Technical issues on EXFOR compilation at JCPRG

Hokkaido Univ.

Theoretical Nuclear Physics Lab.

Tetsuaki Tada

Nuclear Reaction Data Centre (JCPRG)
Faculty of Science, Hokkaido University

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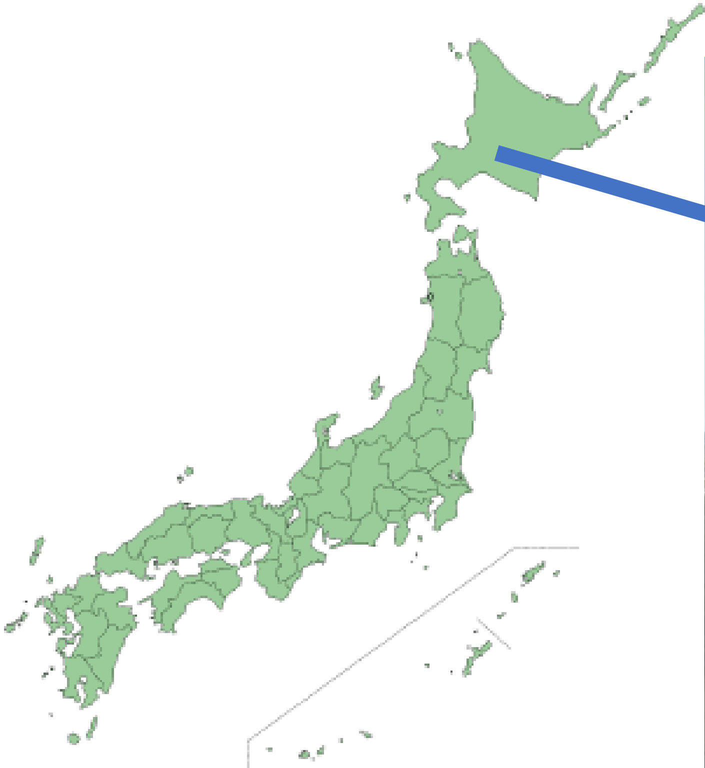
- Self-Introduction
- My research
  - Master course
  - Doctor course
- Compilation in JCPRG

Hokkaido Univ.



JCPRG : 2^{nd} floor

Theoretical Nuclear Physics Lab. : 10^{th} floor

Self-Introduction

Background

- Undergraduate:
  Department of physics, Tokyo University of Science
- Master course:
  Theoretical Nuclear Physics Laboratory, Hokkaido Univ.

Current situation

- Doctor course(D1):
  Theoretical Nuclear Physics Laboratory, Hokkaido Univ.
- Compiler in JCPRG

Nuclear Reaction
Data Centre (JCPRG)
Faculty of Science, Hokkaido University

The meaning of JCPRG logo

The meaning of JCPRG logo

The shape represents the orbit of nuclear reaction.

The meaning of JCPRG logo

The shape represents the orbit of nuclear reaction.

White circle is Target.

The meaning of JCPRG logo

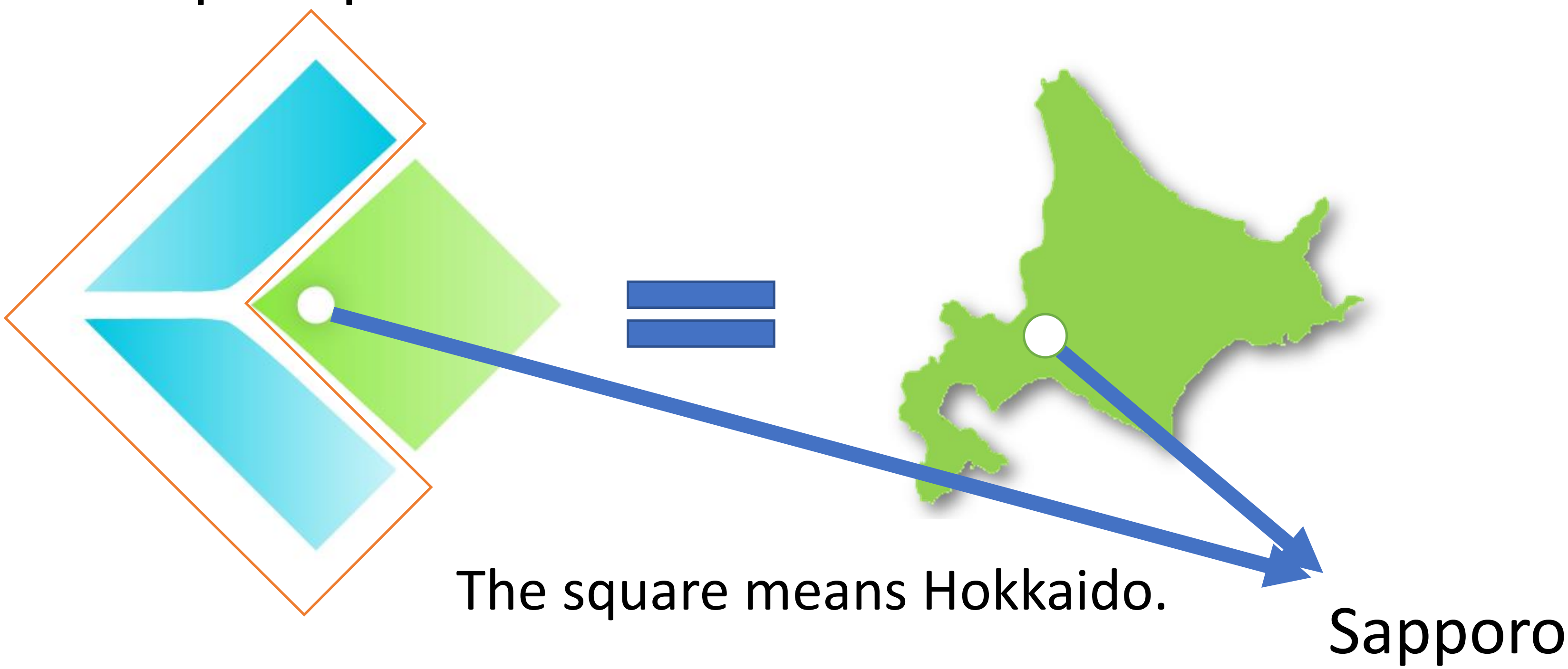
The shape represents the orbit of nuclear reaction.

The square means Hokkaido.

The circle is Target.

The meaning of JCPRG logo

The shape represents the orbit of nuclear reaction.



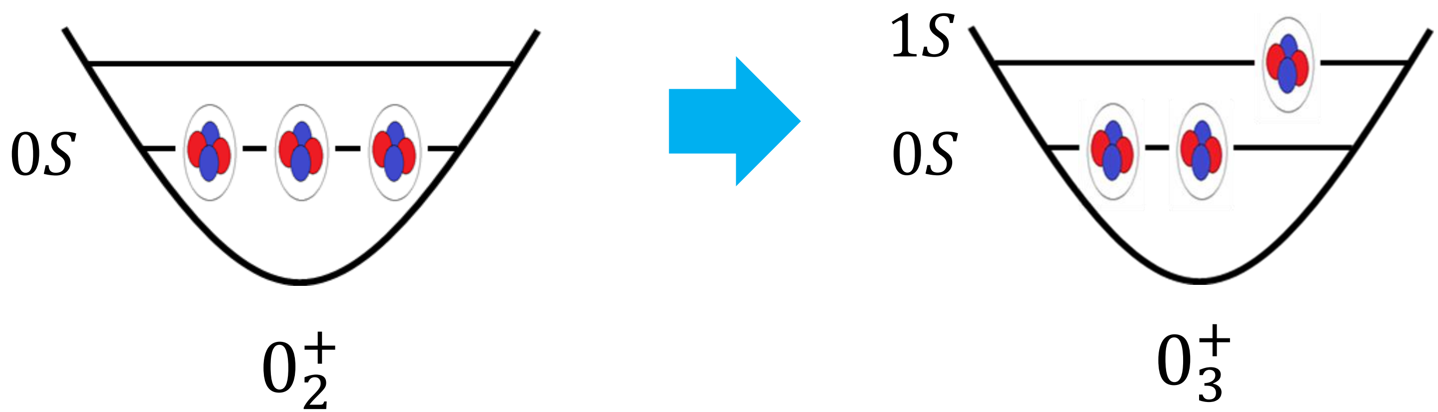
The circle is Target.

My research
in master thesis

Hoyle state and analog state in positive parity

The Hoyle state is dilute gaslike state composed of three α particles .

A. Tohsaki, et al., PRL 87, 192501 (2001)



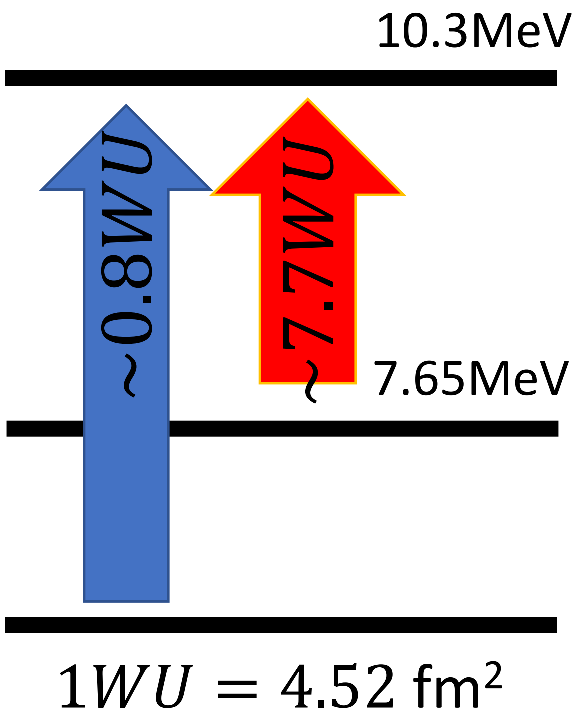
- The Hoyle state can be approximated by the three α particles trapped in the 0S state of harmonic oscillator.
- The 0_3^+ can be interpreted as the α particle excitation from 0S state to 1S state.

Y. Funaki, PRC 92,0211302(2015)

Y. Funaki, PRC 94,024344(2016)

Hoyle state and analog state in positive parity

- The 0_3^+ state has large radius and monopole transition from the Hoyle state.
- The 0_3^+ state is considered to be a family of the Hoyle state.



$0_3^+ \quad \sqrt{\langle r^2 \rangle} = 4.7\text{fm}$

$0_2^+ \quad \sqrt{\langle r^2 \rangle} = 3.7\text{fm}$

$0_1^+ \quad \sqrt{\langle r^2 \rangle} = 2.4\text{fm}$

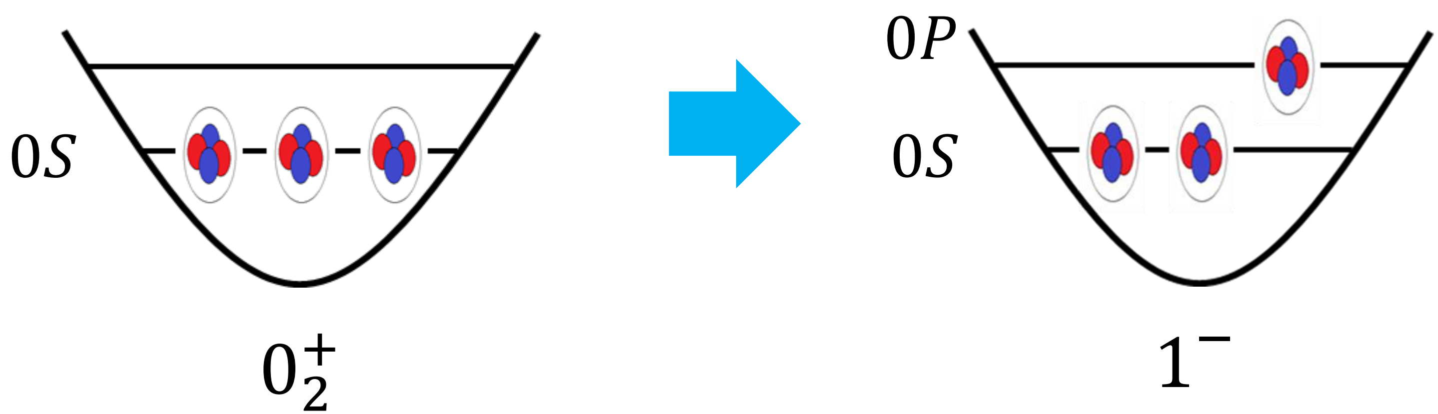
Y. Funaki, PRC 92,0211302(2015)

Y. Funaki, PRC 94,024344(2016)

Hoyle state and analog state in negative parity

Is there an excitation from the Hoyle state in negative parity?

In analogy to the 0_3^+ state



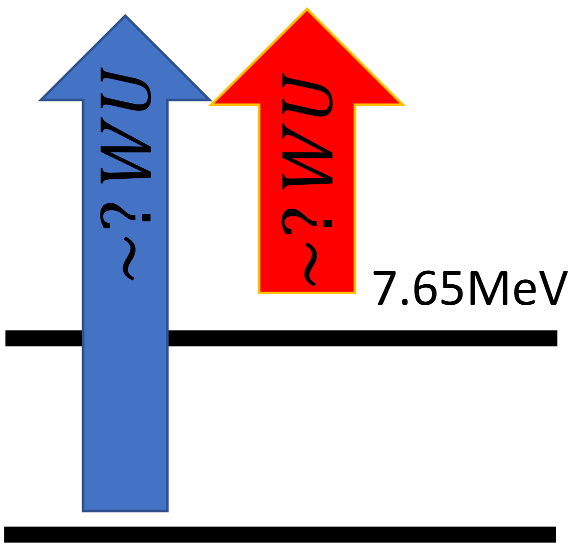
In same potential, we consider an α particle excitation from 0S to 0P which generate 1^- state.

Hoyle state and analog state in negative parity

Does the 1^- state have large radius?

1^- cluster state can be strongly excited from the ground state by the IS dipole transition.

Y. Chiba ,M. Kimura and Y. Taniguchi, PRC93, 034319(2016)



$1^- \quad \sqrt{\langle r^2 \rangle} =$? fm

$0_2^+ \quad \sqrt{\langle r^2 \rangle} = 3.7\text{fm}$

$0_1^+ \quad \sqrt{\langle r^2 \rangle} = 2.4\text{fm}$

Y. Funaki, PRC 92,0211302(2015)

Y. Funaki, PRC 94,024344(2016)

Motivation

1^- has been studied by using cluster model, but the relation between the 1^- **and** alpha condensate state is unknown.

By using Real Time Evolution Method, we investigate the structure of the 1^- state.

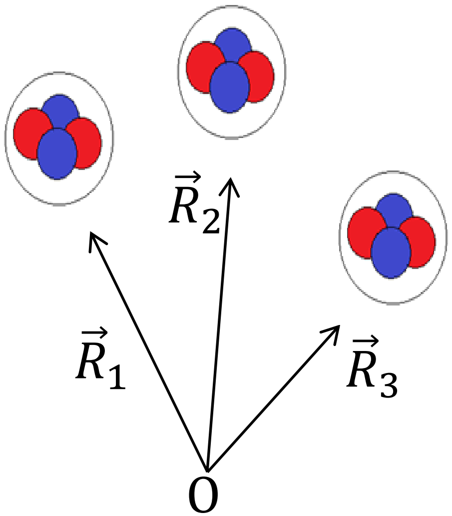
- Does the 1^- state has large radius?
- The 1^- state should have large isoscalar dipole transition to the state that has large radius.

Framework

Hamiltonian

$$H = \sum_i T_i - T_{c.m} + \sum_{i<j} V_{ij} + \sum_{\text{proton}} V_{cc}$$

- V_{ij}:Volkov No.2 potential



Wave function

$$\phi(\vec{R}_1, \vec{R}_2, \vec{R}_3) = \mathcal{A}\{\phi_{\alpha 1}(\vec{R}_1)\phi_{\alpha 2}(\vec{R}_2)\phi_{\alpha 3}(\vec{R}_3)\}$$

$$\phi_{\alpha i}(\vec{R}_i) = \mathcal{A}\{\varphi\left(\vec{r}_{4i-3} - \vec{R}_i\right)|n\uparrow\rangle \ldots \varphi(\vec{r}_{4i} - \vec{R}_i)|p\downarrow\rangle\}$$

$$\varphi(\vec{r} - \vec{R}_i) = (\pi b^2)^{-\frac{3}{4}} \exp[-\frac{1}{2b^2}(\vec{r} - \vec{R}_i)^2]$$

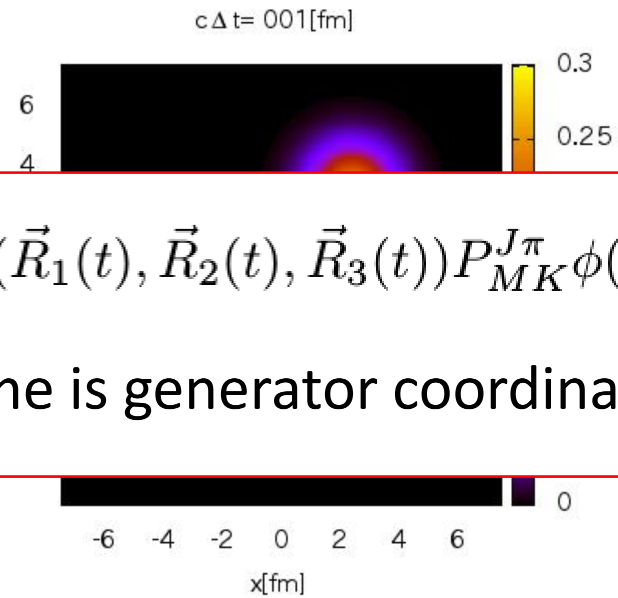
b : the size of α particle , R_i: the center of the ith cluster

$$\psi^{J\pi}_{M,K} = \sum c^{J\pi}_K(\vec{R}_1, \vec{R}_2, \vec{R}_3)\hat{P}^J_{MK}\hat{P}^{\pi}\,\phi(\vec{R}_1, \vec{R}_2, \vec{R}_3)$$

Framework Real Time Evolution Method

We generate basis function by solving equation of motion.

◎time dep



$$\psi^{J\pi}_{M,K} = \sum_t F^{J\pi}_K(\vec{R}_1(t), \vec{R}_2(t), \vec{R}_3(t)) P^{J\pi}_{MK} \phi(\vec{R}_1(t), \vec{R}_2(t), \vec{R}_3(t))$$

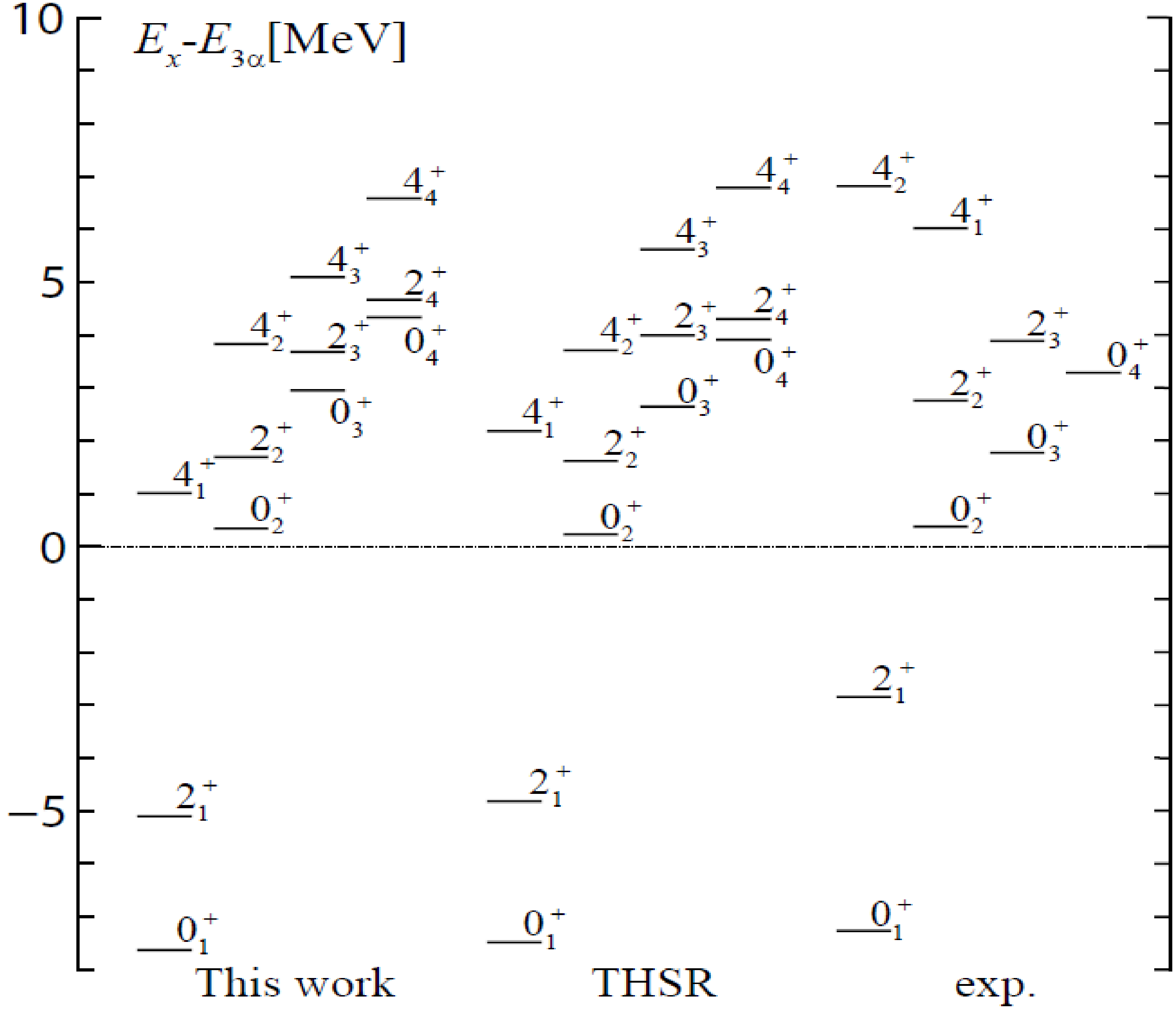
Real time is generator coordinate.

$$H \equiv \frac{\langle \phi(\vec{R}_1, \ldots}{\langle \phi(\vec{R}_1 \ldots} \qquad \frac{\partial^2}{i\tau\,\partial R^*_{i\sigma}} \ln N$$

If we evolve time long enough, all configurations will appear on constant-energy surface(ergodic hypothesis).

Result Spectrum of positive parity states

Y. Funaki, PRC 92,0211302(2015)
M. Freer et al., PRC 83, 034314(2011)
M. Itoh et al., PRC 84,054308(2011)



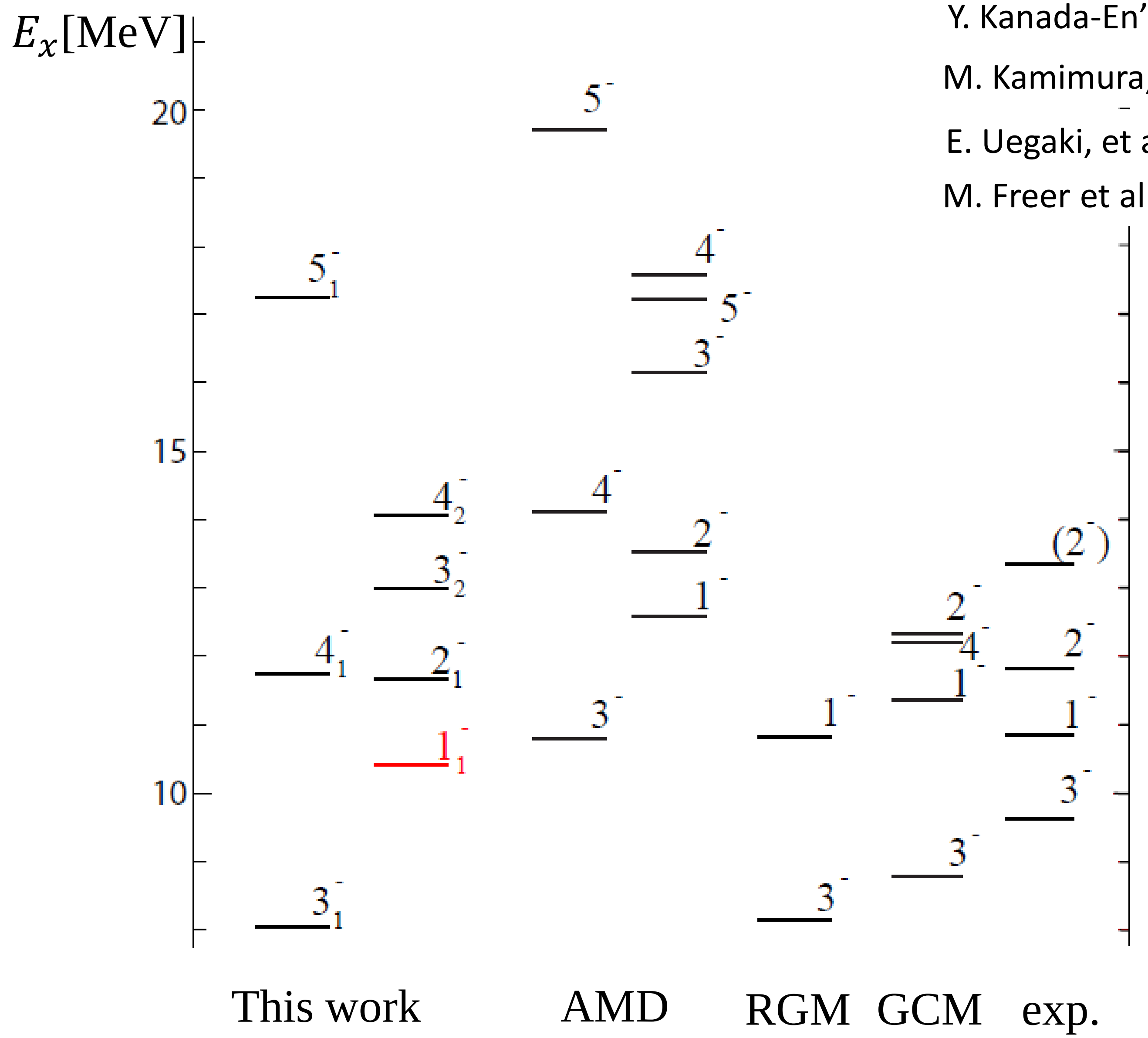
Result Spectrum of negative parity states

Y. Kanada-En'yo, PTP 117(2007)

M. Kamimura, NPA.351,456(1981)

E. Uegaki, et al., PTP 57, 1262(1977)

M. Freer et al., PRC 83, 034314(2011)



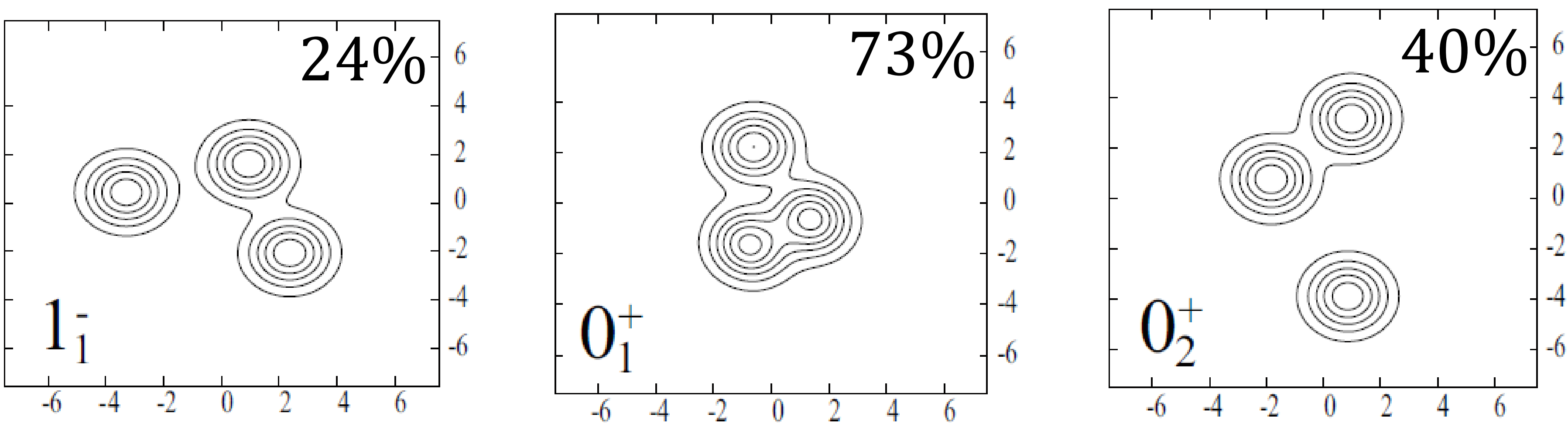
Result Radius of the 1_1^-

E. Uegaki, et al., PTP 57, 1262(1977)
M. Kamimura, NPA.351,456(1981)
Y. Kanada-En'yo, PTP 117(2007)
Y. Funaki ,Phys. Rev. C 92 021302(2015)

	$\sqrt{\langle r^2 \rangle}$				
J^π	This work	AMD	THSR	GCM	RGM
1_1^-	4.09	3.42		3.29	3.36
0_1^+	2.39	2.53	2.4	2.40	2.40
0_2^+	3.63	3.27	3.7	3.40	3.47
0_3^+	4.76	3.98	4.7	3.52	

1_1^- has larger radius than the Hoyle state.

Density distributions



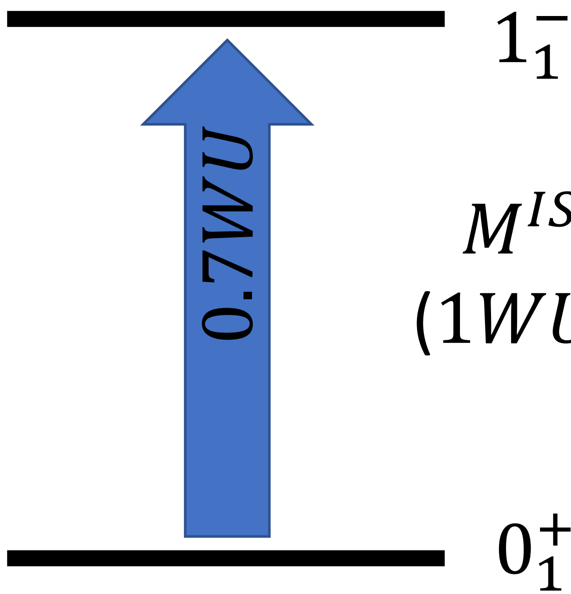
1_1^- is so dilute that the state can't be described by single slater determinant.

Result IS1

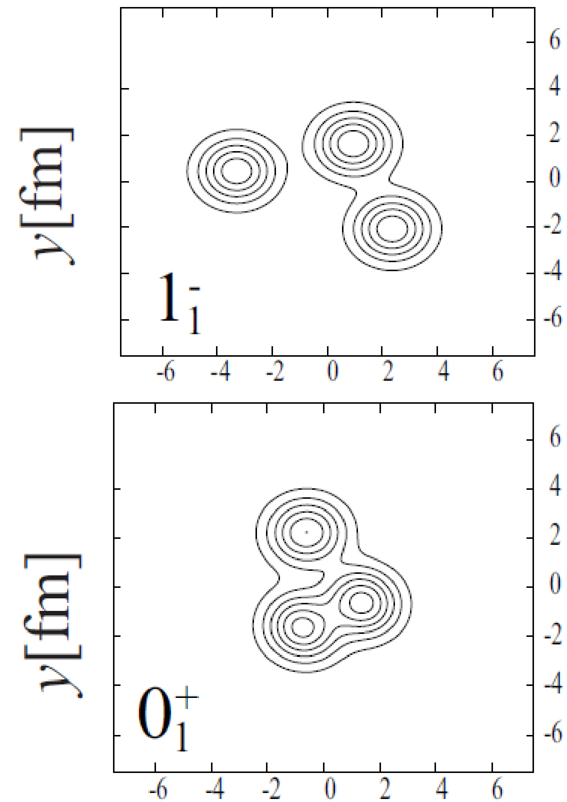
1^- cluster state can be strongly excited from the ground state by the IS dipole transition. Y. Chiba, et al., PRC93, 034319(2016)

$$\mathcal{M}^{IS1}_{\mu} = \sum_{i=1}^{A} (\boldsymbol{r}_i - \boldsymbol{r}_{\text{c.m.}})^2 \mathcal{Y}_{1\mu}(\boldsymbol{r}_i - \boldsymbol{r}_{\text{c.m.}})$$

$$M^{\text{IS1}} = \langle 1^- || \mathcal{M}^{\text{IS1}} || 0^+_1 \rangle$$



$$M^{IS1} = 0.7WU$$
$$(1WU = 5.06\text{fm}^3)$$



The transition strength is as strong as one particle estimate.

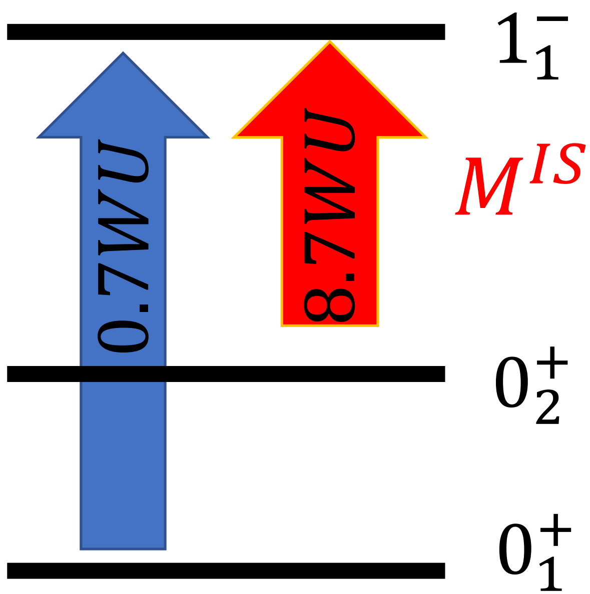
Result IS1

1^- cluster state can be strongly excited from the ground state by the IS dipole transition.

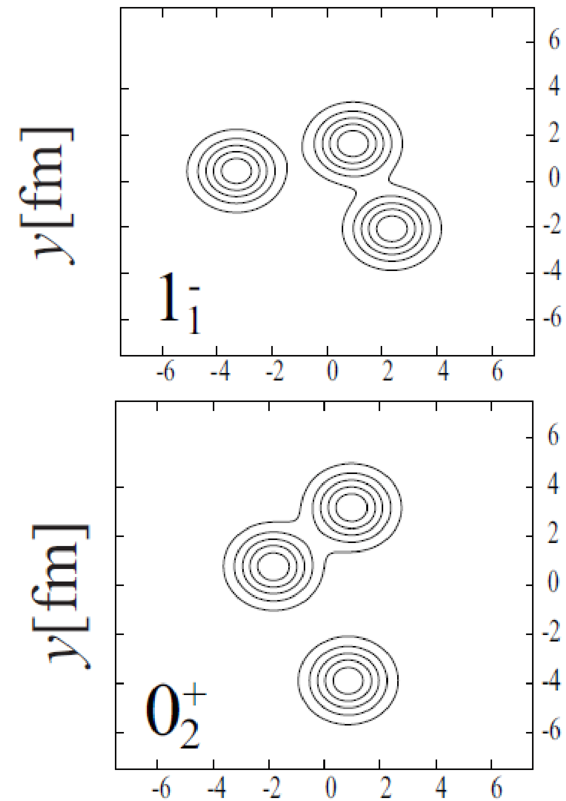
Y. Chiba, et al., PRC93, 034319(2016)

$$\mathcal{M}^{IS1}_{\mu} = \sum_{i=1}^{A} (\boldsymbol{r}_i - \boldsymbol{r}_{\mathrm{c.m.}})^2 \mathcal{Y}_{1\mu}(\boldsymbol{r}_i - \boldsymbol{r}_{\mathrm{c.m.}})$$

$$M^{\mathrm{IS1}} = \langle 1^- || \mathcal{M}^{\mathrm{IS1}} || 0_1^+ \rangle$$



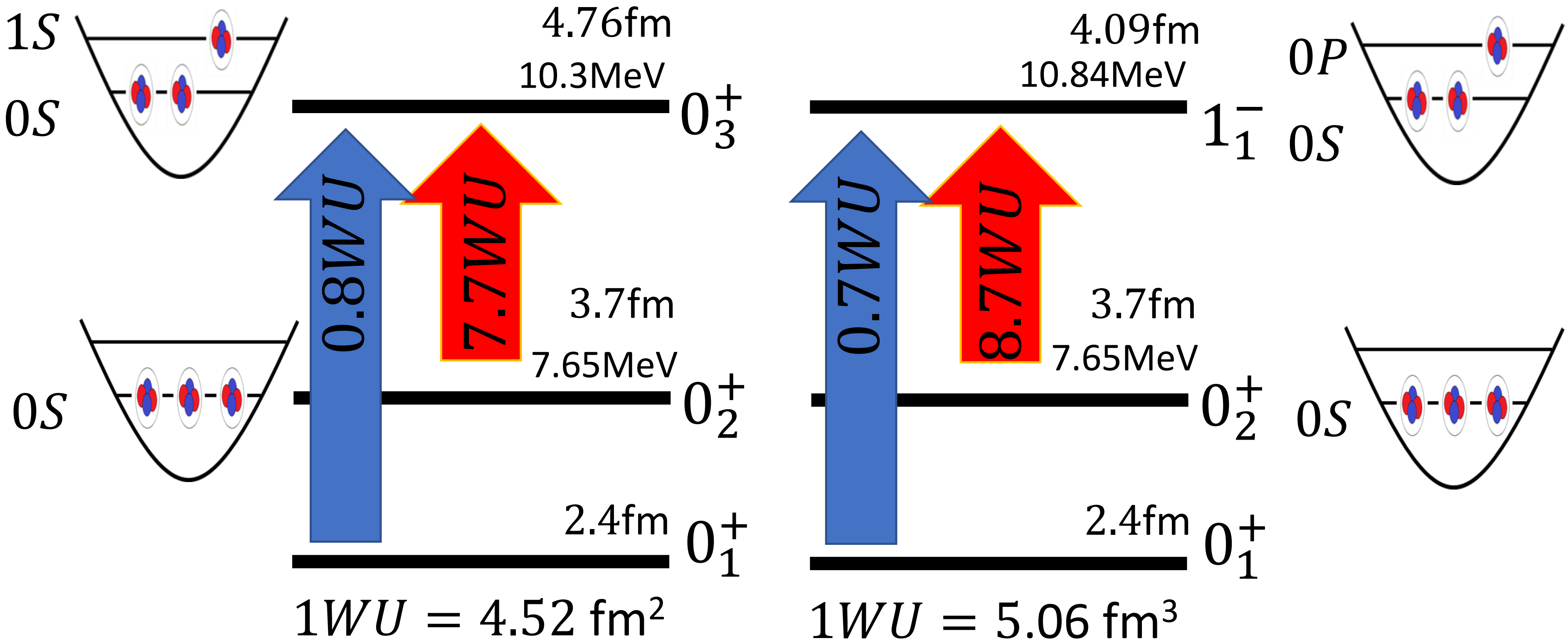
$$M^{IS1} = 8.7WU$$



The 1_1^- state has large IS1 transition to the Hoyle state.

Summary of master thesis

- We investigated the property of the 1_1^- state by using Real Time Evolution Method.



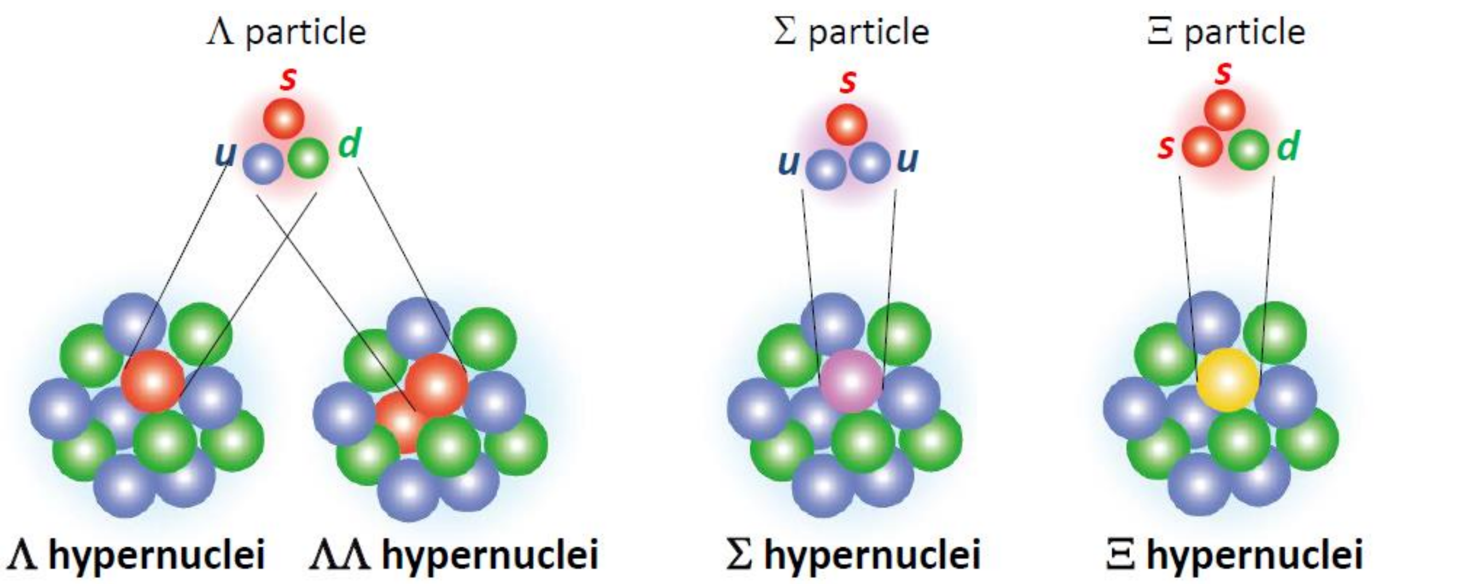
Future work

- We will research the orbit of the α particle to check that the description of the 1_1^- state is correct.

Rasearch
in doctor course

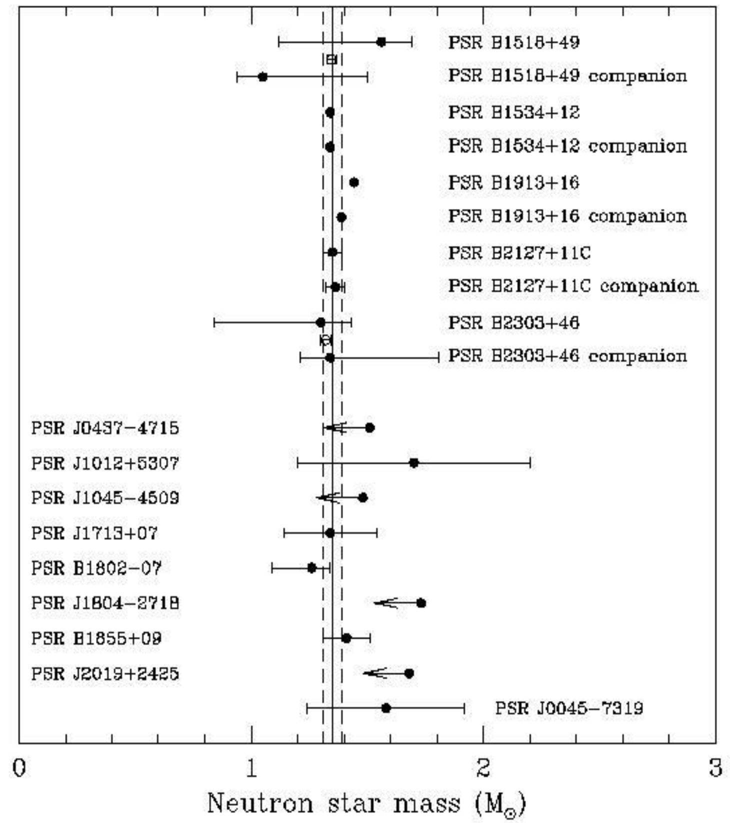
Hyper-nuclei

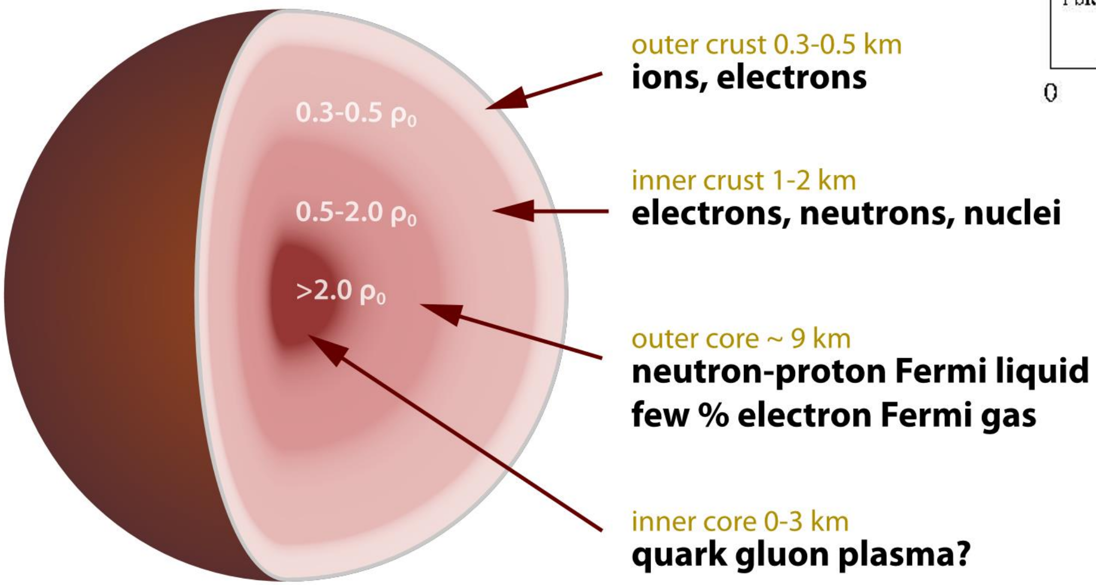
- Why the hypernuclei are interested in?
  - ➢YN, YY interaction
  - ➢Impurity effects



Background

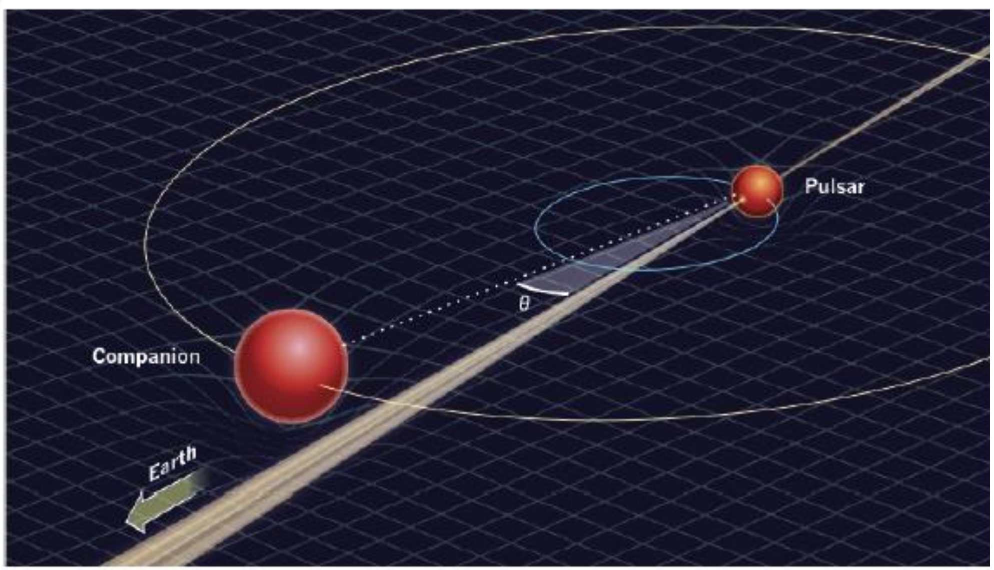
- Neutron star
  - ➢Mass is 1.1～1.4$M_{\odot}$.
  - ➢Radius is about 10 km.
  - ➢High density

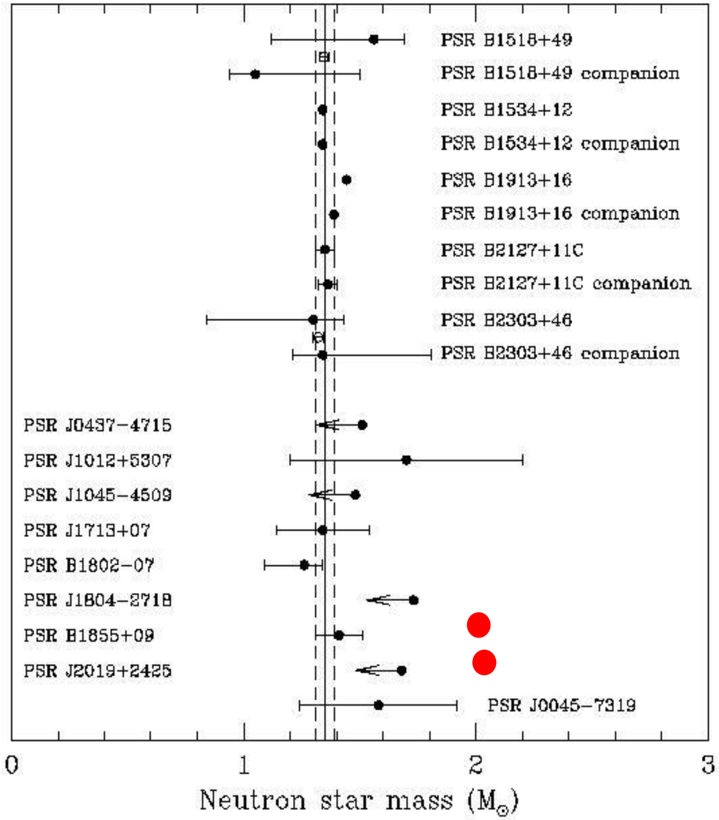




Background

In 2010, PSR J1614-2230($1.97 \pm 0.04 M_{\odot}$) and
in 2013, PSR J0348+0432($2.01 \pm 0.04 M_{\odot}$) were observed.

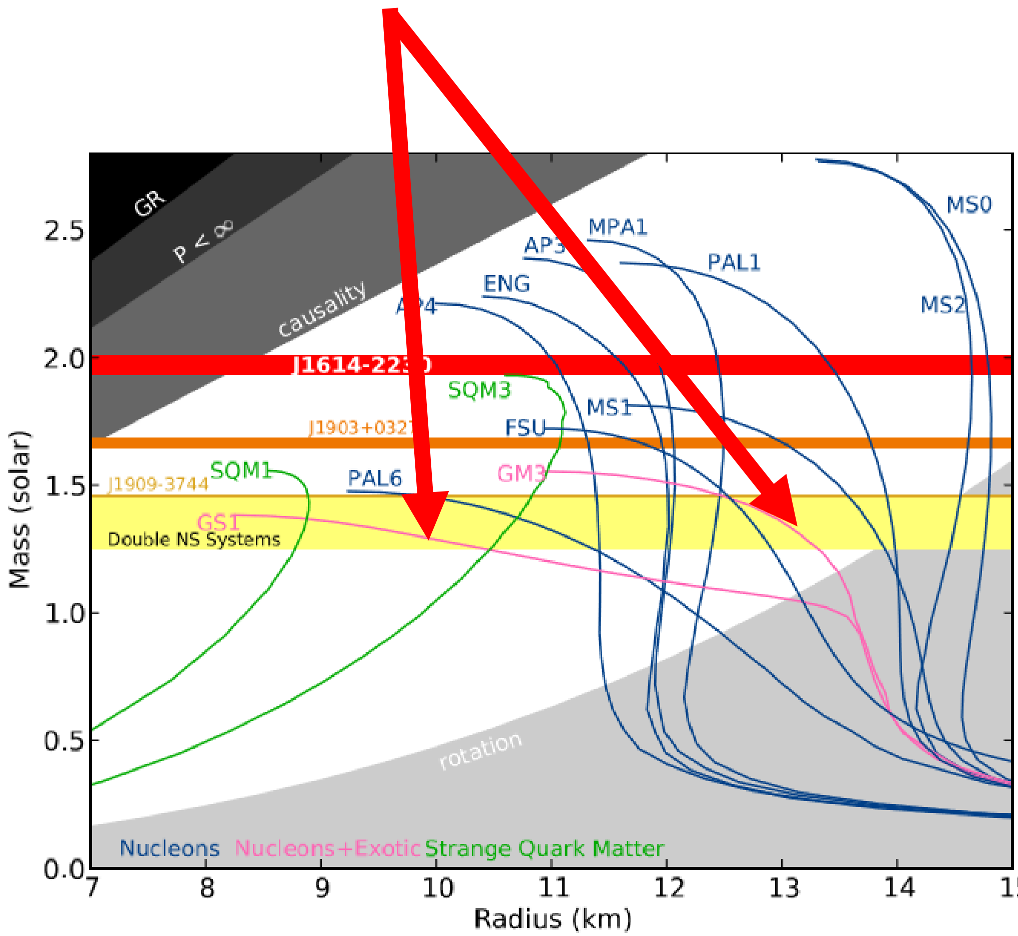




Hyperon puzzle

- But the calculations including hyperon cannot reproduce the large mass.
- How do the YN and YY interaction change for high density?
    - ➢ This is important to solve the Hyperon puzzle.
- Hypernuclei give us the information about the YN interaction.

EOS with hyperons or Kaons



P. Demorest, et al.,(2010)

Ξ hypernuclei

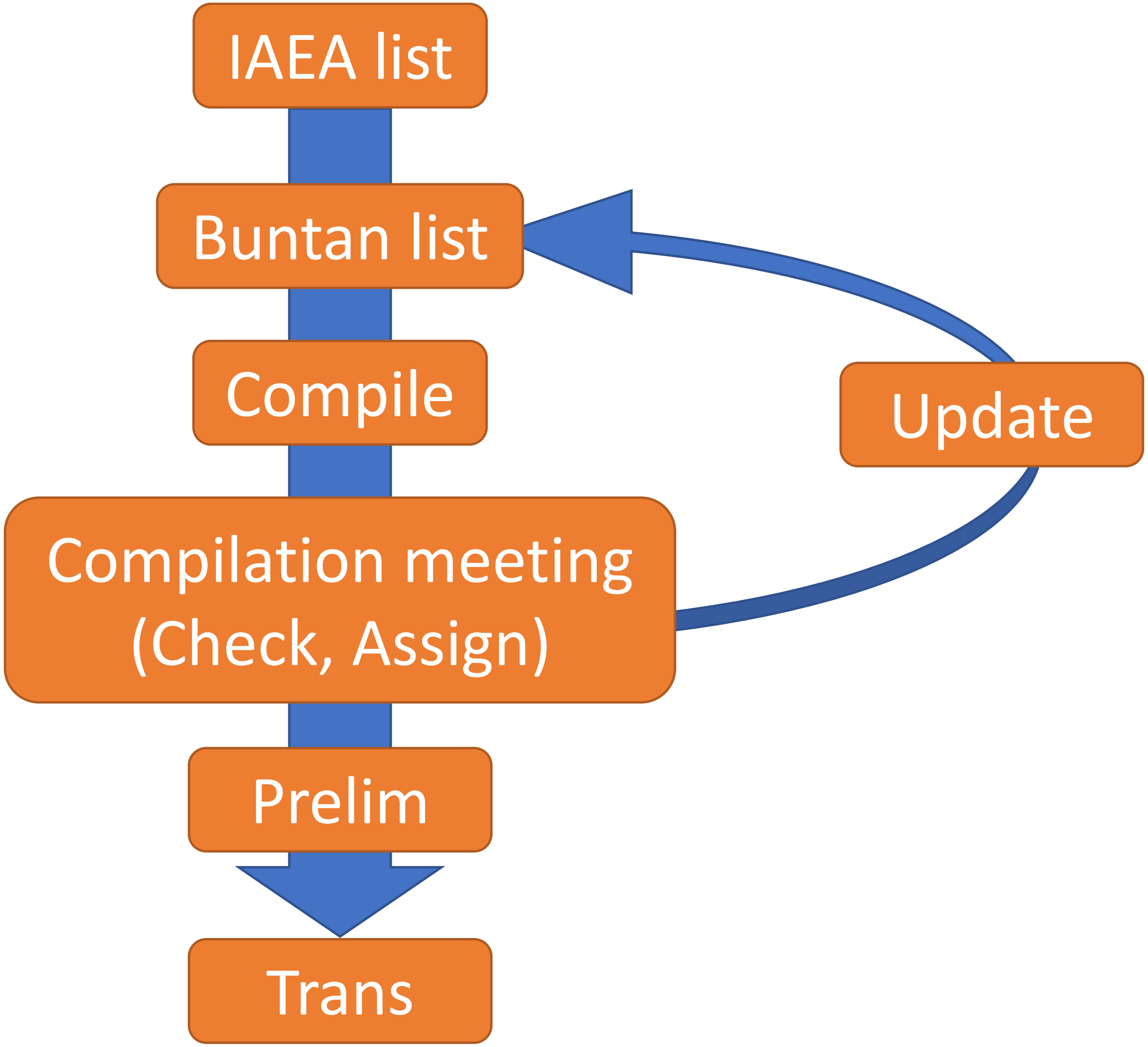
- I will calculate the spectrum of Ξ hypernuclei by AMD.
    - E05 experiment was planned. $^{12}\mathrm{C}(K^-, K^+)$ reaction(T.Nagae et al.)
    - ➢ To observe Ξ hypernuclei
    - ➢ To observe Ξ hyper nuclear potential of $^{12}_{\Xi}\mathrm{Be}$

⬇

Information about Ξ-N interaction

Compilation in JCPRG

Flowchart of Compilation in the JCPRG



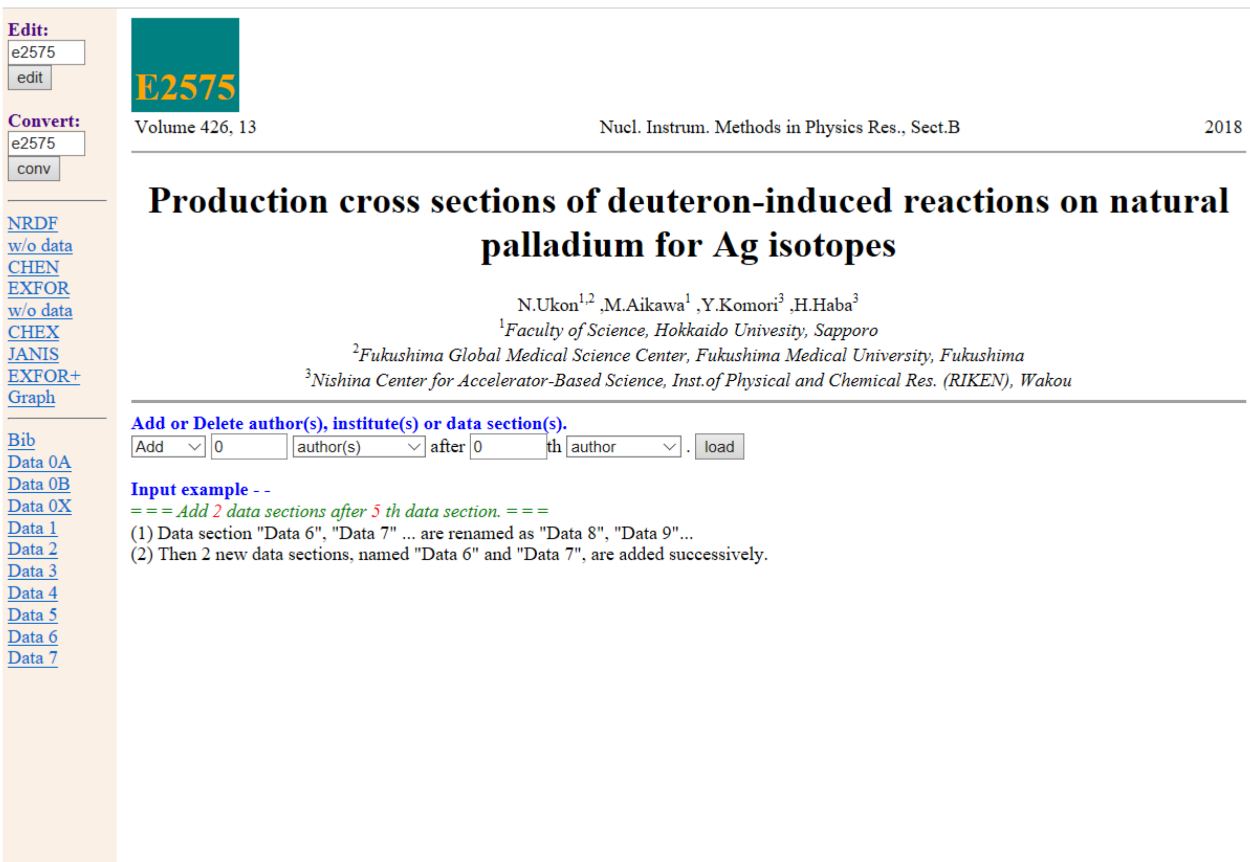
Buntan(分担) list

I distributes the paper from the IAEA list to the “buntan list”.

2565	JPJ25(1968)901	Single particle strength of collective 3- state in medium mass nuclei	Tada (finished)	All (finished)
2564	JPJ25(1968)301	Inelastic alpha-particle scattering on copper 65 at 29 MeV	Tada (finished)	All (finished)
2563	JIN43(1981)1727	Production of 119mSn by alpha particle bombardment of 116Cd and its carrier-free separation	Saito (finished)	All (finished)
2562	JPJ87(2018)014203	Observation of new neutron-rich isotopes among fission fragments from in-flight fission of 345 MeV/nucleon 238U: search for new isotopes conducted concurrently with decay measurement campaigns	Jagjit (finished)	All (finieshed)
2561	JPJ87(2018)014202	Identification of new neutron-rich isotopes in the rare-earth region produced by 345 MeV/nucleon 238U	Jagjit (finished)	All (finished)
2560	PTEP2017(2017)083D01	Neutron production cross sections for (d,n) reactions at 55 MeV	Murata, Saito (finished)	All (finished)
2559	PRL119(2017)182503	Test of the Brink-Axel Hypothesis for the Pygmy Dipole Resonance	Tada	All
2558	PRL118(2017)252501	Electric Dipole Polarizability of 48Ca and Implications for the Neutron Skin	Ichinkhorloo	All
2557	PRL118(2017)202502	Gamma Decay of Unbound Neutron-Hole States in 133Sn	Jagjit (finished)	All (finished)
2556	PR/C96(2017)044604	Photoneutron cross-section measurements in the 209Bi(g,xn) reaction with a new method of direct neutron-multiplicity sorting	Jagjit	All
2555	PR/C96(2017)044316	Low-lying dipole strength in 52Cr	Tada	All
2554	PR/C96(2017)034604	Discovery of new isotopes 81,82Mo and 85,86Ru and a determination of the particle instability of 103Sb	Jagjit (finished)	All (finished)

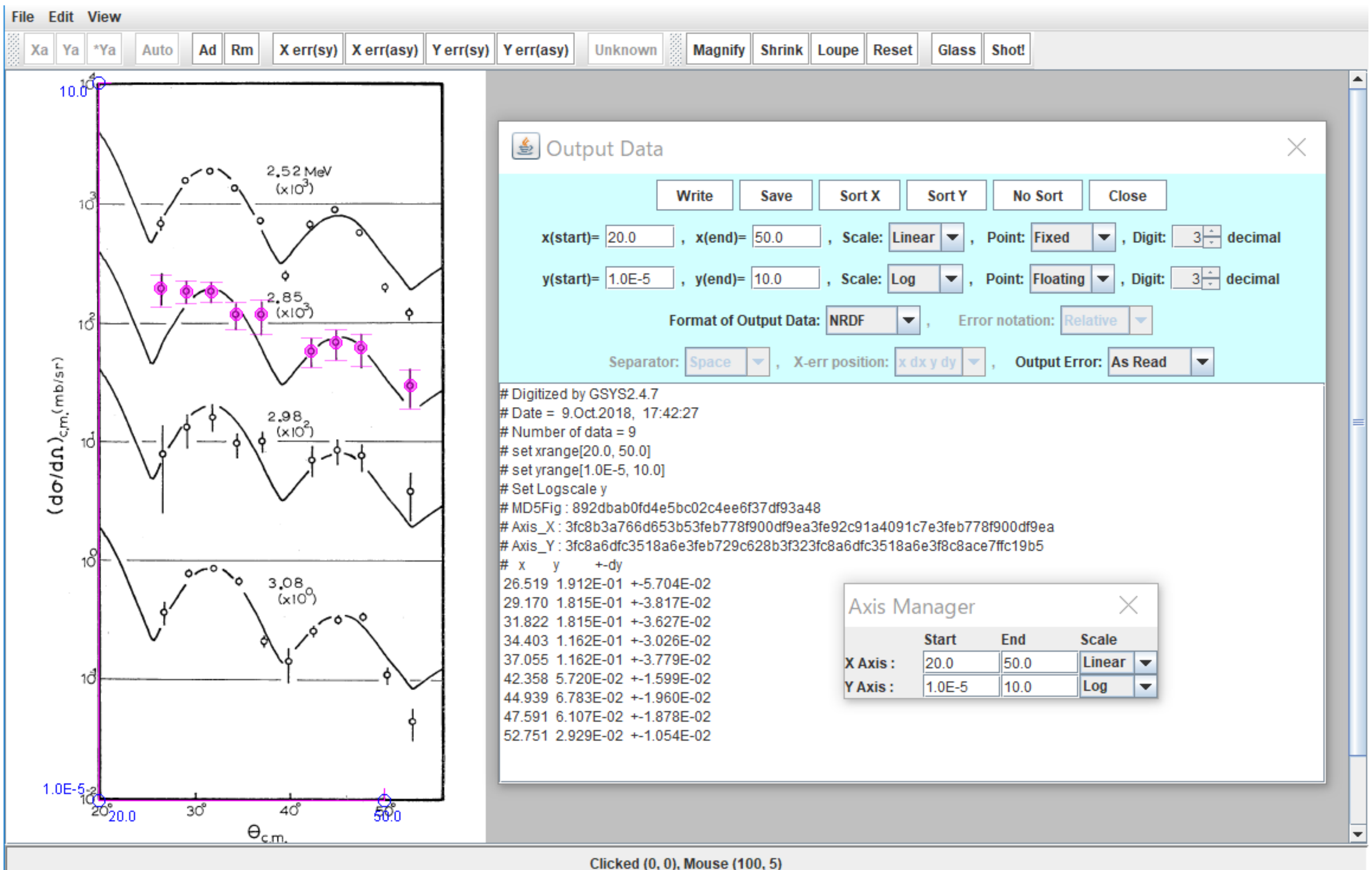
Compile

- We compile by using tools hendel and Gsys.



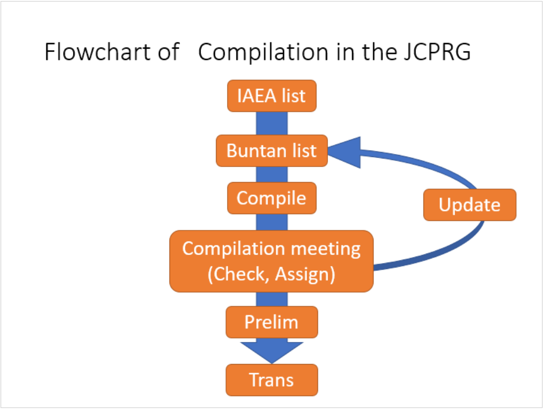
Compile

Gsys is the Graph digitizing system.



Compilation meeting

- This meeting is held once a week.(member: Aikawa, Kimura, Jagjit, Ichinkhorloo and Tada)
- Agenda
  - Check(1 or 2 papers)
  - Correction
  - Next schedule
    (which entry, date)



Plan for my internship

- My task
  - Compilation of old E entry in the buntan list.
  - Correction for the IAEA comments.

Plan for my internship

- My task
  - ➢Compilation of old E entry in the buntan list.
  - ➢Correction for the IAEA comments.

You must finish 65 corrections
for IAEA comments.

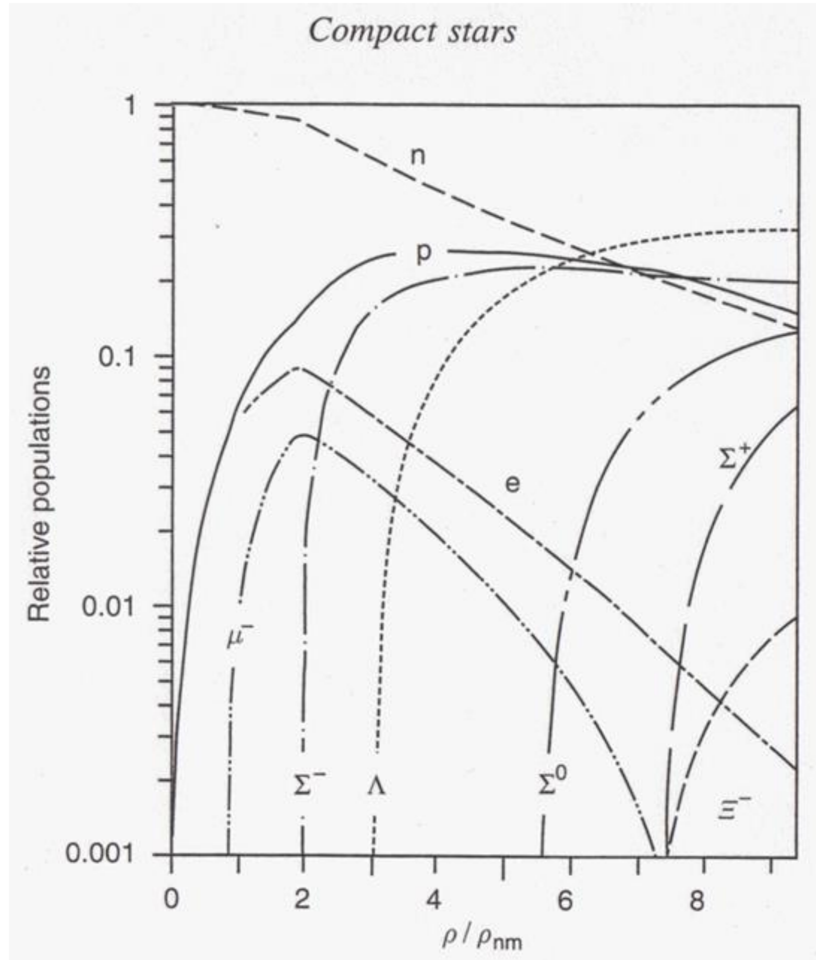
Technical Issue in JCPRG

- We have a few members.
- Members are too busy, so that all members can’t attend every compilation meeting.
- Members are not fixed in some years.

Thank you!

backup

It is thought that hyperon appear in the neutron star.



$$\rho_{nm} = 1.6\text{fm}^{-3}$$

Result

transitions [fm^2]	TGCM	THSR	exp.
$M(E0; 0_2^+ \to 0_1^+)$	6.57	6.3-6.4	5.4(2)
$M(E0; 0_2^+ \to 0_3^+)$	30.60	34-37	
$M(E0; 0_2^+ \to 0_4^+)$	1.37	0.5-1.4	

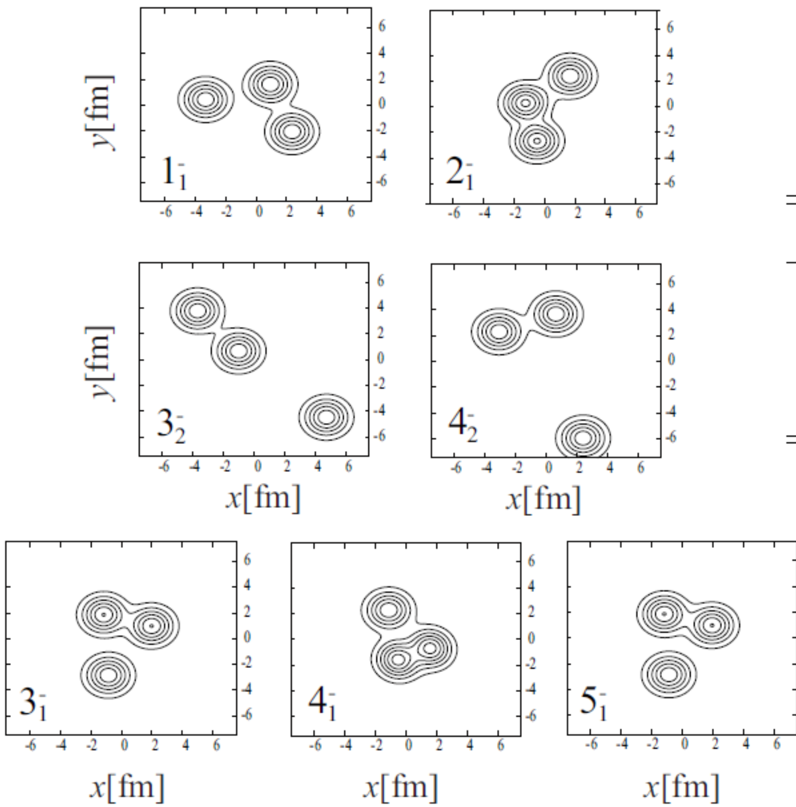
transitions [$e^2 fm^4$]	TGCM	THSR	exp.
$B(E2; 2_1^+ \to 0_1^+)$	9.01	9.5	7.6(4)
$B(E2; 2_1^+ \to 0_2^+)$	0.84	1.0	2.6(4)
$B(E2; 2_2^+ \to 0_1^+)$	2.64	2.0-2.5	0.73(13)
$B(E2; 2_2^+ \to 0_2^+)$	270.20	295-340	
$B(E2; 2_2^+ \to 0_3^+)$	143.81	88-220	
$B(E2; 2_2^+ \to 0_4^+)$	11.49	22-31	
$B(E2; 4_2^+ \to 2_2^+)$	605.30	560-730	

0^+ states has strong monopole excitation.

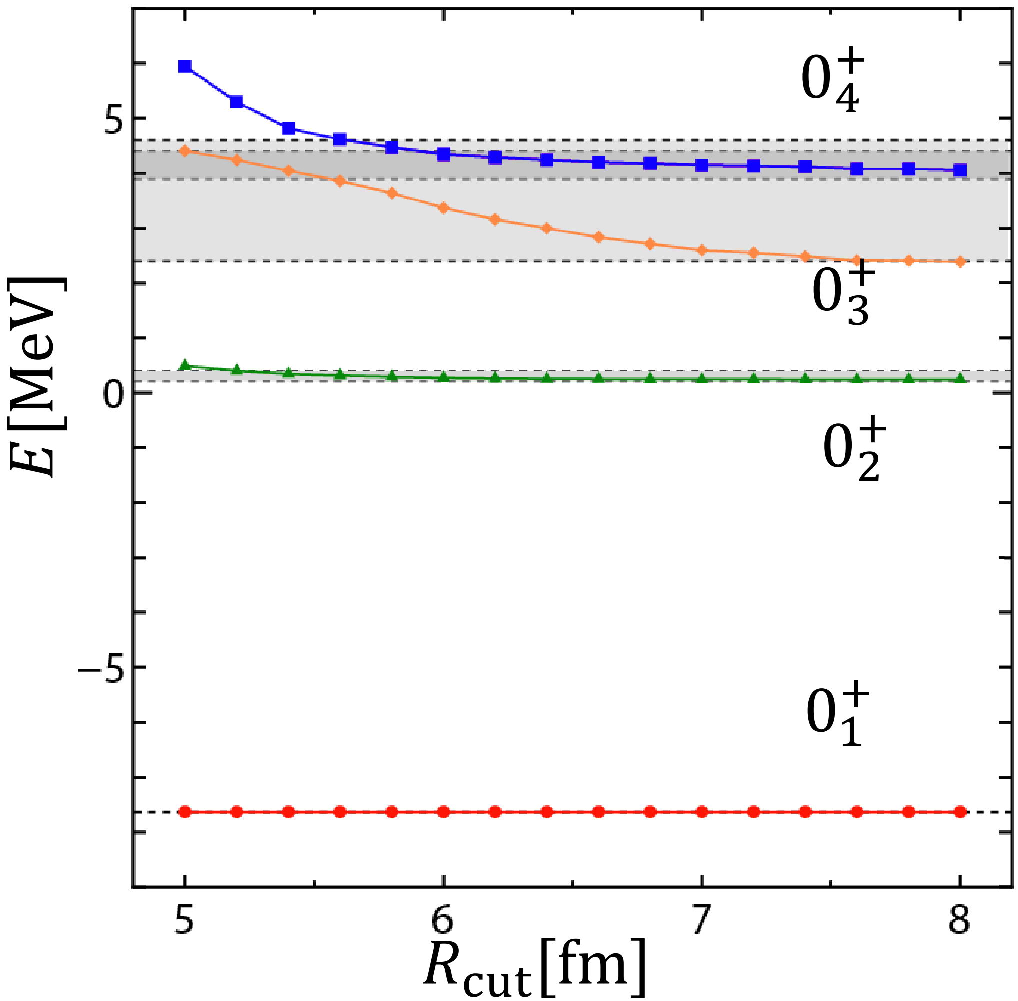
This results consistent with the THSR calculation and reproduce tendency of exp.

B. Zhou et al., PRC 94, 044319(2016)

Y. Funaki, PRC 94, 024344(2016)



J^π	$\langle \psi_\alpha \mid \tilde{\phi}_i \rangle$	J^π	$\langle \psi_\alpha \mid \tilde{\phi}_i \rangle$	J^π	$\langle \psi_\alpha \mid \tilde{\phi}_i \rangle$
1^-_1	24 %	2^-_1	37 %		
3^-_2	18 %	4^-_2	15 %		
3^-_1	53 %	4^-_1	50 %	5^-_1	46 %



Y. Funaki, PRC 92, 021302(R) (2015)