Collaboration with George Bertsch started 1983 in MSU

PHYSICAL REVIEW C VOLUME 39, NUMBER 3 MARCH 1989

High-energy reaction cross sections of light nuclei

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(Received 26 September 1988)

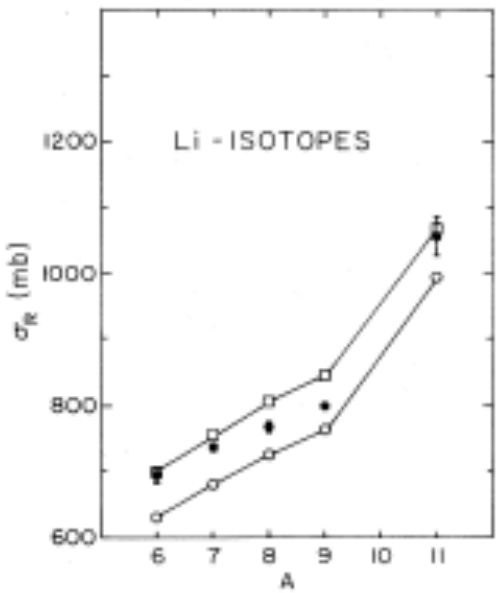


FIG. 2. The reaction cross section for Li isotopes on ^{12}C target. A solid line connecting boxes (circles) shows the theoretical cross sections obtained by Eq. (2) [Eq. (3)] with the finite-range interaction (zero-range interaction). The nucleon-nucleon cross section parameter σ_{nn} is taken as 40 mb, while the finite-range size r_0 of the interaction in Eq. (2) is taken as 1 fm. The data are taken from Ref. 1.

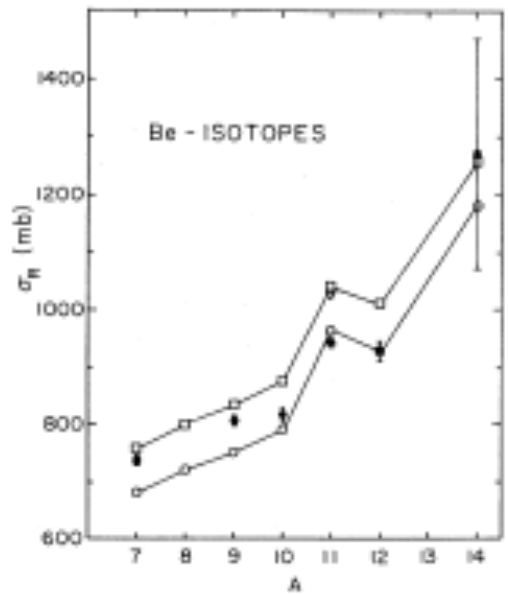


FIG. 3. The reaction cross section for Be isotopes on ^{12}C target. Two solid lines connecting boxes and circles show the theoretical cross sections obtained by Eqs. (2) and (3), respectively. The triangles for ^{11}Be show the results for the first excited state. The data are taken from Ref. 1. For details, see the caption to Fig. 2.

Still many activities are going on in RIKEN, GSI and other institutes.

Pairing correlations under Extreme conditions
----- Bertschfest -----
Sept 7-9,2012, Seattle, USA

H. Sagawa
University of Aizu/RIKEN, Japan

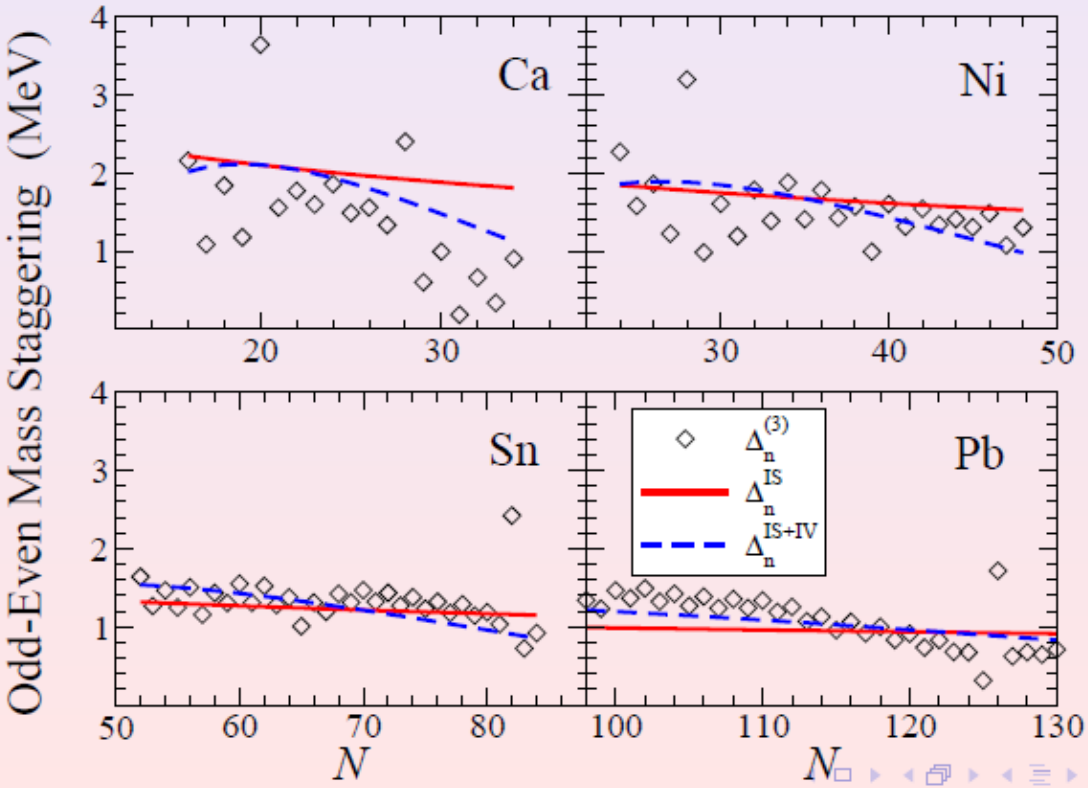
1. Isospin dependent global T=1 paring interaction
2. Cooperation of T=0 with T=1 pairings in Gamow-Teller transitions
3. Summery

Isospin effects in the pairing gaps

P. Vogel, B. Jonson, and P. G. Hansen, Phys. Lett. **139B**, 227 (1984).

$$\Delta_n^{\mathrm{IS}} = 13.3/A^{1/2} \quad (23)$$

$$\Delta_n^{\mathrm{IS+IV}} = [7.2 - 44(1 - 2Z/A)^2]/A^{1/3} \quad (24)$$



Odd-Even mass staggering

$$\Delta_3 = \frac{(-)^A}{2}\left(\mathrm{B(A)}-2\cdot\mathrm{B(A+1)}+\mathrm{B(A+2)}\right)\cdot$$

PHYSICAL REVIEW C **79**, 034306 (2009)

Odd-even mass differences from self-consistent mean field theory

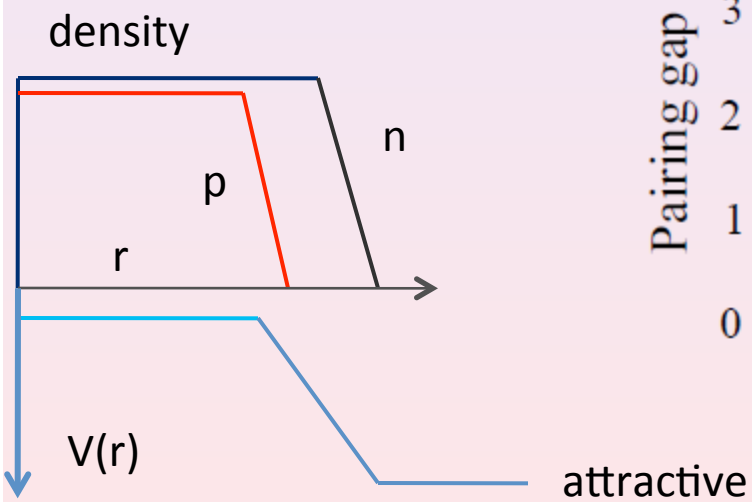
G. F. Bertsch,[1] C. A. Bertulani,[2] W. Nazarewicz,[3,4,5] N. Schunck,[6] and M. V. Stoitsov[6]

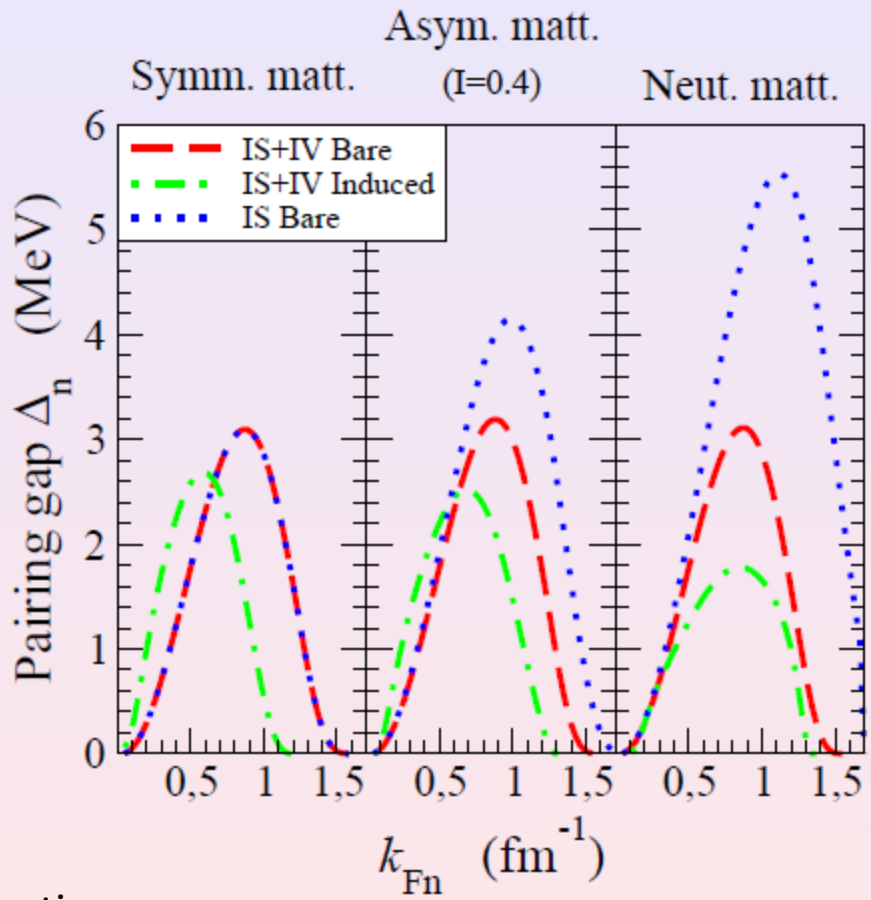
TABLE V. Average $\Delta_o^{(3)}$ (in MeV) calculated in HFB+LN sorted by neutron excess. See text for details.

Data set		Low isospin	High isospin	Difference
Neutrons	Exp	1.13	0.94	−0.19
	HFB+LN	1.05	1.02	−0.03
Protons	Exp	1.05	0.88	−0.17
	HFB+LN	0.99	0.93	−0.06

Pairing in Finite Nuclei

Question 2 :
→ Role of the isospin-dependent term ?





Isospin (IS+IV) dependent T=1 Pairing Interaction

J. Margeuron, Orsay
K. Hagino, Tohoku University, Japan
HS, Aizu,Japan

Systematic Study including odd nuclei by EV8-odd

Carlos Bertulani, Texas A&M University at Commerce
Hong Feng Lu, China Agricultural University/UoA
Hiroyuki Sagawa, University of Aizu
Hongliang Lui, Peking University

Optimum parameter sets of IS+IV pairing

M. Yamagami, U.of Aizu
K. Hagino, HS, J. Margueron

Isospin dependent Pairing Interaction

$$V_{pair}(1,2) = \frac{1-\mathrm{P}_o}{2} V_0 g_\tau \left[\rho, \beta\tau_z\right] \delta(\vec{r}_1 - \vec{r}_2)$$

$$g_\tau \left[\rho, \beta\tau_z\right] = g^1{}_\tau \left[\rho, \beta\tau_z\right] + g^2{}_\tau \left[\rho, \beta\tau_z\right]$$

$$g^1{}_\tau \left[\rho, \beta\tau_z\right] = 1 - \mathrm{f_s}(\beta\tau_z)\eta_s \left(\frac{\rho}{\rho_0}\right)^{\alpha_s} - \mathrm{f_n}(\beta\tau_z)\eta_n \left(\frac{\rho}{\rho_0}\right)^{\alpha_n}$$

$$\mathrm{f_s}(\beta\tau_z) = 1 - \mathrm{f_n}(\beta\tau_z),\ \mathrm{f_n}(\beta\tau_z) = \beta\tau_z = \frac{\rho_n(r) - \rho_p(r)}{\rho(r)} \tau_z$$

J.Margueron, HS and K. Hagino
PRC76,064316(2007) and PRC77,054309(2008)

Guideline for the parameters

No free parameters!

$V_0 \rightarrow$ nn scattering length

$\eta_s, \alpha_s, \eta_n, \alpha_n \rightarrow$ pairing gaps in nuclear and neutron matter

T-matrix theory provides the formulas

(G. F. Bertsch and H. Esbensen)

$$k \cot \delta = -\frac{2}{\alpha\pi}\left[1 + \alpha k_c + \frac{\alpha k}{2}\ln\frac{k_c - k}{k_c + k}\right]$$

$$= -\frac{1}{a_{nn}} - \frac{k}{\pi}\ln\frac{k_c - k}{k_c + k}$$

$$V_0 = 2\pi^2 \alpha \hbar^2 / m \qquad \alpha = 2a_{nn} / (\pi - 2k_c a_{nn})$$

HF+BCS with odd particle (EV8-odd)

SkP +isospin dependent pairing
SLy4+isospin dependent pairing

Odd-even mass difference and isospin dependent pairing interaction

C. A. Bertulani,[1] H. F. Lü,[2] and H. Sagawa[3]

[1] *Department of Physics, Texas A&M University-Commerce, Commerce, Texas 75429, USA*
[2] *College of Science, China Agricultural University, Beijing, P.R.China*
[3] *Center for Mathematics and Physics, University of Aizu, Aizu-Wakamatsu, 965-8580 Fukushima, Japan*

(Dated: August 12, 2009)

PRC80, 027303(2009)

A systematic study by optimum coupling strength V_0
C. Bertulani, Hongliang Liu and HS, PRC85, 014321(2012).

HF+BCS with odd particle (EV8-odd)

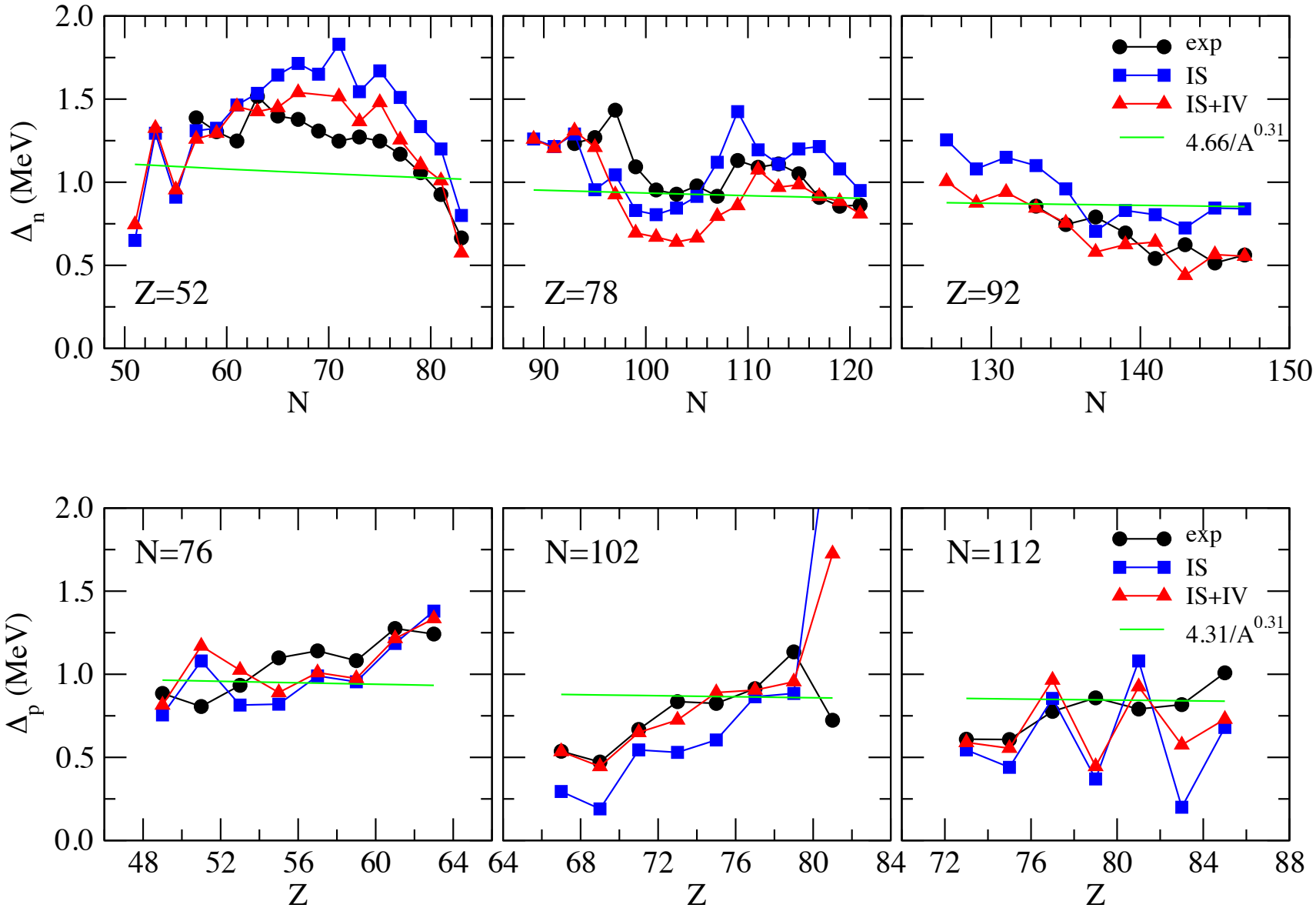


TABLE I:

Data set			Low isospin	High isospin	Difference
Neutrons	$Z = 52$	Exp	1.36	1.08	-0.28
		IS	1.52	1.41	-0.11
		IS+IV	1.40	1.19	-0.21
	$Z = 78$	Exp	1.13	0.99	-0.14
		IS	0.96	1.16	0.20
		IS+IV	0.87	0.91	0.04
	$Z = 92$	Exp	0.77	0.56	-0.21
		IS	0.90	0.80	-0.10
		IS+IV	0.70	0.55	-0.15
Protons	$N = 76$	Exp	1.19	0.93	-0.26
		IS	1.13	0.87	-0.26
		IS+IV	1.13	0.98	-0.15
	$N = 102$	Exp	0.96	0.63	-0.33
		IS	0.79	0.39	-0.40
		IS+IV	0.92	0.59	-0.33
	$Z = 112$	Exp	0.87	0.66	-0.21
		IS	0.58	0.61	0.03
		IS+IV	0.67	0.70	0.03

T=1 pairing interaction

Density dependence of pairing correlations determined from global fitting or (IS and IV density dependence of global pairing energy density functional)

M. Yamagami,[1] J. Margueron,[2] H. Sagawa,[1] and K. Hagino[3]

PRC, To be published

IS

$$H_{\text{pair}}(\boldsymbol{r}) = \frac{V_0}{4}\left\{1 - \eta_0\left[\frac{\rho(\boldsymbol{r})}{\rho_0}\right]^{\beta}\right\}\sum_{\tau=n,p}\left[\tilde{\rho}_\tau(\boldsymbol{r})\right]^2$$

IS+IV

$$H_{\text{pair}}(\boldsymbol{r}) = \frac{1}{4}\sum_{\tau=n,p} V_\tau\, g_\tau\left[\rho,\rho_1\right]\left[\tilde{\rho}_\tau(\boldsymbol{r})\right]^2$$

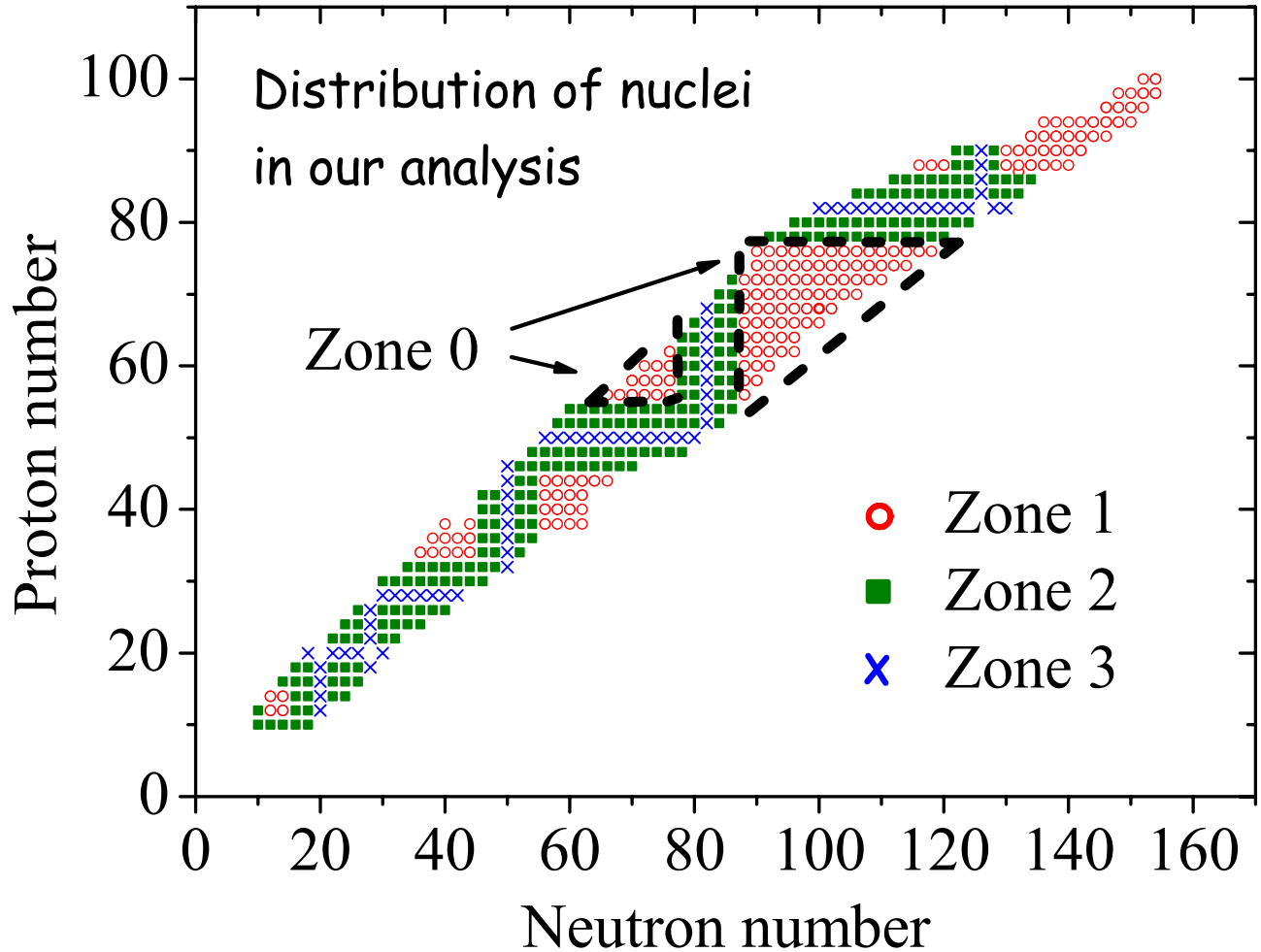
with

$$g_\tau\left[\rho,\rho_1\right] = 1 - \eta_0\frac{\rho(\boldsymbol{r})}{\rho_0} - \eta_1\frac{\tau_3\rho_1(\boldsymbol{r})}{\rho_0} - \eta_2\left[\frac{\rho_1(\boldsymbol{r})}{\rho_0}\right]^2.$$

$\rho = \rho_n + \rho_p$ $\quad$ $\tilde{\rho}_\tau = pair\ density\ (\tau = n,p)$

$\rho_1 = \rho_n - \rho_p$

Fitting Experimental Data to obtain 4 parameters



	Region of N and Z	A	α	$N_{\rm nucl}^{(i)}$	$N_n^{(i)}$	$N_p^{(i)}$
Zone 0	Inside Zone 1 restricted to $56 \leq Z \leq 76$	$122 \leq A \leq 194$	$0.08 < \alpha < 0.23$	94	93	84
Zone 1	$\lvert Z - Z_{\rm mag}\rvert \geq 6$ and $\lvert N - N_{\rm mag}\rvert \geq 6$	$24 \leq A \leq 254$	$-0.08 < \alpha < 0.24$	170	159	139
Zone 2	$2 \leq \lvert Z - Z_{\rm mag}\rvert \leq 4$, and $2 \leq \lvert N - N_{\rm mag}\rvert \leq 4$	$20 \leq A \leq 220$	$-0.09 < \alpha < 0.29$	216	211	191
Zone 3	Semi-magic nuclei	$32 \leq A \leq 216$	$-0.05 < \alpha < 0.25$	69	40	29

	Region of N and Z	A	α	$N_{\rm nucl}^{(i)}$	$N_n^{(i)}$	$N_p^{(i)}$
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Zone 3	Semi-magic nuclei	$32 \le A \le 216$	$-0.05 < \alpha < 0.25$	69	40	29

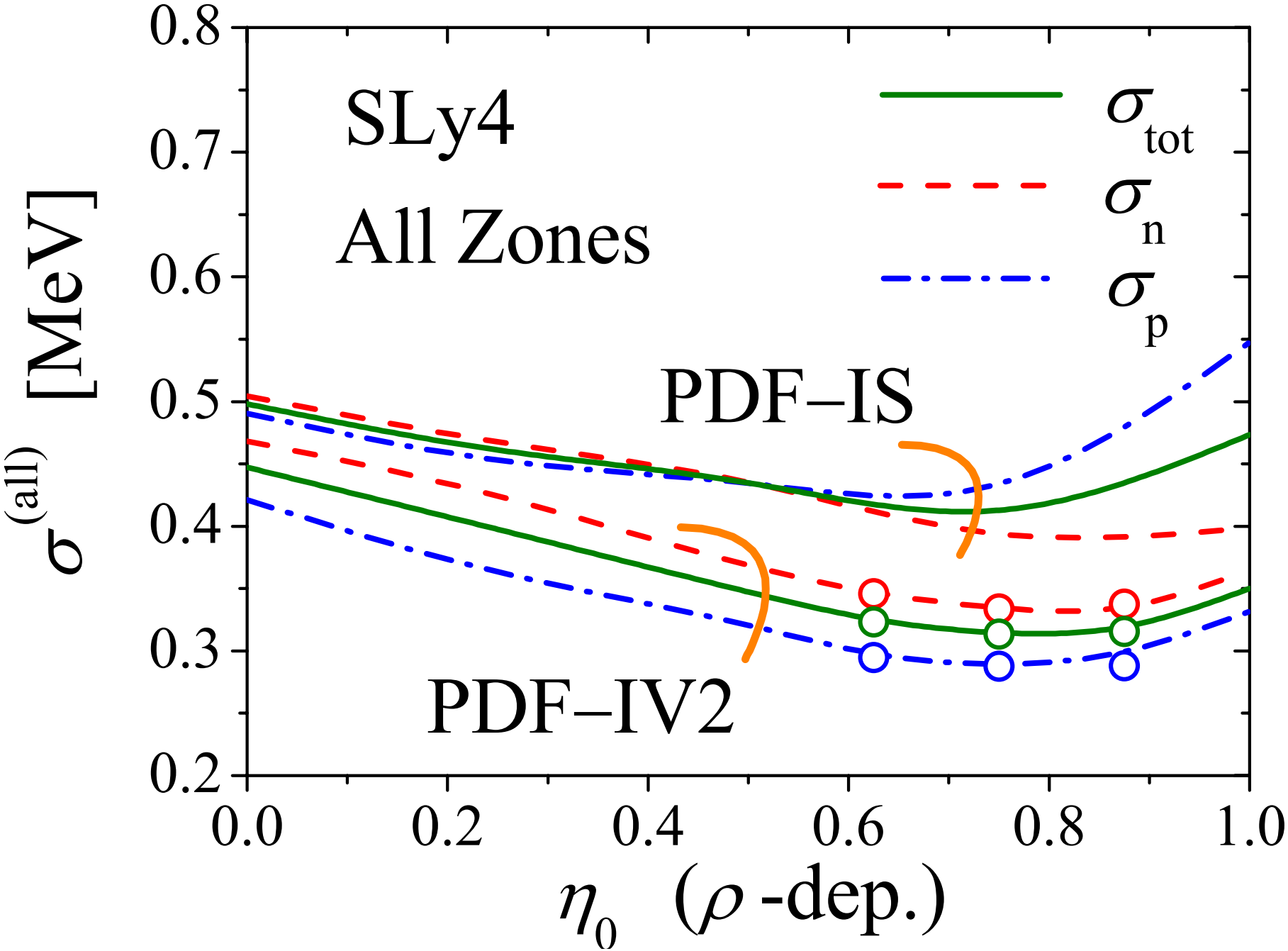
TABLE I: Definition of Zone 0, 1, 2 and 3 shown in Fig. 1. The $N_{\rm nucl}^{(i)}$ is the number of nuclei which have the experimental data of neutron and/or proton pairing gaps, and the $N_n^{(i)}$ ($N_p^{(i)}$) represents the number of experimental neutron (proton) pairing gaps in Zone i ($i = 0, 1, 2, 3$). The symbols $Z_{\rm mag}$ and $N_{\rm mag}$ are the nearest magic number, 20, 28, 50, 82, and 126.

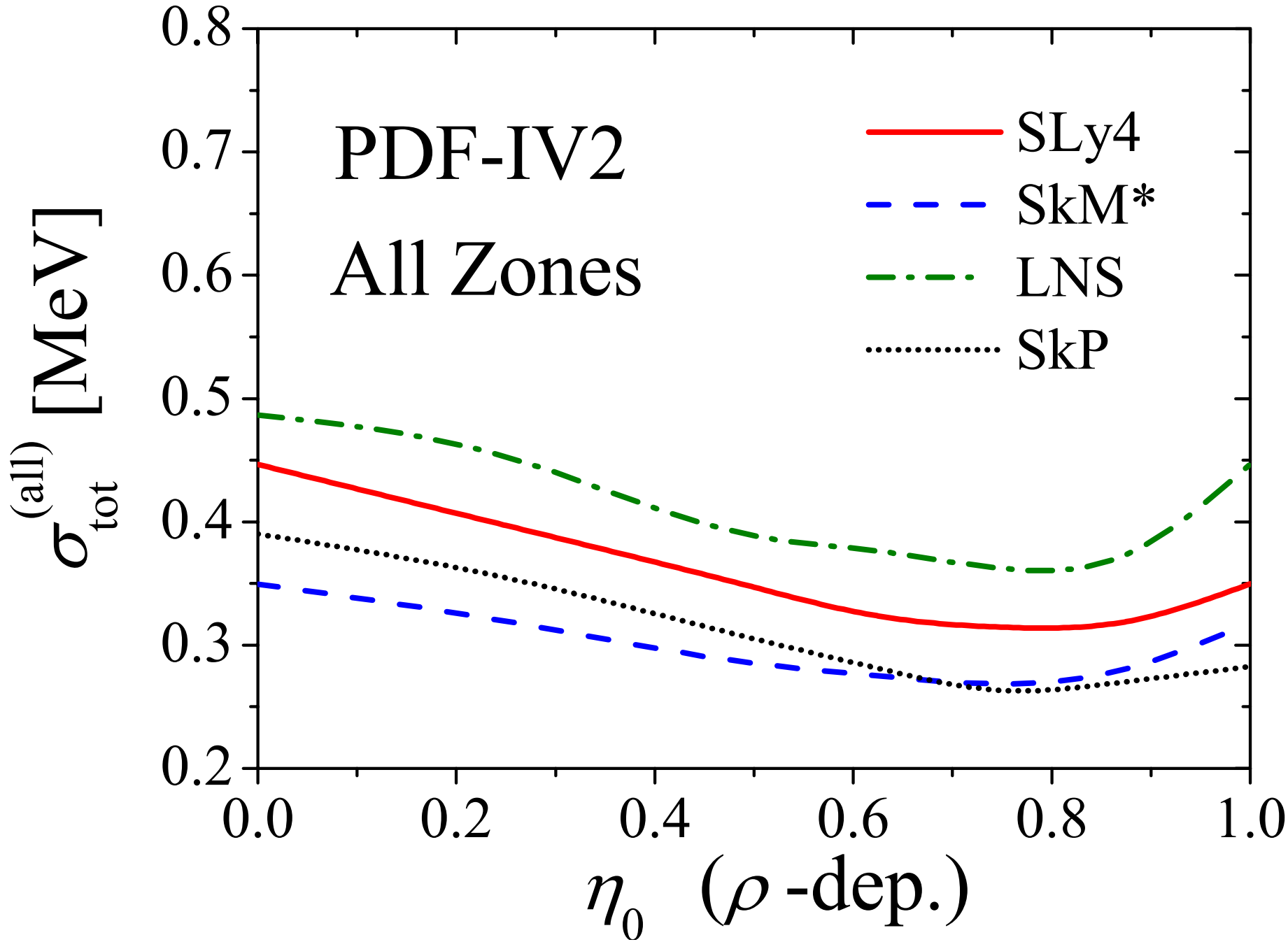
SLy4 plus PDF-IV2 ($\eta_0 = 0.75$)										
Procedure	Condition for V_0	V_0	Condition for (η_1, η_2)	η_1	η_2	$\sigma_{\rm tot}^{\rm (Zone\ 0)}$	$\sigma_{\rm tot}^{\rm (Zone\ 1)}$	$\sigma_{\rm tot}^{\rm (Zone\ 2)}$	$\sigma_{\rm tot}^{\rm (Zone\ 3)}$	$\sigma_{\rm tot}^{\rm (all)}$
$V_0^{(^{156}{\rm Dy})}$	$\Delta_n(^{156}{\rm Dy})$	-434.07	Fit in Zone 0	**0.270**	**2.5**	**0.186**	0.559	0.461	0.588	0.520
$V_0^{\rm (Zone\ 0)}$	Fit in Zone 0	**-427.07**	unchanged	0.270	2.5	**0.163**	0.493	0.386	0.508	0.450
Two-step	Fit in Zone 1	**-396.47**	unchanged	0.270	2.5	0.400	**0.333**	0.302	0.269	0.314
Direct	Fit in Zone 1	**-396.26**	Fit in Zone 1 with $\eta_2 = 2.5$	**0.390**	2.5	0.411	**0.324**	0.308	0.278	0.313

TABLE II: The four fitting procedures for PDF-IV2 are demonstrated at fixed $\eta_0 = 0.75$. The strength parameter V_0 [MeV fm^{-3}] and the isovector-density dependence η_1 and η_2 are shown. The $\sigma_{\rm tot}^{\rm (Zone\ 0)}$, $\sigma_{\rm tot}^{\rm (Zone\ 1)}$, $\sigma_{\rm tot}^{\rm (Zone\ 2)}$, $\sigma_{\rm tot}^{\rm (Zone\ 3)}$, and $\sigma_{\rm tot}^{\rm (all)}$ [MeV] are also listed. The bold numbers indicate the result of each optimization procedure. The Skyrme SLy4 is used for the particle-hole channel. See text for the details.

$$H_{\rm pair}(\boldsymbol{r}) = \frac{1}{4}\sum_{\tau=n,p} V_\tau\, g_\tau[\rho,\rho_1]\,[\tilde{\rho}_\tau(\boldsymbol{r})]^2$$

$$g_\tau[\rho,\rho_1] = 1 - \eta_0\frac{\rho(\boldsymbol{r})}{\rho_0} - \eta_1\frac{\tau_3\rho_1(\boldsymbol{r})}{\rho_0} - \eta_2\left[\frac{\rho_1(\boldsymbol{r})}{\rho_0}\right]^2 .$$


SLy4
All Zones
σ_{tot}
σ_n
σ_p
PDF–IS
PDF–IV2
$\sigma^{(all)}$ [MeV]
η_0 (ρ-dep.)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.0
0.2
0.4
0.6
0.8
1.0


PDF-IV2
All Zones
SLy4
SkM*
LNS
SkP
$\sigma_{tot}^{(all)}$ [MeV]
η_0 (ρ-dep.)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.0
0.2
0.4
0.6
0.8
1.0

η_0, η_2 are fixed

Skyrme	(m_s^*/m)	V_0	η_1	$\sigma_{\rm tot}^{\rm (all)}$	$\sigma_{\rm n}^{\rm (all)}$	$\sigma_{\rm p}^{\rm (all)}$
SLy4	(0.69)	-396.47	0.270	0.314	0.334	0.289
SkM*	(0.79)	-371.60	0.427	0.268	0.282	0.251
LNS	(0.83)	-388.60	0.400	0.362	0.365	0.359
SkP	(1.00)	-317.50	0.300	0.264	0.297	0.218

TABLE IV: The parameter sets of PDF-IV2 at $(\eta_0, \eta_2) = (0.75, 2.5)$ for SLy4, SkM*, LNS, and SkP. The two-step procedure is performed. The $\sigma_{\rm tot}^{\rm (all)}$, $\sigma_{\rm n}^{\rm (all)}$, $\sigma_{\rm p}^{\rm (all)}$ are listed. The m_s^*/m is the isoscalar effective mass parameter of the Skyrme force.

V_0, η_2 are fixed

Skyrme	(m_s^*/m)	η_0	η_1	$\sigma_{\rm tot}^{\rm (all)}$	$\sigma_{\rm n}^{\rm (all)}$	$\sigma_{\rm p}^{\rm (all)}$
SLy4	(0.69)	0.903	0.483	0.322	0.345	0.293
SkM*	(0.79)	0.942	0.600	0.300	0.314	0.282
LNS	(0.83)	0.875	0.612	0.374	0.401	0.340
SkP	(1.00)	1.095	0.700	0.309	0.344	0.261

TABLE V: The parameters set of PDF-IV2 for SLy4, SkM*, LNS and SkP determined under the assumption $V_0 = V_{\rm vac}$ and $\eta_2 = 2.5$. The optimization procedure for (η_0, η_1) is performed in Zone 1. The $\sigma_{\rm tot}^{\rm (all)}$, $\sigma_{\rm n}^{\rm (all)}$, and $\sigma_{\rm p}^{\rm (all)}$ are also compared.

PHYSICAL REVIEW C **79**, 034306 (2009)

Odd-even mass differences from self-consistent mean field theory

G. F. Bertsch,[1] C. A. Bertulani,[2] W. Nazarewicz,[3,4,5] N. Schunck,[6] and M. V. Stoitsov[6]

TABLE IV. Root-mean-square residuals of $\Delta_o^{(3)}$ obtained in various models. All energies are in MeV. The last column shows the ratio of proton and neutron effective pairing strengths obtained through the optimization procedure. The mass predictions of the HFB-14 model [17] were taken from Ref. [53].

Theory	Pairing	Residual neutrons	Residual protons	$V_0^{\rm eff}(p)/V_0^{\rm eff}(n)$
Constant		0.31	0.27	
c/A^α		0.24	0.22	
HF+BCS	Volume	0.31	0.38	1.05
HF+BCS	Mixed	0.30	0.36	1.08
HF+BCS	Surface	0.27	0.35	1.12
HFB	Mixed	0.27	0.33	1.11
HFB+LN	Mixed	0.23	0.28	1.11
HFB-14		0.46	0.44	1.10

IS+IV paring: Summary and Perspectives

- IS+IV pairing interaction looks promising for the global fitting purpose.

- Extension to include $((N-Z)/A)^2$ term + Two-body Coulomb.

  (M. Yamagami et al.,) (M. Yamagami and H. Nakada)

- η_0 is determined robustly to be ~0.75, η_1 and η_2 needs more data to fix precisely.

- Coulomb two-body effect can be mimiced by η_1.

- Better EDF with pairing correlations: Can pairing correlation properties be isolated from the full functional

Recent progress of Pairing correlation study
----- Bertschfest -----
Sept 7-9,2012, Seattle, USA

H. Sagawa
University of Aizu/RIKEN, Japan

1. Isospin dependent global T=1 paring interaction
2. Cooperation of T=0 with T=1 pairings in Gamow-Teller transitions
3. Summery

T=1 S=0 pairing and T=0 S=1 pairing interactions

T=1 pairing (n-n, p-p pairing correlations)

- mass (odd-even staggering)
- energy spectra (gap between the first excited state and the ground state in even-even nuclei
- moment of inertia
- n-n or p-p Pair transfer reactions
- fission barrier (large amplitude collective motion)

T=0 pairing (p-n pairing with S=1)

- N=Z Wigner energy (still contravertial)
- Energy spectra in nuclei with N=Z (T=0 and $J=J_{max}$)
- n-p pair transfer reaction
- Super-allowed Gamow-Teller transition between SU(4) supermultiples (C.L. Bai et al.)

Nuclear pairing: basic phenomena revisited

G.F. Bertsch

Institute for Nuclear Theory and Dept. of Physics, University of Washington, Seattle, Washington

2.2.2. *Spin-triplet pairing*

The strong attraction between identical nucleons was the starting point for the discussion of the pairing interaction in the previous section. In fact, the attraction is even stronger between neutrons and protons in the spin $S = 1$ channel. Here the interaction gives rise to the deuteron bound state. Nevertheless, all the pairing phenomena seen above are a result of $S = 0$ pairing between identical nucleons.

This connundrum is resolved in two ways. First of all, pairing is only favored when all the particles can participate. The spin triplet interaction is only strong in neutron-proton pairs, so it would be suppressed in nuclei with a large imbalance between neutron and proton numbers. The other factor working against spin-triplet pairing is the spin-orbit field of the nucleus. It breaks the spin coupling of the pair wave function, but it is more effective in the spin-triplet channel.[11] In any case, an increase in nuclear binding energies is seen along the $N = Z$ line, called the "Wigner energy".[12]

arXiv:1203.5529

Cooperation of T=0 and T=1 pairing in Gamow-Teller states in N=Z nuclei

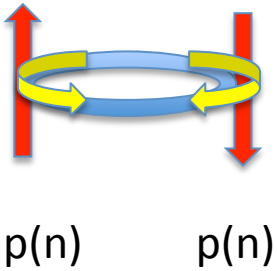
C. L. Bai, H.S., M.Sasano, T. Uesaka, K. Hagino, H.Q. Zhang, X.Z. Zhang,F.R.Xu

As a possble manifestation of T=0 S=1 pairing correlations in nuclei N=Z.

If there is no spin-orbit splitting,
T=0 S=1 pairs may condensate as much as T=1 S=0 pairs in the grouns state in nuclei N~Z.

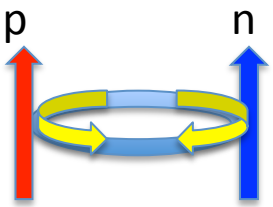
Two particle systems

T=1, S=0 pair



$$\left|(L=S=0)J=0,T=1\right\rangle \Rightarrow \left|(j=j')J=0,T=1\right\rangle$$

T=0, S=1 pair



$$\left|(L=0,S=1)J=1,T=0\right\rangle \Rightarrow$$

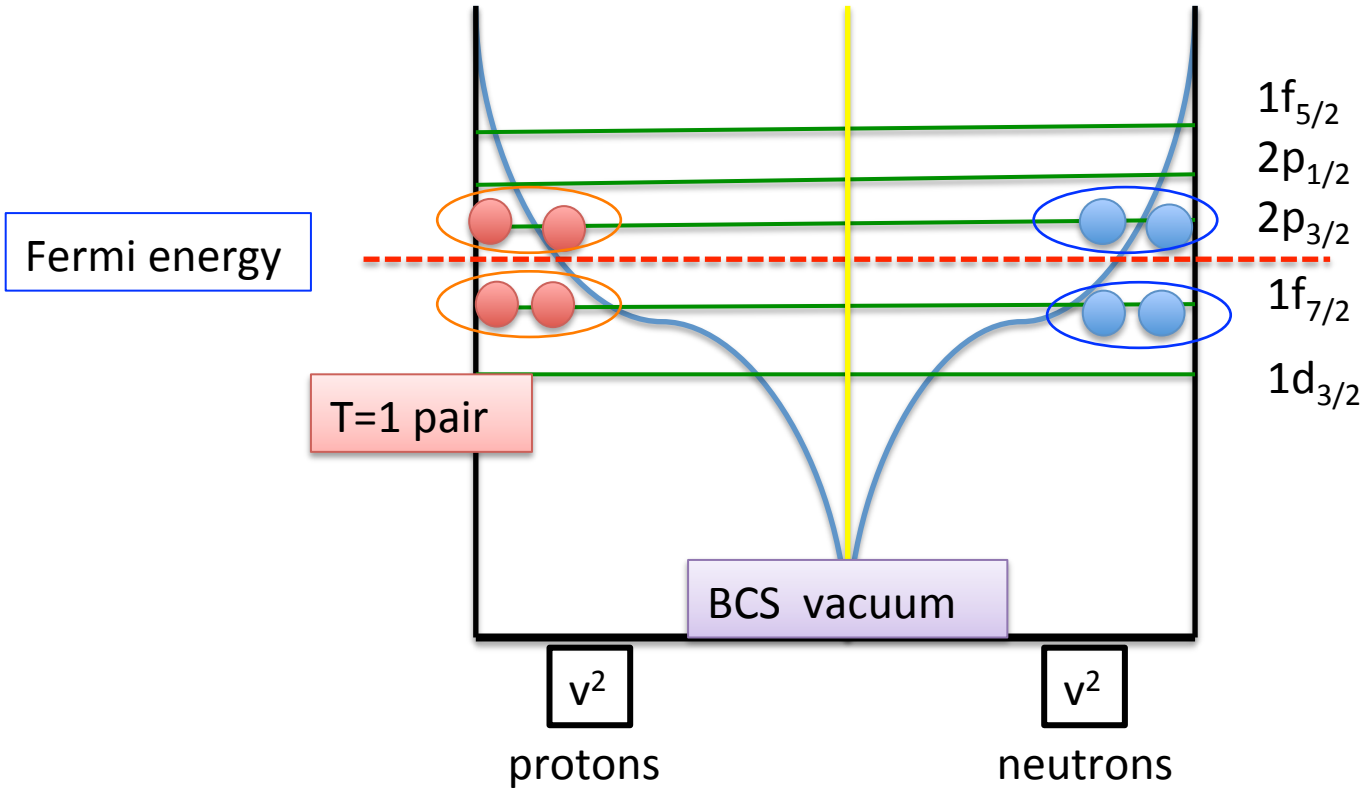
$$a\left|(l=l'\,j=j')J=1,T=0\right\rangle + b\left|((l=l')j,j'=j\pm 1)J=1,T=0\right\rangle$$

If there is strong spin-orbit splitting, it is difficult to make (T=0,S=1)pair.

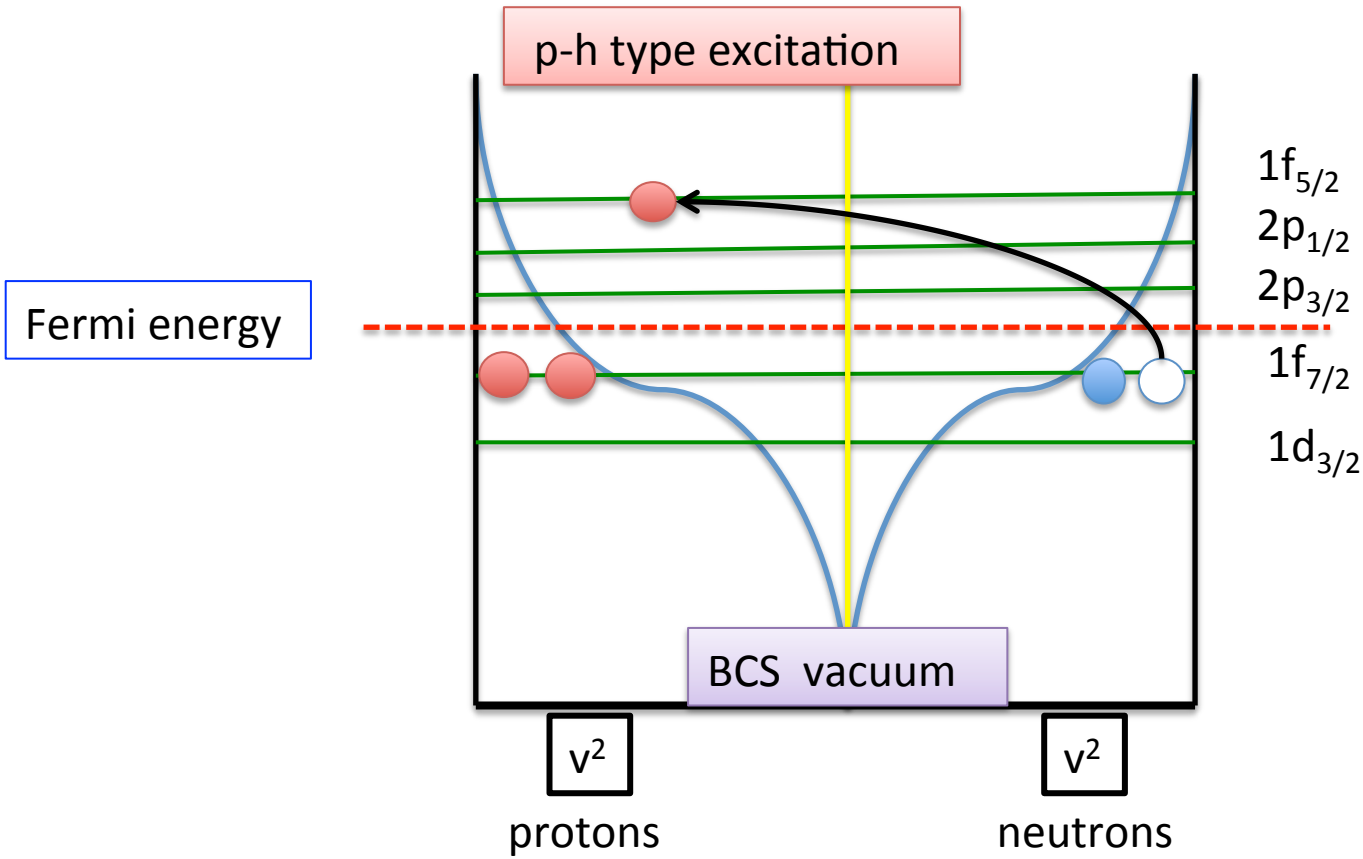
T=0 J= 1^+ ground state inN=Z nuclei

➔ ^{58}Cu is only one N=Z nucleus known in pf shell

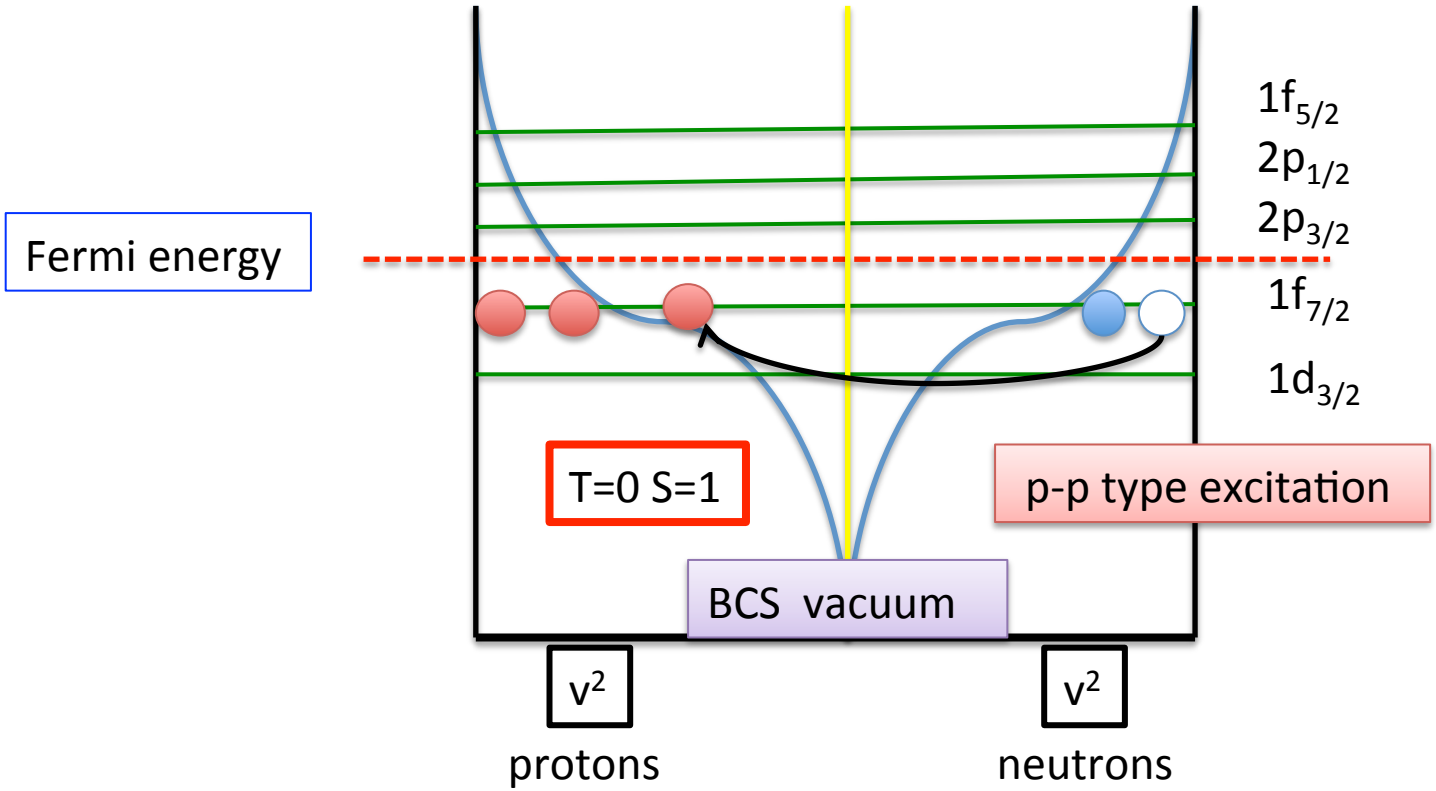
Gamow-Teller transitions from BCS vacuum in N=Z nuclei



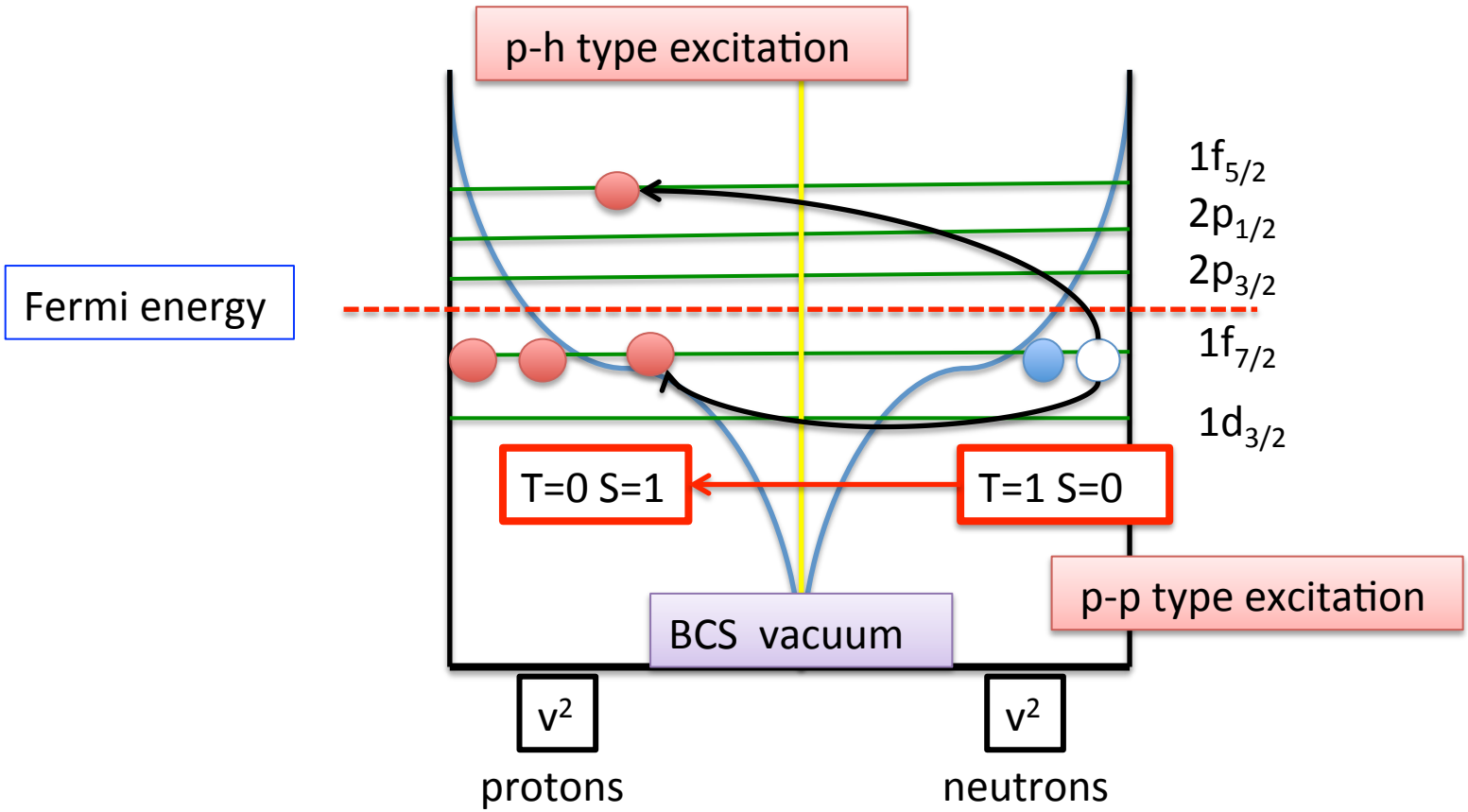
Gamow-Teller transitions in BCS vacuum



Gamow-Teller transitions in BCS vacuum



Gamow-Teller transitions in BCS vacuum



A pair of SU(4) supermultiplet

Supermultiplet : Wigner SU(4) symmetry
(T=1, S=0) →(T=0, S=1) GT transition is allowed and enhanced .

$$\hat{O}(GT) = \sigma\tau_{\pm}$$

σ and τ are generators of SU(4)

$$\langle \{(1f_{7/2}^2)^{T=1,S=0}; (2p_{3/2}^{\nu}2p_{3/2}^{\pi})^{T=0,S=1}\}T_f = S_f = 1||O(\hat{GT})||\{(1f_{7/2}^2)^{T=1,S=0}; (2p_{3/2}^{\nu}, 2p_{3/2}^{\nu})^{T=1,S=0}\}T_i = S_i = 0\rangle$$
$$= \langle (2p_{3/2}^{\nu}, 2p_{3/2}^{\pi})^{T=0,S=1}||O(\hat{GT})||(2p_{3/2}^{\nu}, 2p_{3/2}^{\nu})^{T=1,S=0}\rangle \quad (4)$$

HFB+QRPA with T=1 and T=0 pairing
T=1 pairing in HFB
T=0 pairing in QRPA

$$V_{T=1}(\mathbf{r}_1, \mathbf{r}_2) = V_0 \frac{1 - P_\sigma}{2}\left(1 - \frac{\rho(\mathbf{r})}{\rho_o}\right)\delta(\mathbf{r}_1 - \mathbf{r}_2), \quad (1)$$

$$V_{T=0}(\mathbf{r}_1, \mathbf{r}_2) = fV_0 \frac{1 + P_\sigma}{2}\left(1 - \frac{\rho(\mathbf{r})}{\rho_o}\right)\delta(\mathbf{r}_1 - \mathbf{r}_2), \quad (2)$$

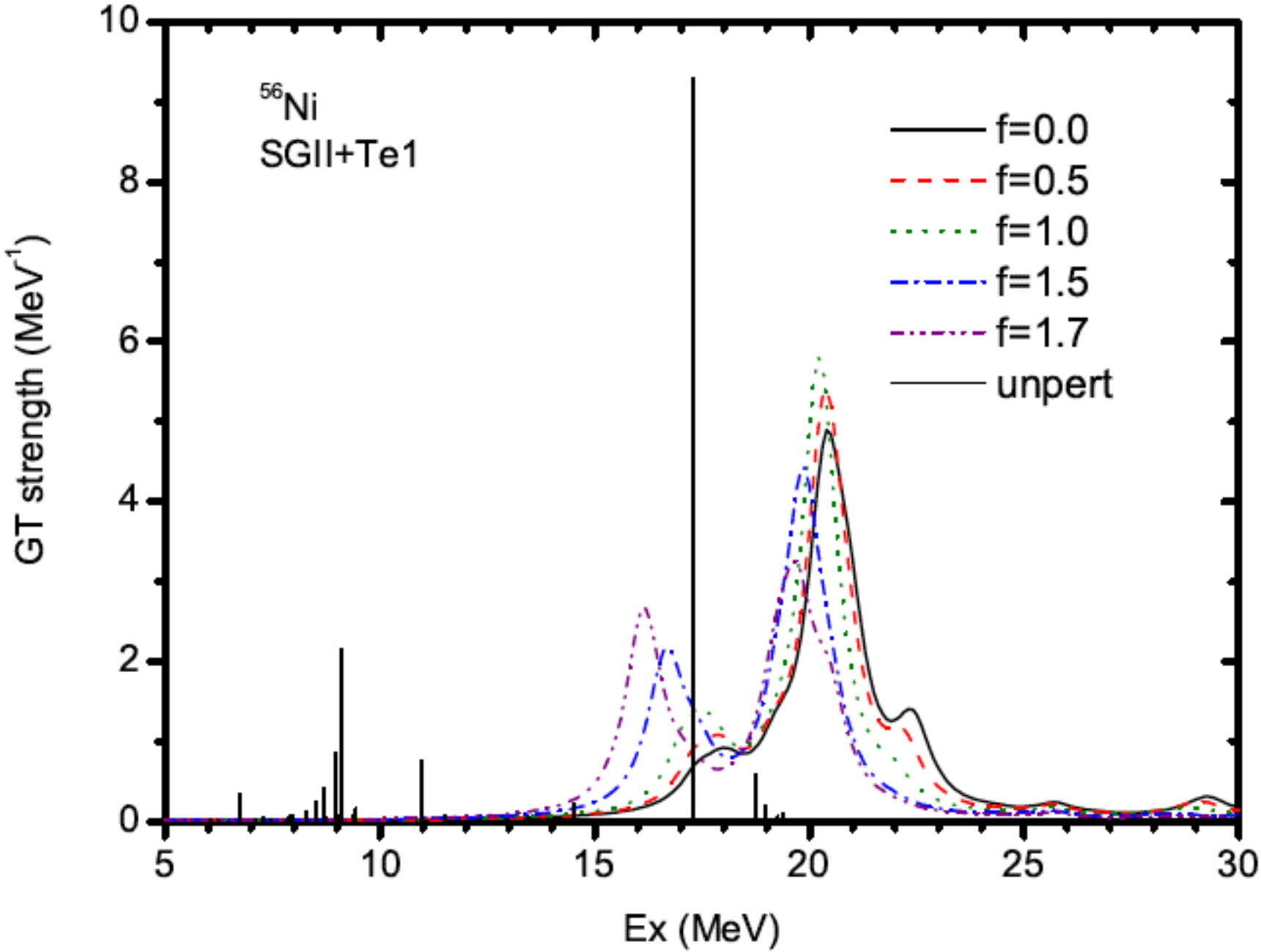

^{56}Ni
SGII+Te1
f=0.0
f=0.5
f=1.0
f=1.5
f=1.7
unpert
GT strength (MeV^{-1})
Ex (MeV)
0
2
4
6
8
10
5
10
15
20
25
30

TABLE I: Amplitudes of main (np) particle-hole and particle-particle type configurations of GT states in ^{56}Ni. The QRPA calculations are performed without and with the T=0 pairing interaction in the cases of $f = 0$ and $f = 1.5$, respectively. The Skyrme interaction T21 is used for HF and p-h matrix calculations. The abbreviations B and C correspond to the GT reduced matrix element B=$(Xu_\pi v_\nu - Yu_\nu v_\pi)\langle\pi\|\hat{O}(\mathrm{GT})\|\nu\rangle$ and the normalization factor C=$X^2 - Y^2$, respectively, where X,Y are QRPA amplitudes and $\hat{O}$(GT) is GT transition operator in Eq. (3).

^{56}Ni		$f = 0$			
E_x (MeV)	B(GT)	$\nu(v_\nu^2)$	$\pi(v_\pi^2)$	B	C
17.5	1.41	$2p_{3/2}(0.20)$	$2p_{3/2}(0.21)$	0.358	0.127
		$1f_{7/2}(0.69)$	$1f_{5/2}(0.09)$	−0.229	0.006
		$1f_{7/2}(0.69)$	$1f_{7/2}(0.67)$	1.341	0.802
18.3	1.49	$2p_{1/2}(0.10)$	$2p_{3/2}(0.21)$	0.260	0.153
		$2p_{3/2}(0.20)$	$2p_{1/2}(0.11)$	0.846	0.740
21.3	7.88	$1f_{7/2}(0.69)$	$1f_{5/2}(0.09)$	2.48	0.742
S$_-$(GT)=18.28					
^{56}Ni		$f = 1.5$			
E_x (MeV)	B(GT)	$\nu(v_\nu^2)$	$\pi(v_\pi^2)$	B	C
16.6	4.82	$2p_{3/2}(0.20)$	$2p_{1/2}(0.11)$	−0.203	0.049
		$2p_{3/2}(0.20)$	$2p_{3/2}(0.21)$	−0.682	0.491
		$1f_{7/2}(0.69)$	$1f_{5/2}(0.09)$	−0.237	0.007
		$1f_{7/2}(0.69)$	$1f_{7/2}(0.67)$	−0.790	0.339
20.5	4.10	$1f_{7/2}(0.69)$	$1f_{5/2}(0.09)$	−1.900	0.437
S$_-$(GT)=14.75					

$$B = (Xu_\pi v_\nu - Yu_\nu v_\pi)\left\langle \pi \left\| \hat{O}(GT) \right\| \nu \right\rangle$$

$$C = X^2 - Y^2$$

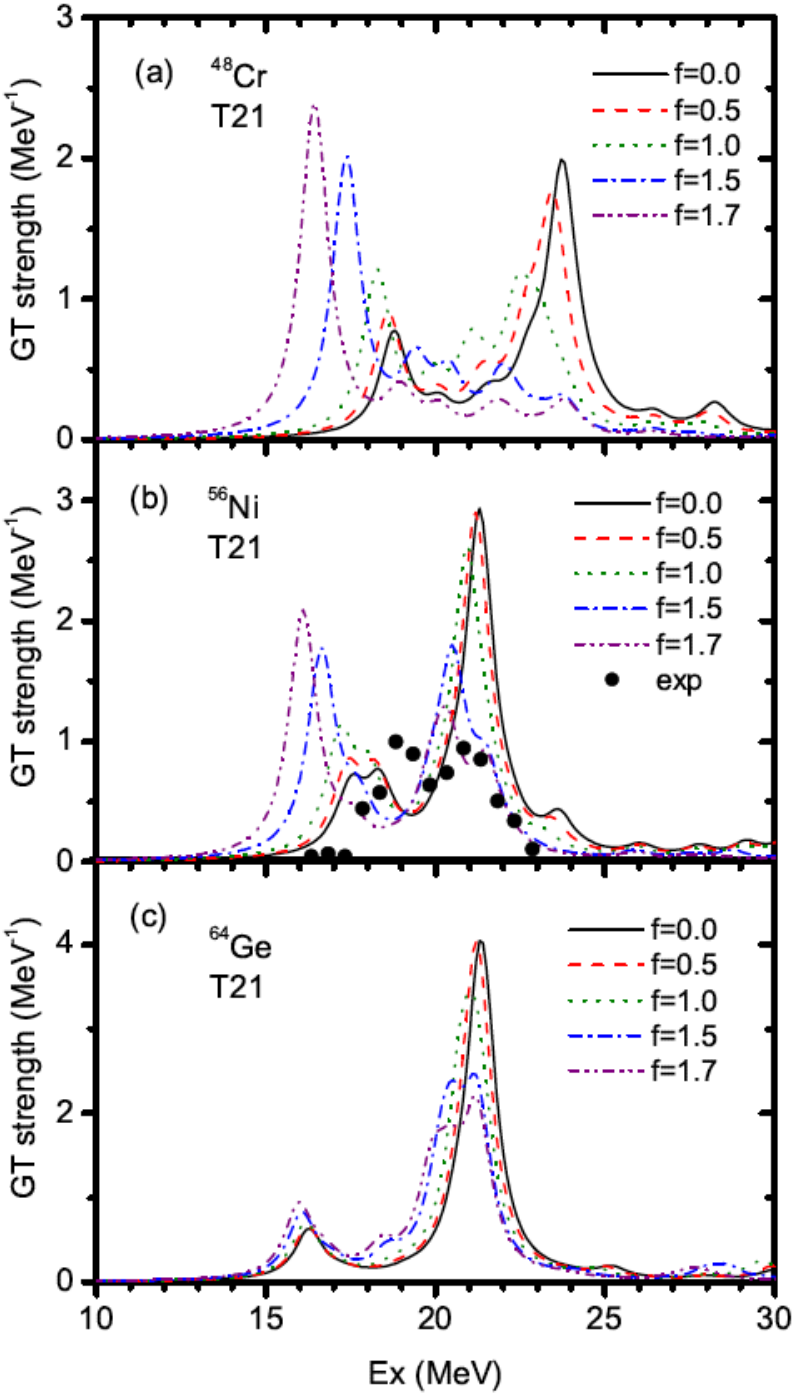
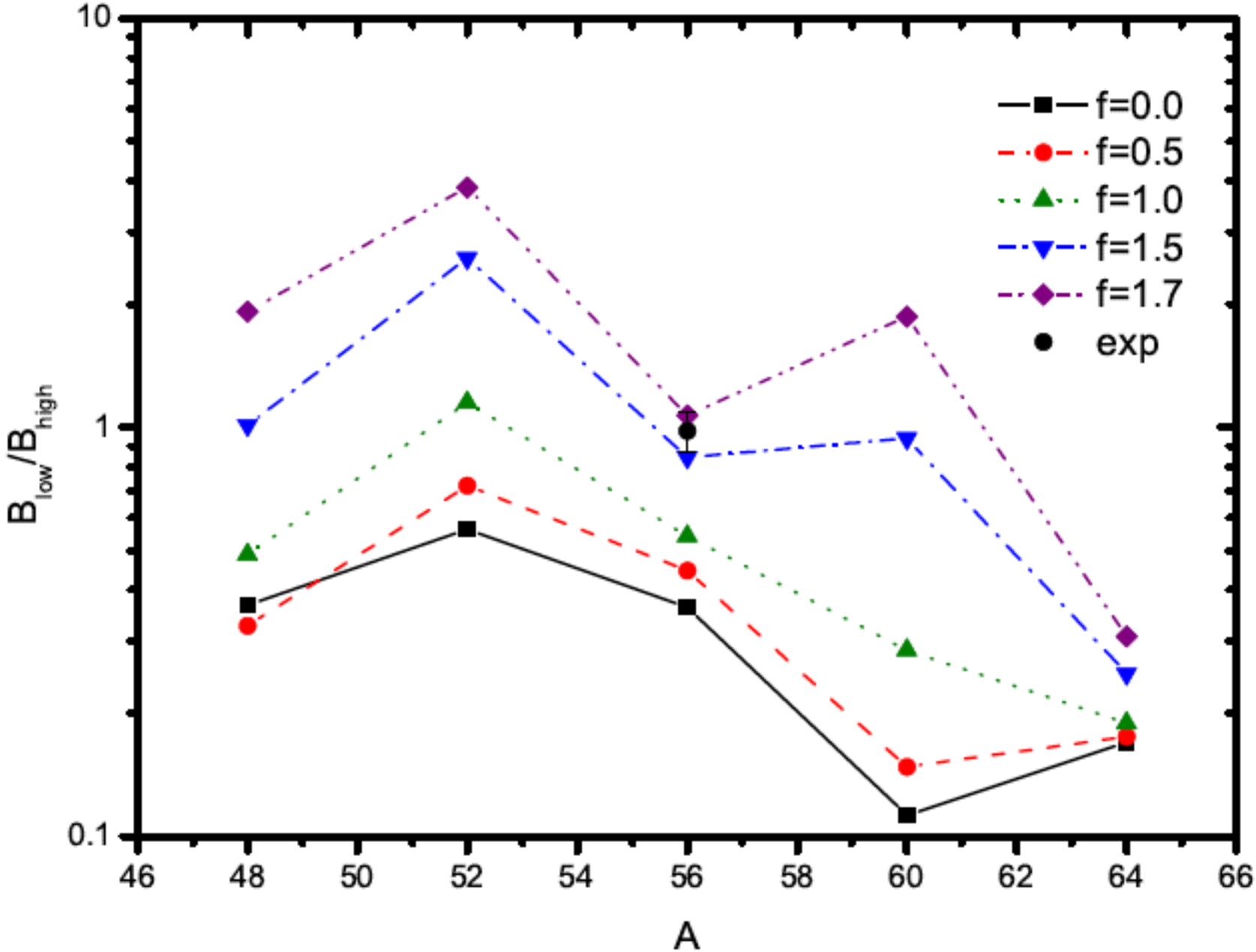


TABLE II: Same as Table I, but for ^{48}Cr and ^{64}Ge with the T=0 pairing interaction $f = 1.5$.

^{48}Cr		$f = 1.5$			
E_x (MeV)	B(GT)	$\nu(v_\nu^2)$	$\pi(v_\pi^2)$	B	C
17.4	5.68	$2p_{3/2}(0.12)$	$2p_{3/2}(0.12)$	0.186	0.062
		$1d_{3/2}(0.85)$	$1d_{3/2}(0.84)$	0.251	0.204
		$1f_{7/2}(0.33)$	$1f_{5/2}(0.07)$	0.268	0.021
		$1f_{7/2}(0.33)$	$1f_{7/2}(0.32)$	1.04	0.558
19.4	1.19	$2p_{3/2}(0.12)$	$2p_{1/2}(0.07)$	0.215	0.081
		$2p_{3/2}(0.12)$	$2p_{3/2}(0.12)$	0.559	0.461
		$1d_{3/2}(0.85)$	$1d_{3/2}(0.84)$	−0.217	0.142
		$1f_{7/2}(0.33)$	$1f_{5/2}(0.07)$	0.383	0.038
		$1f_{7/2}(0.33)$	$1f_{7/2}(0.32)$	−0.384	0.054
S_-(GT)=11.77					
^{64}Ge		$f = 1.5$			
E_x (MeV)	B(GT)	$\nu(v_\nu^2)$	$\pi(v_\pi^2)$	B	C
16.1	2.15	$2p_{3/2}(0.48)$	$2p_{1/2}(0.21)$	−1.316	0.889
21.2	5.21	$1f_{5/2}(0.14)$	$1f_{7/2}(0.90)$	−0.187	0.353
		$1f_{7/2}(0.92)$	$1f_{5/2}(0.15)$	2.392	0.561
S_-(GT)=17.26					


10
1
0.1
46
48
50
52
54
56
58
60
62
64
66
A
B_{low}/B_{high}
f=0.0
f=0.5
f=1.0
f=1.5
f=1.7
exp

Summary

1. Role of T=0 pairing is studied in Gamow-Teller transitions of N=Z nuclei in cooperation with T=1 pairing.
2. It is pointed out two peak structure will appear due to the strong T=0 pairing correlations in the final states.

   Implementation of Supermultiplets of T=1,S=0 and T=0 and S=1 pair

3. Future perspective:
   T= 0 pairing in the ground state ➔ no solid condensation but quenching of GT strength in N=Z nuclei?
   New experiments in N=Z nuclei, ^{48}Cr, was approved by PAC in RIKEN June, 2012. Further experiment in ^{64}Ge.

a. Further study of Particle-vibration coupling: Yifei Niu, Gianluca Colo
b. In comparison with Shell model calculations: Toshio Suzuki, Michio Honma

Conclusion

Happy 70th anniversary for George!

Keep your good health and give us more and more stimulating ideas for exciting physics in future!

Thank you very much for your patience