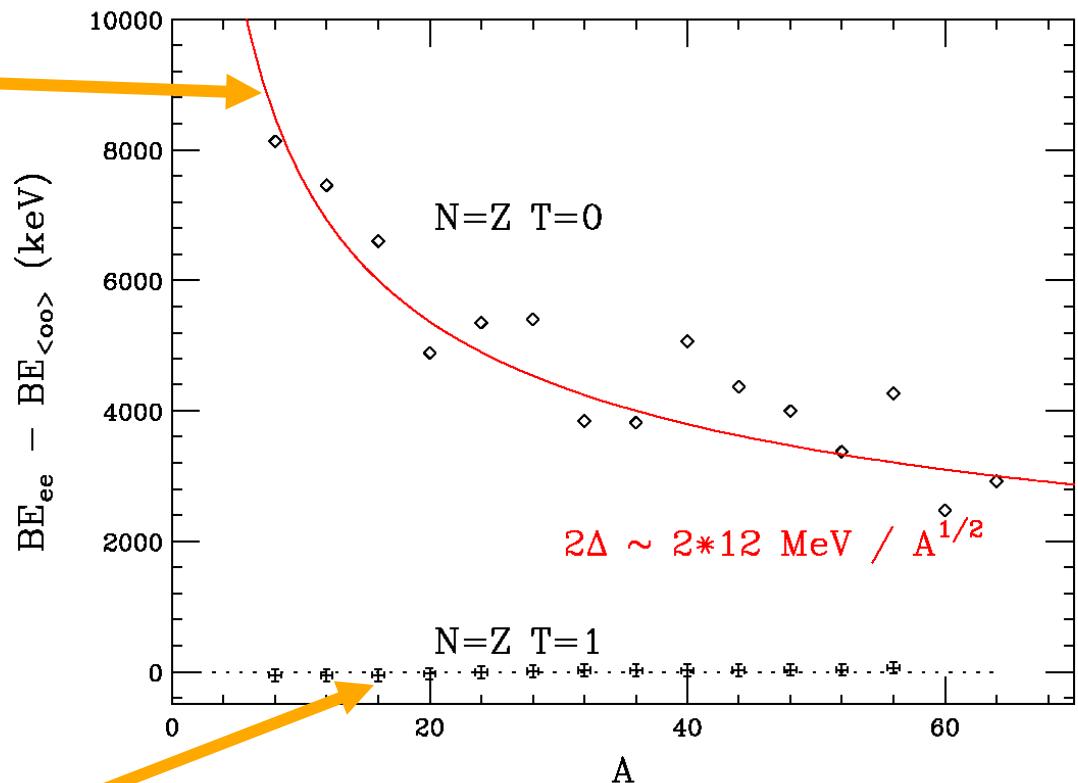
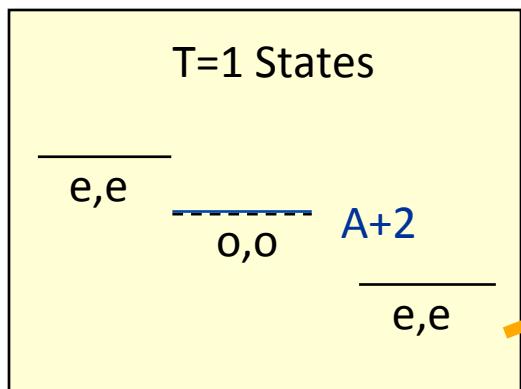
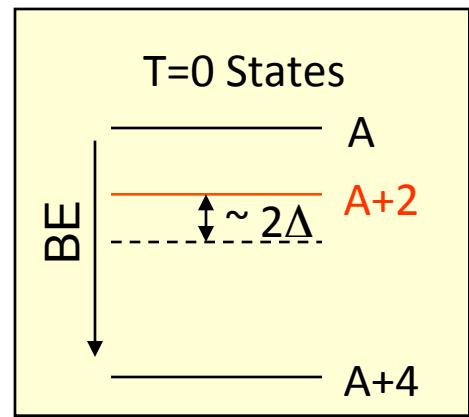


An Experimentalist's View

- Binding Energies
- Pairing Vibrations
- Boson Condensates
- Transfer Reactions
- Quartetting
- Other Observables

On Binding Energy Differences

T=0 states give a pair gap



T = 1 states give no pair gap

Two
ingredients



Isovector pairing gap $\Delta_{T=1}$

Symmetry energy $E_S(T)$

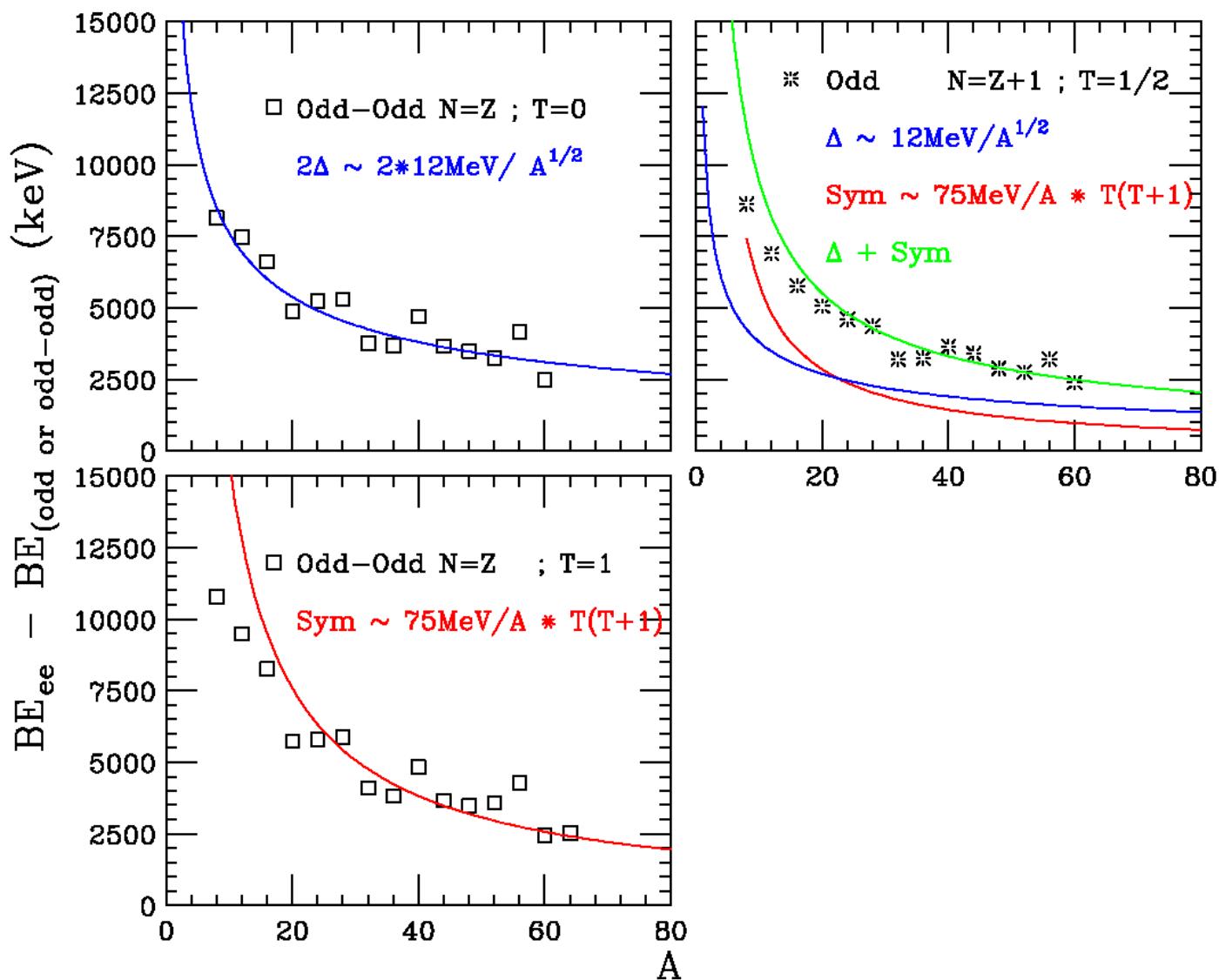
Even-even $T=0$ $E0$

Odd-odd $T=0$ $E0 + 2\Delta_{T=1} + E_S(0)$

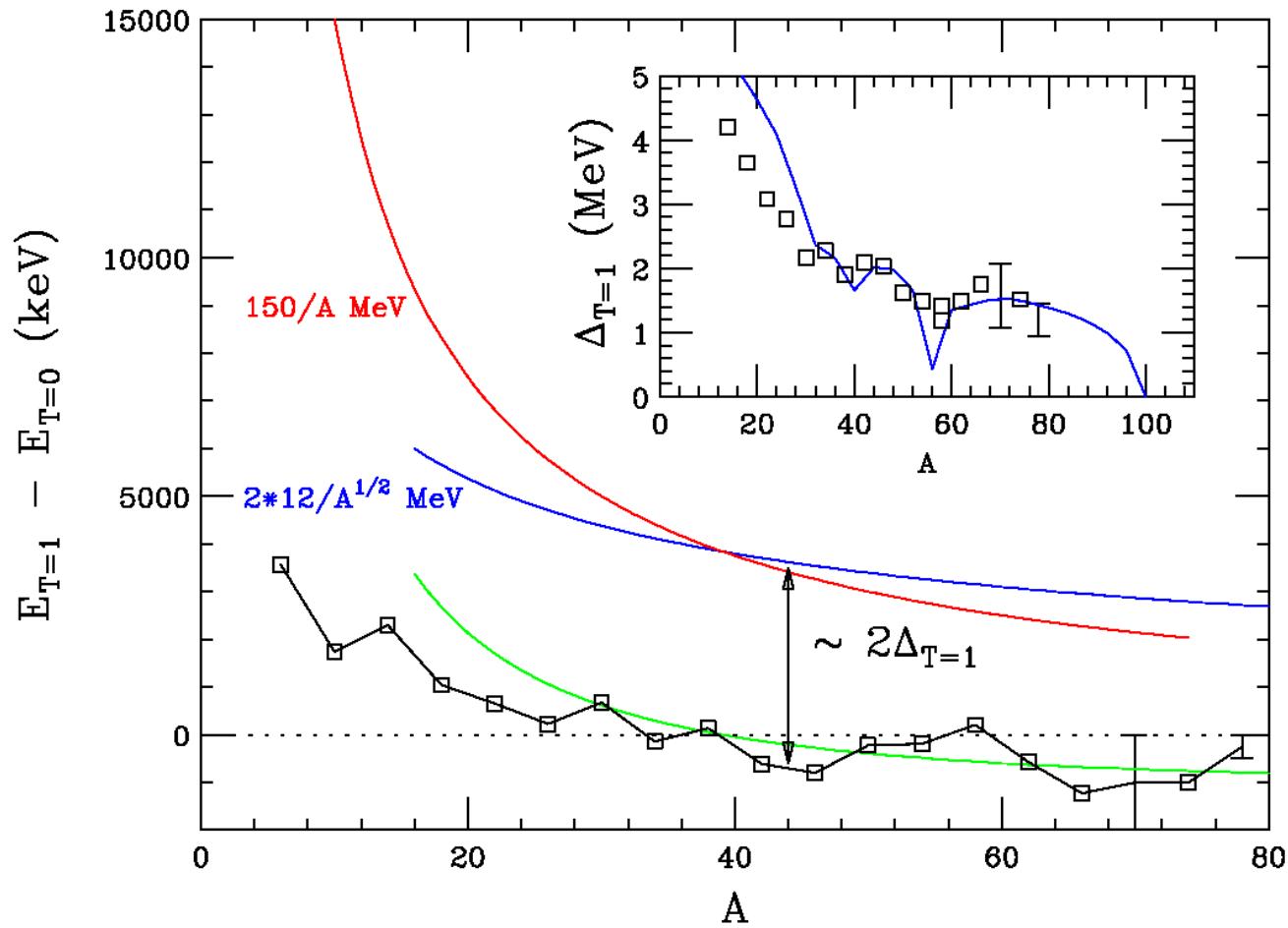
$T=1$ $E0 + 0 + E_S(1)$

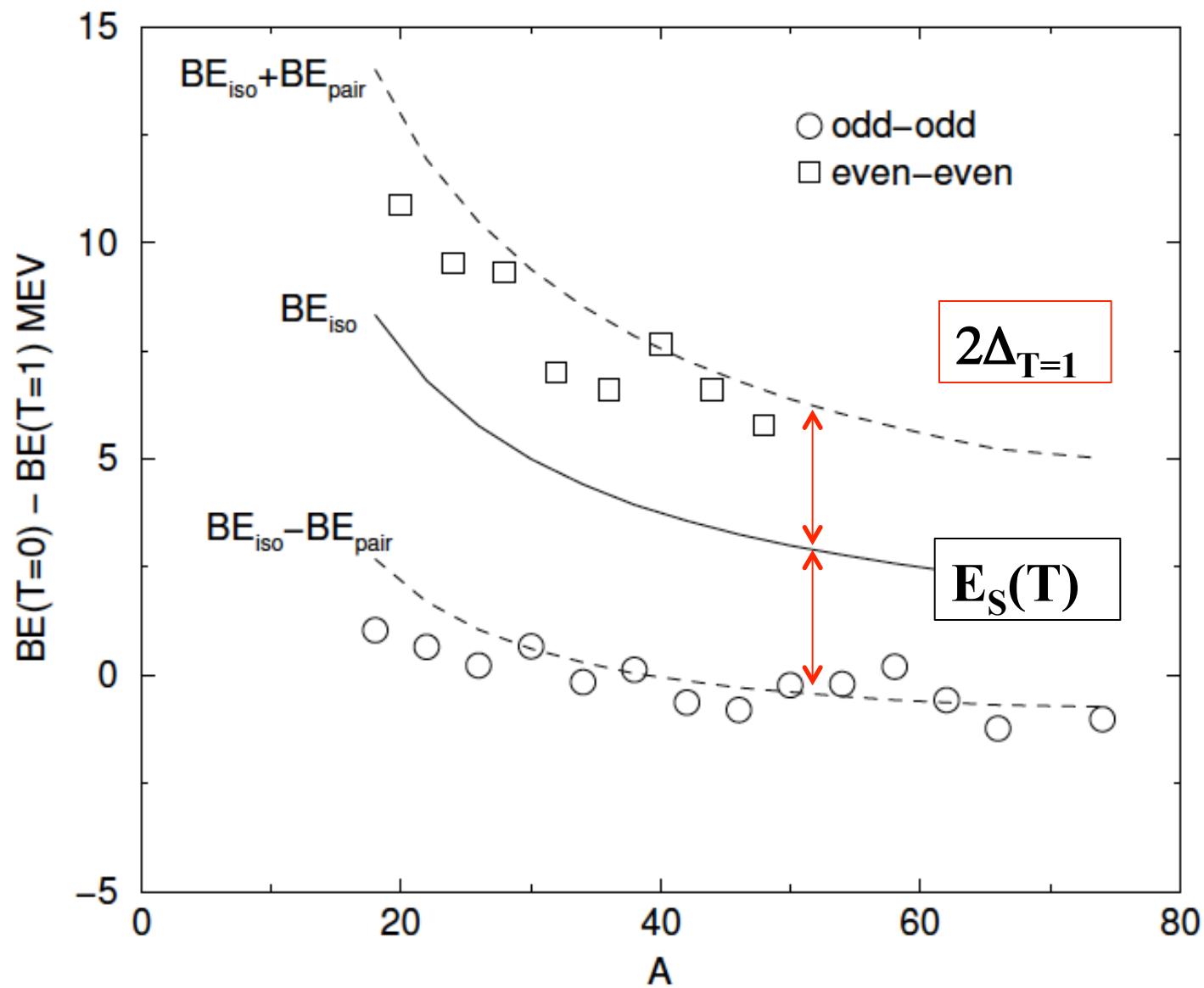
Even-even $T=1$ $E0 + 2\Delta_{T=1} + E_S(1)$

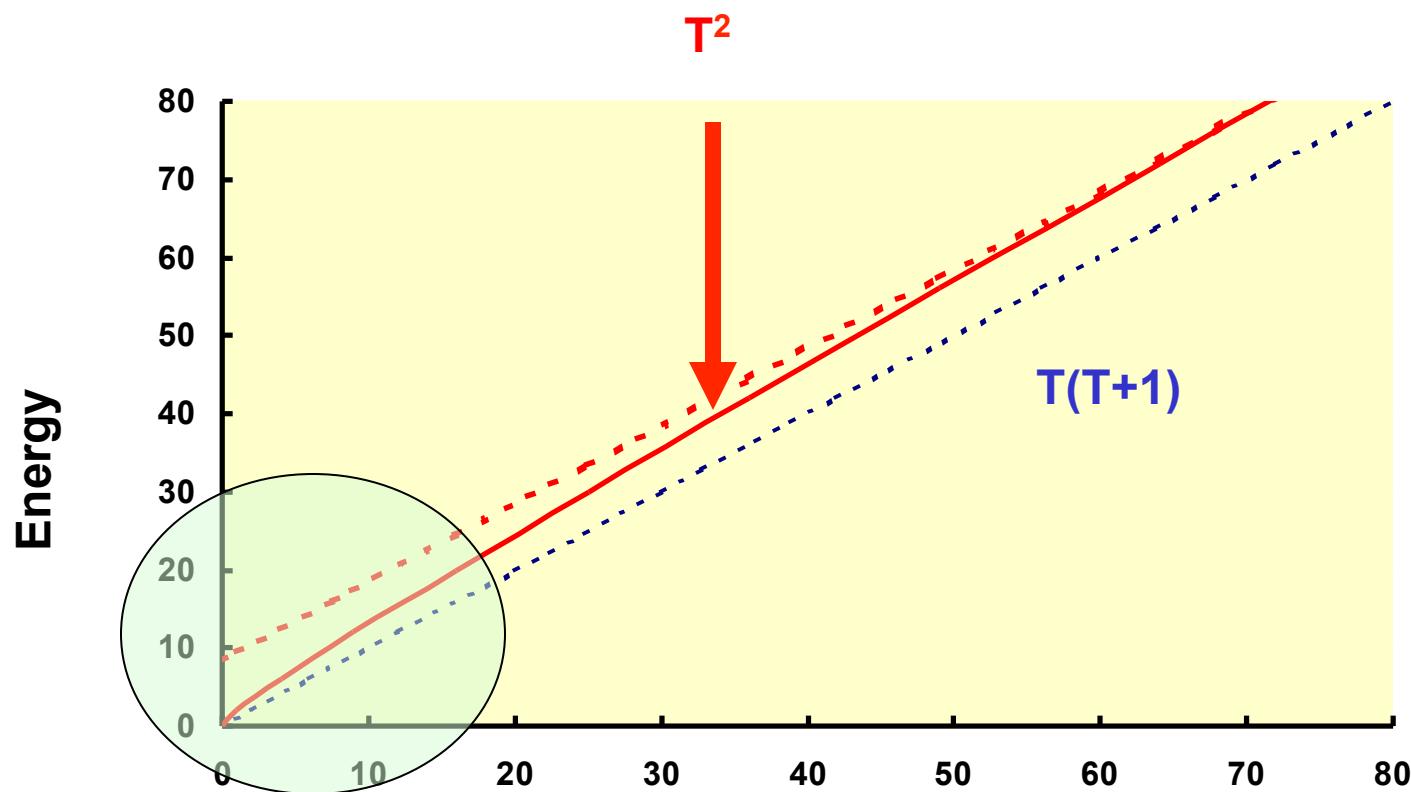
Odd-even $T=1/2$ $E0 + \Delta_{T=1} + E_S(1/2)$



Ground state of odd-odd self conjugate nuclei







T^2 or $T(T+1)$

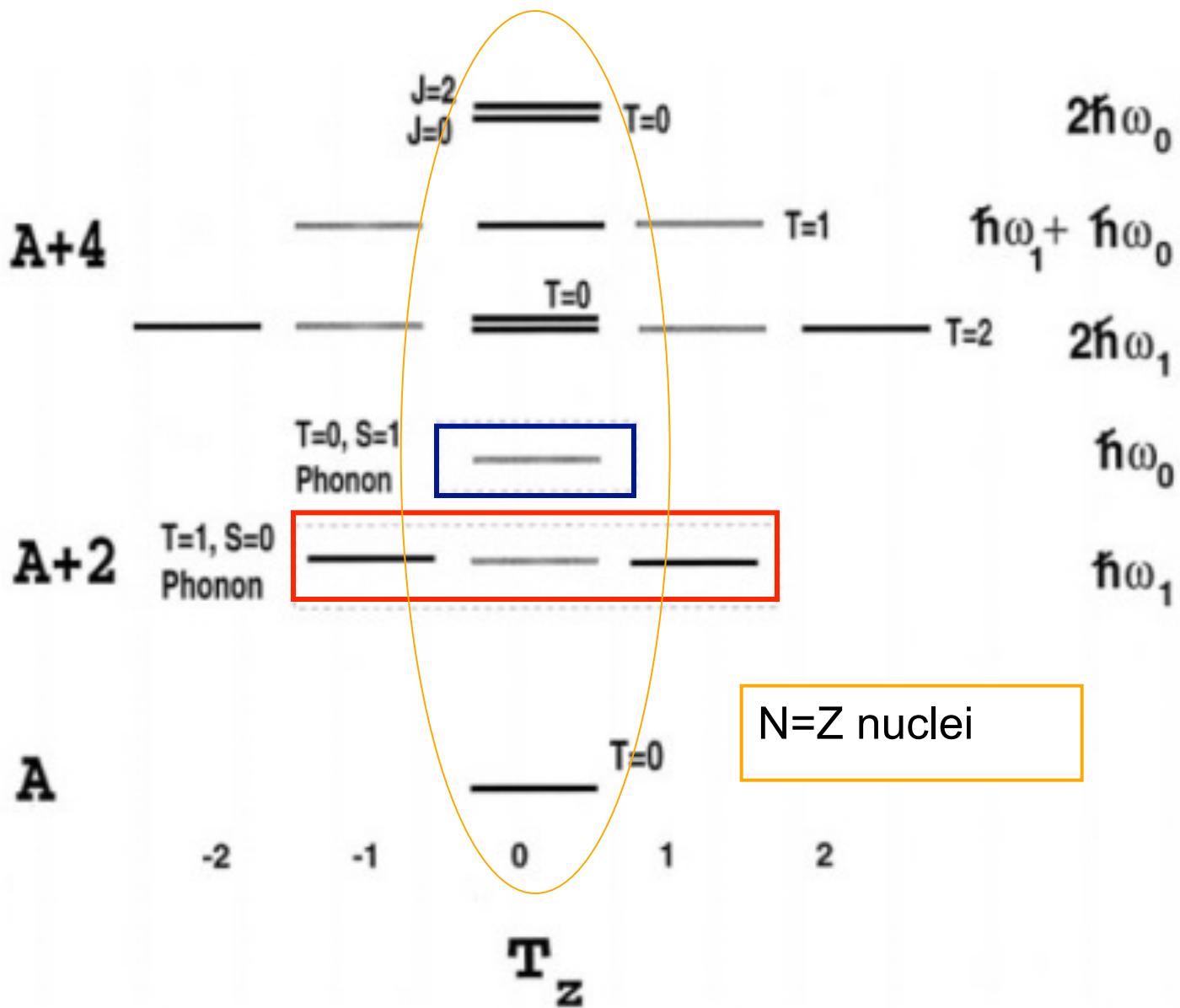
K.Neergard, Phys.Lett. B572 (2003) 159

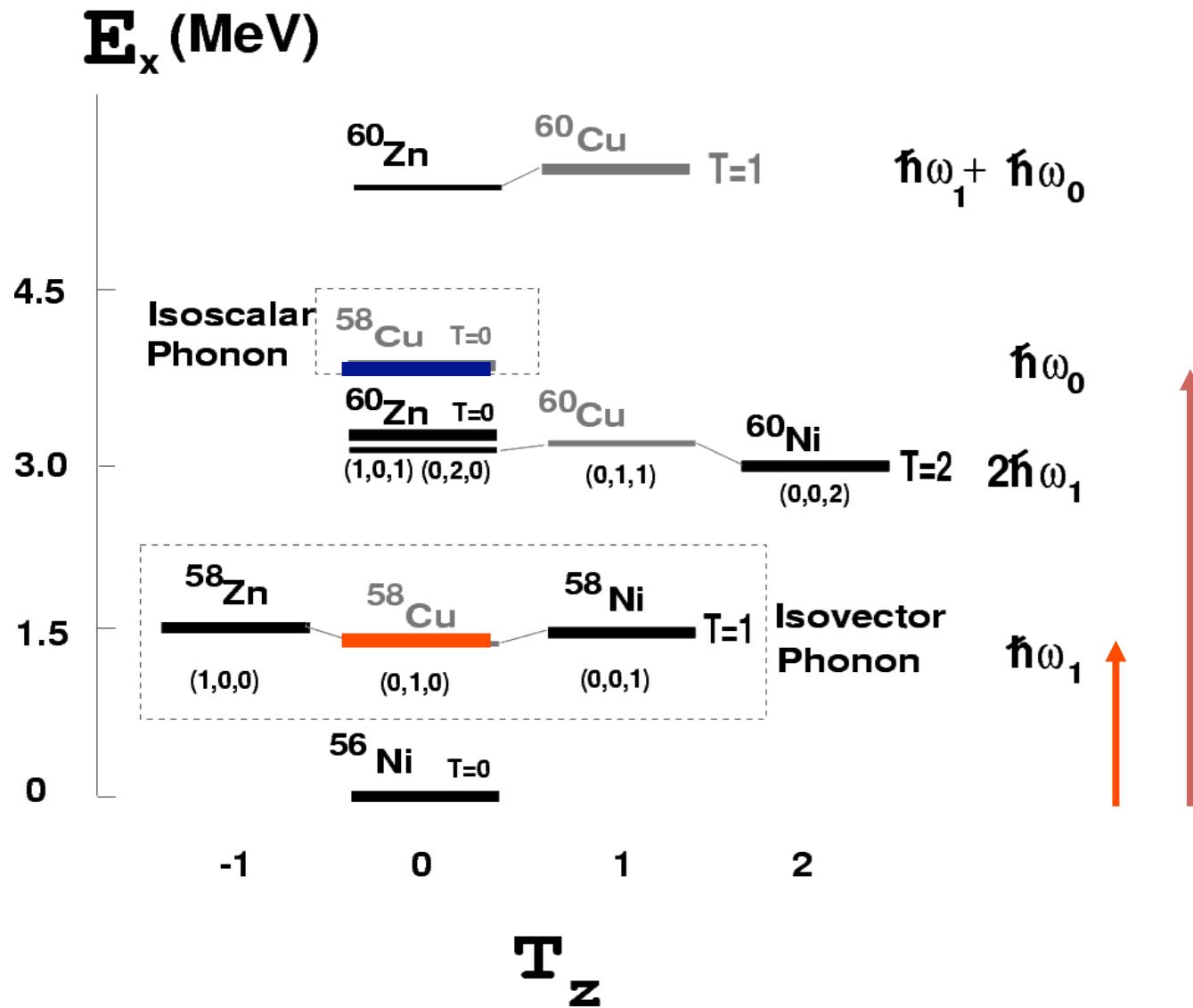
Linear term $\sim 1.025 \cdot T$ from RPA with only isovector pairing

S.Frauendorf, Nuclear Structure 2010.

R.Chasman, Phys.Lett B577 (2003)

On Pairing Vibrations





Collective $T = 0$ pairing in $N = Z$ nuclei?
 Pairing vibrations around ^{56}Ni revisited

A.O. Macchiavelli, P. Fallon, R.M. Clark, M. Cromaz, M.A. Deleplanque,
 R.M. Diamond, G.J. Lane, I.Y. Lee, F.S. Stephens, C.E. Svensson, K. Vetter,
 D. Ward

Nuclear Science Division, Lawrence Berkeley National Laboratory, Berkeley, CA 94720, USA

Table 1
 Properties of pairing vibrational phonons

Closed shells nucleus	Phonon energy (MeV)	Single-particle level spacing (MeV) ^{b)}	G/G_{crit}	$1/A^{1/3}$ ^{a)}
^{40}Ca	0.8 ($T = 1$)	5–6	~ 1	1
	4.9 ($T = 0$)		~ 0.2	
^{56}Ni	1.5 ($T = 1$)	4–5	~ 0.9	0.89
	4.0 ($T = 0$)		~ 0.2	
^{208}Pb	2.3 (neutrons)	3–4	~ 0.55	0.58

^{a)} Normalized to 1 for ^{40}Ca ; ^{b)} From Ref. [16].

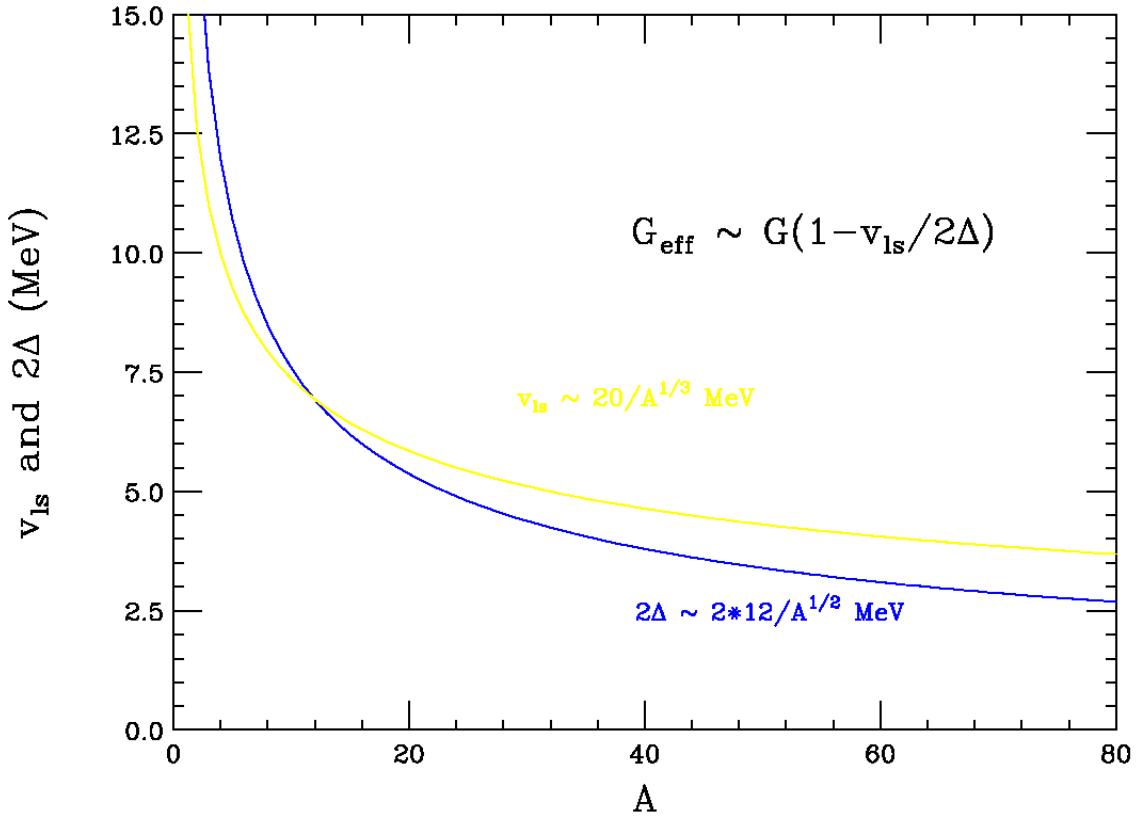
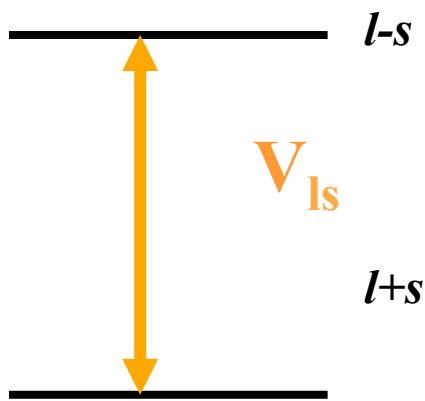
Study binding energies around closed shells (^{40}Ca and ^{56}Ni)

$T=0$ Energy comparable with single particle separation - low collectivity.

$T=1$ Energy consistent with collective excitations.

On Boson Condensates

Spin-Orbit Splitting



Properties of isoscalar-pair condensates

P. Van Isacker

Grand Accélérateur National d'Ions Lourds, CEA/DRF–CNRS/IN2P3, Bvd Henri Becquerel, F-14076 Caen, France

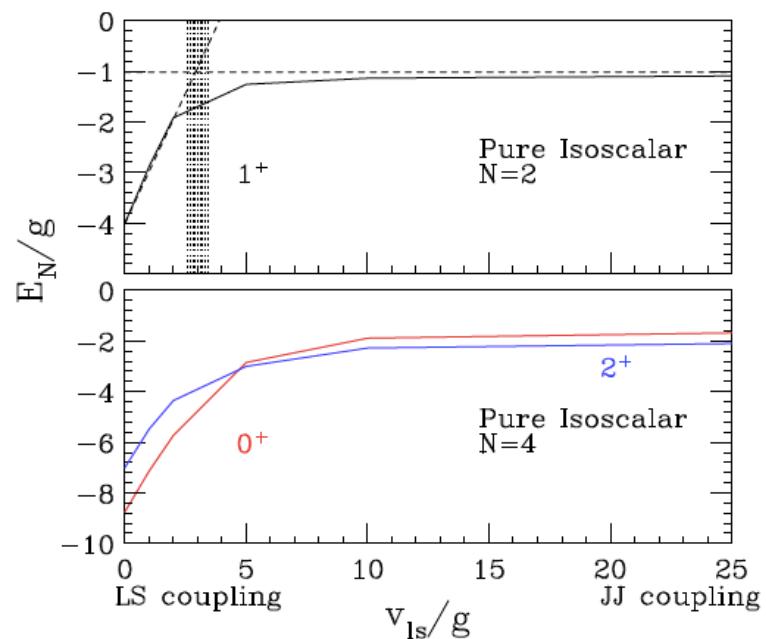
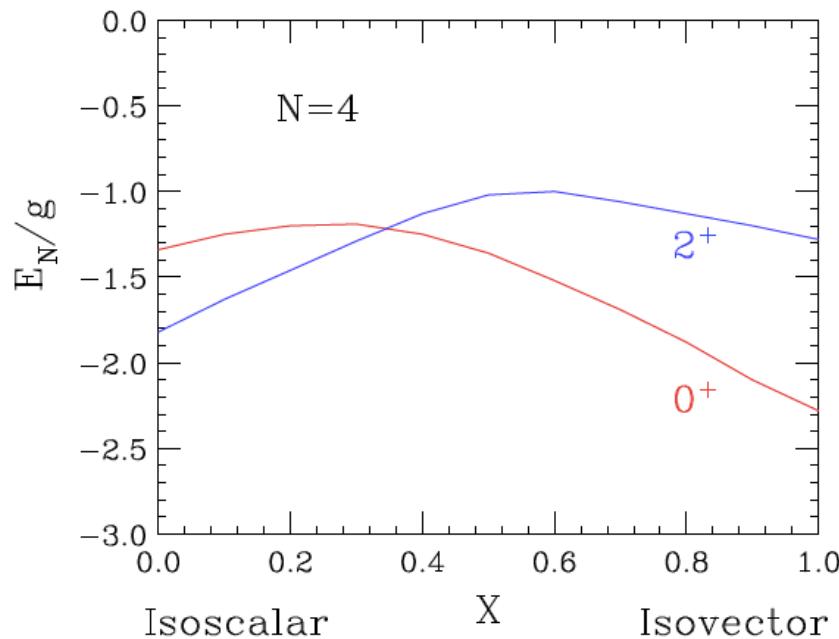
A. O. Macchiavelli and P. Fallon

Nuclear Science Division, Lawrence Berkeley National Laboratory, Berkeley, California 94720, USA

S. Zerguine

Department of Physics, PRIMALAB Laboratory, University of Batna, Avenue Boukhellouf M El Hadi, 05000 Batna, Algeria

(Received 2 June 2016; published 17 August 2016)



Properties of isoscalar-pair condensates

P. Van Isacker

Grand Accélérateur National d'Ions Lourds, CEA/DRF–CNRS/IN2P3, Bvd Henri Becquerel, F-14076 Caen, France

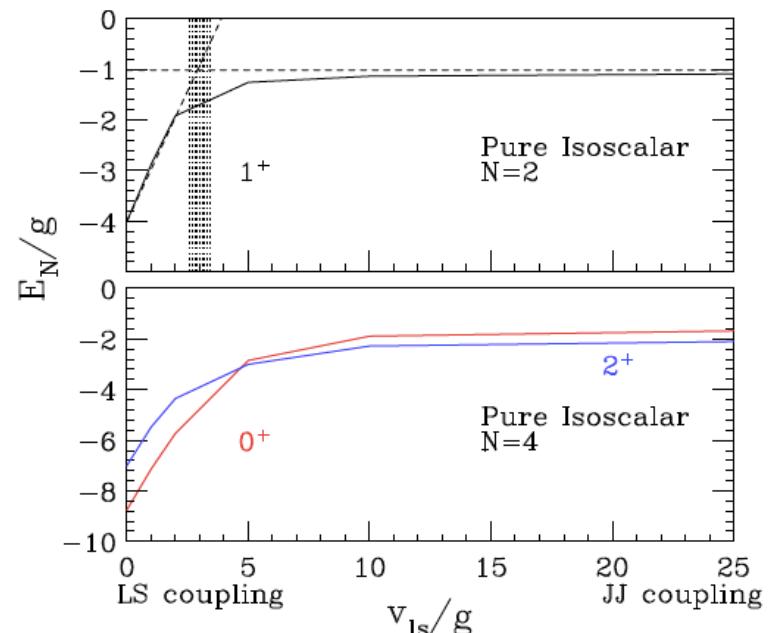
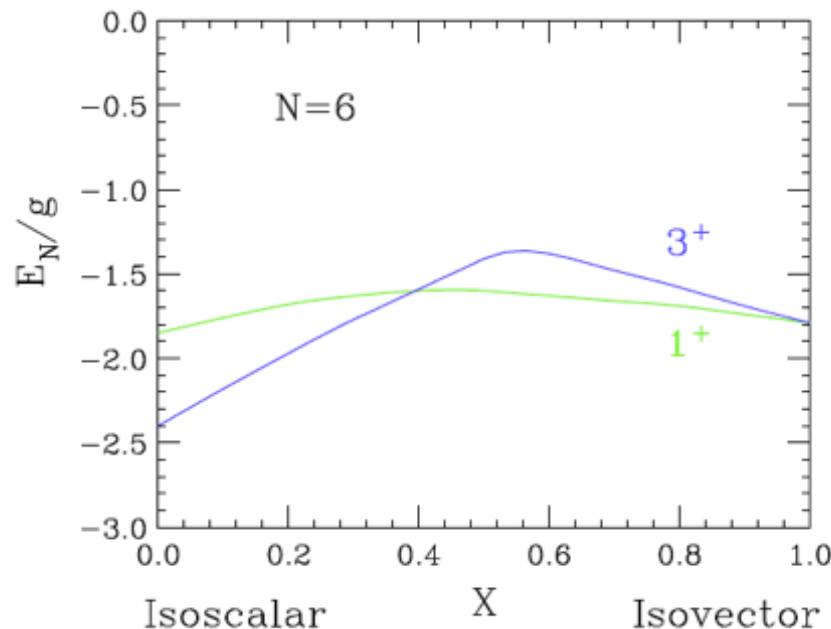
A. O. Macchiavelli and P. Fallon

Nuclear Science Division, Lawrence Berkeley National Laboratory, Berkeley, California 94720, USA

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Department of Physics, PRIMALAB Laboratory, University of Batna, Avenue Boukhellouf M El Hadi, 05000 Batna, Algeria

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Aligned configuration of $n=N/2$ quasi-deuteron pairs \rightarrow

$|J, \pi\rangle$

On Transfer Reactions

M. Assié on Thursday



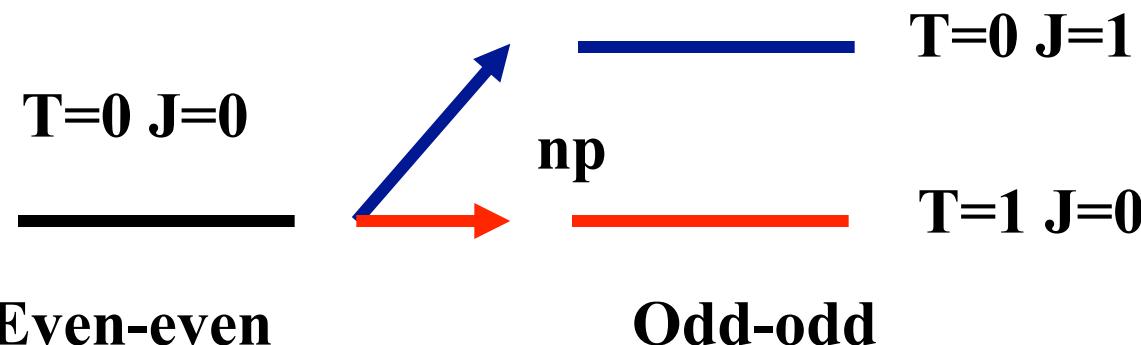
The smoking gun ?

$(p, {}^3He)$, $({}^3He, p)$ $\Delta T=0, 1$

(d, α) , (α, d) $\Delta I=0$

$(\alpha, {}^6Li)$, $({}^6Li, \alpha)$ $\Delta T=0$

$\sigma ?$



$({}^3He, p)$ $L=0$ transfer – forward peaked

Measure the np transfer cross section to $T=1$ and $T=0$ states

Both absolute $\sigma(T=0)$ and $\sigma(T=1)$ and relative $\sigma(T=0) / \sigma(T=1)$ tell us about the character and strength of the correlations

On Probing Quarteting

M. Assié on Thursday

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PHYSICAL REVIEW C

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OCTOBER 1977

Alpha-transfer reactions and the pairing-vibration model*

R. R. Betts

A. W. Wright Nuclear Structure Laboratory, Yale University, New Haven, Connecticut 06520

(Received 20 June 1977)

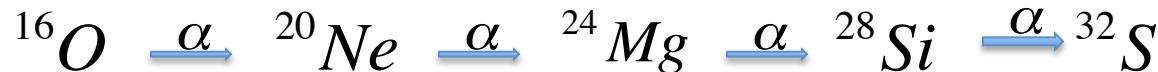
The pairing-vibration model with isospin is extended to include α -transfer reactions. Selection rules and expressions for transition strengths are derived and compared with experimental results for $A = 40\text{--}66$ nuclei. The selection rules are found to be followed quite well in the examples studied. The systematics of ground-state transition strengths are qualitatively quite well reproduced although the quantitative agreement is poor. When the changing nature of the pairing quanta is incorporated using two-particle transfer data the agreement becomes quantitatively good. Evidence is presented for clustering other than that due to pairing in ^{40}Ca and ^{44}Ti .

Quartet Pairing Vibrations Revisited

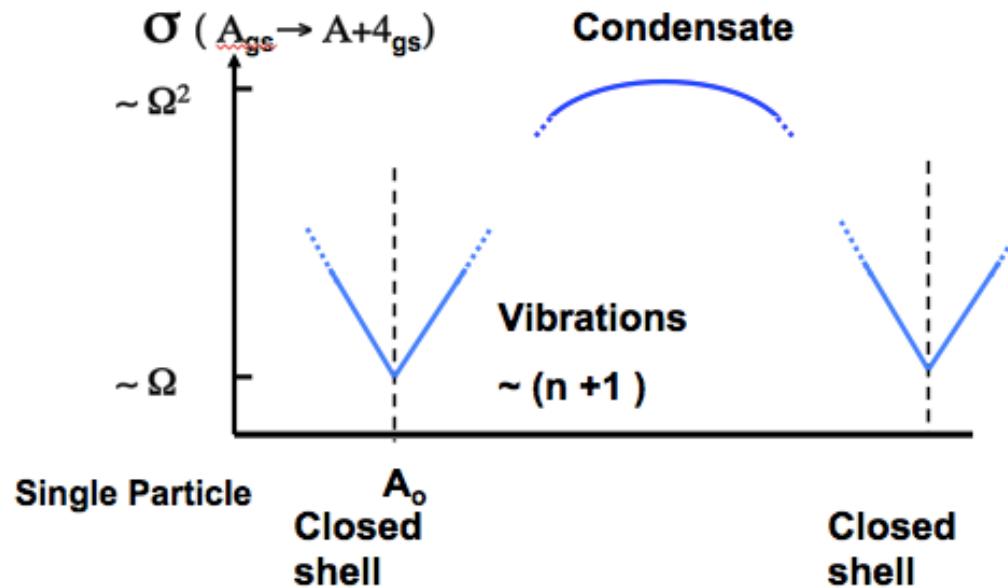
Testing alpha-like quartet condensation in N=Z nuclei ?

- test of quartet condensation *alpha particle transfer along N=Z line*

$$\langle QCM(A+4) | Q^+ | QCM(A) \rangle \quad |QCM\rangle \equiv (Q^+)^{n_q} |-\rangle$$

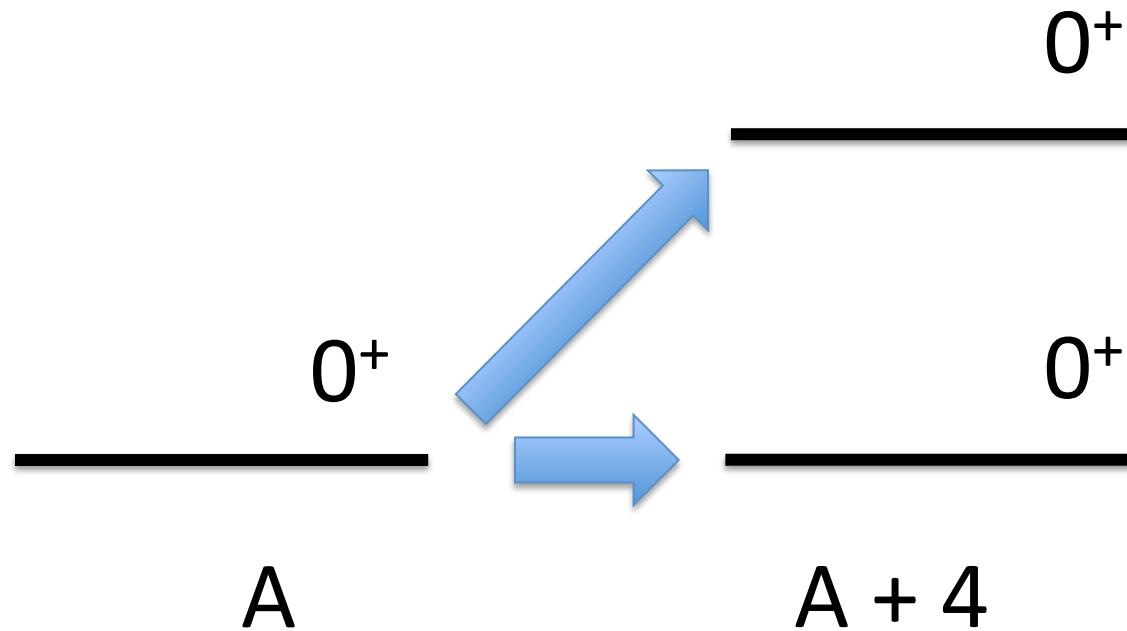


experiments for heavier N=Z nuclei (ph-shell) ?



Testing alpha-like quartet condensation in N=Z nuclei ?

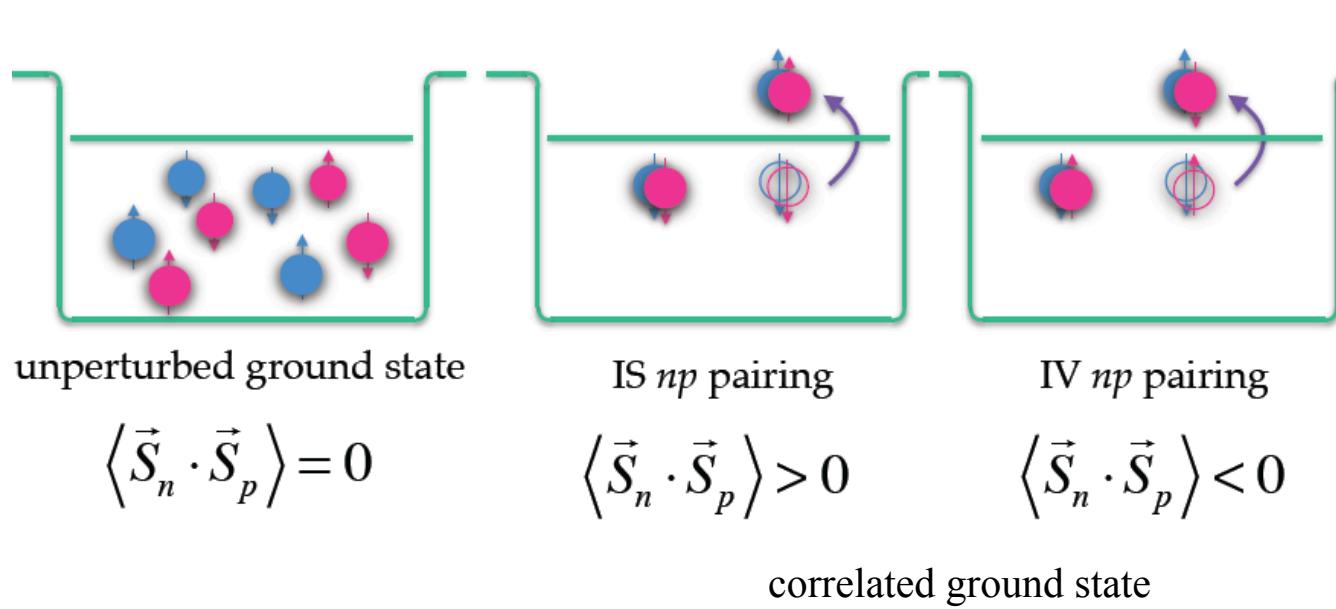
- test of quartet condensation *alpha particle transfer along N=Z line*



HOW ABOUT $I=2^+$ states and $B(E2 \ 0^+ \rightarrow 2^+)$

On Other Observables

$$\langle \vec{s}_n \cdot \vec{s}_p \rangle = \begin{cases} +\frac{1}{4} & \text{for IS } np \text{ pair (deuteron)} \\ -\frac{3}{4} & \text{for IV } np \text{ pair} \end{cases}$$

Nonquenched Isoscalar Spin-*M*1 Excitations in *sd*-Shell Nuclei

H. Matsubara,^{1,†} A. Tamii,¹ H. Nakada,² T. Adachi,¹ J. Carter,³ M. Dozono,^{5,‡} H. Fujita,¹ K. Fujita,^{1,§} Y. Fujita,¹ K. Hatanaka,¹ W. Horiuchi,⁶ M. Itoh,⁷ T. Kawabata,^{4,||} S. Kuroita,⁵ Y. Maeda,⁹ P. Navrátil,¹⁰ P. von Neumann-Cosel,¹¹ R. Neveling,¹² H. Okamura,^{1,*} L. Popescu,^{13,¶} I. Poltoratska,¹¹ A. Richter,¹¹ B. Rubio,¹⁴ H. Sakaguchi,¹ S. Sakaguchi,^{4,§} Y. Sakemi,⁷ Y. Sasamoto,⁴ Y. Shimbara,^{15,**} Y. Shimizu,^{4,††} F. D. Smit,¹² K. Suda,^{1,††} Y. Tameshige,^{1,‡‡} H. Tokieda,⁴ Y. Yamada,⁵ M. Yosoi,¹ and J. Zenihiro^{8,††}

