Pairing with Random Interaction

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Sep 25, 2018

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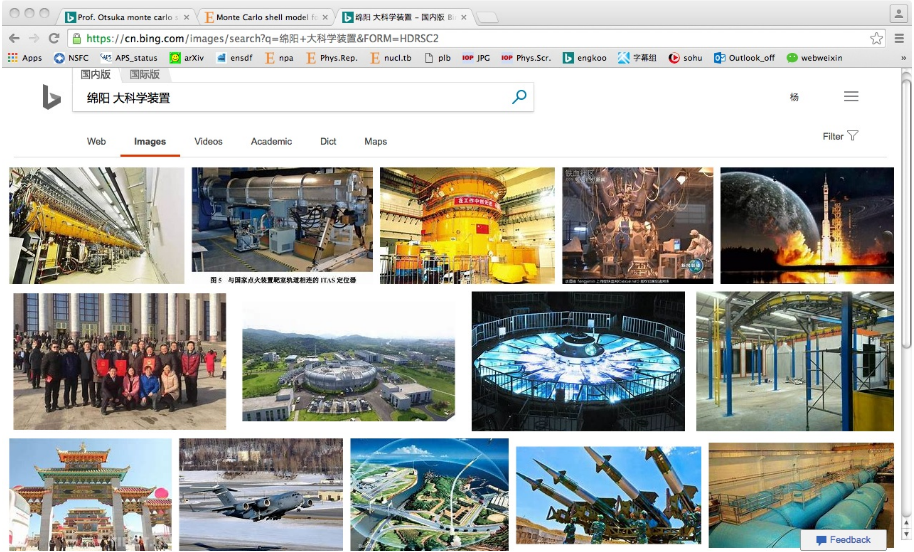
SWUST, Mianyang, Sichuan—City of Human and Nature

Li's birthplace

Jiuzaigou

SWUST, Mianyang, Sichuan—BIG City of Sci. and Tech.



Publications out of the collaboration with Prof. Arima

- Y. M. Zhao, **A. Arima**, and N. Yoshinaga, Many-body systems interacting via a two-body random ensemble. I. Angular momentum distribution in the ground states, Physical Review C 66, 064322 (2002)
- Y. Lei, Z. Y. Xu, Y. M. Zhao, S. Pittel, and **A. Arima**, Emergence of generalized seniority in low-lying states with random interactions, Physical Review C 83, 024302 (2011)
- G. J. Fu, L. Y. Jia, Y. M. Zhao, and **A. Arima**, Monopole pairing correlations with random interactions, Physical Review C 96, 044306 (2017)

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Background on random interaction

Orderly Spectra from Random Interactions

C. W. Johnson,[1] G. F. Bertsch,[2] and D. J. Dean[3]
[1]*Department of Physics and Astronomy, Louisiana State University, Baton Rouge, Louisiana 70803-4001*
[2]*Department of Physics, FM-15, University of Washington, Seattle, Washington 98195*
[3]*Physics Division, Oak Ridge National Laboratory, P.O. Box 2008, Oak Ridge, Tennessee 37831, and Department of Physics and Astronomy, University of Tennessee, Knoxville, Tennessee 37996*
(Received 17 November 1997)

We investigate the low-lying spectra of many-body systems with random two-body interactions, specifying that the ensemble be invariant under particle-hole conjugation. Surprisingly we find patterns reminiscent of more orderly interactions, such as a predominance of $J = 0$ ground states separated by a gap from the excited states, and evidence of phonon vibrations in the low-lying spectra.

Johnson *et al.*: Pairing is a robust feature of two-body Hamiltonian.

C. W. Johnson, G. F. Bertsch, and D. J. Dean, Phys. Rev. Lett. 80, 2749 (1998).

C. W. Johnson, G. F. Bertsch, D. J. Dean, and I. Talmi, Phys. Rev. C 61, 014311 (1999).

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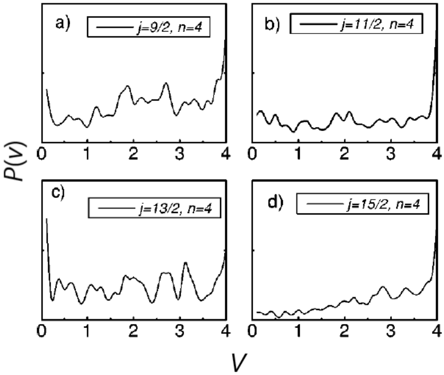
Single-j system

where seniority number v (unpaired particle number) is well defined:



Zhao, $et\ al.$: No bias of low seniority in $J=0$ g.s..

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Y. M. Zhao, **A. Arima**, and N. Yoshinaga, Phys. Rev. C 66, 064322 (2002).

Multiple-j system

- generalized seniority: $S^\dagger = \sum \beta_i (a_i^\dagger \times a_i^\dagger)^{I=0} \Rightarrow (S^\dagger)^N|\rangle$

- non-iteration algorithm for fitting β_i to seniority truncation.

  Z. Y. Xu, Y. Lei, Y. M. Zhao, S. W. Xu, Y. X. Xie, and **A. Arima**, Phys. Rev. C 79, 054315 (2009).

- overlap between generalized seniority and shell-model wave functions.

  Y. Lei, Y. M. Zhao and **A. Arima**, Phys. Rev. C 84, 044301 (2011); Y. Lei, Z. Y. Xu, Y. M. Zhao and **A. Arima**, Phys. Rev. C 82, 034303 (2010); *ibid.*, 80, 064316 (2009).

$$\theta_0 = \langle \mathrm{SM}|(S^\dagger)^N\rangle$$

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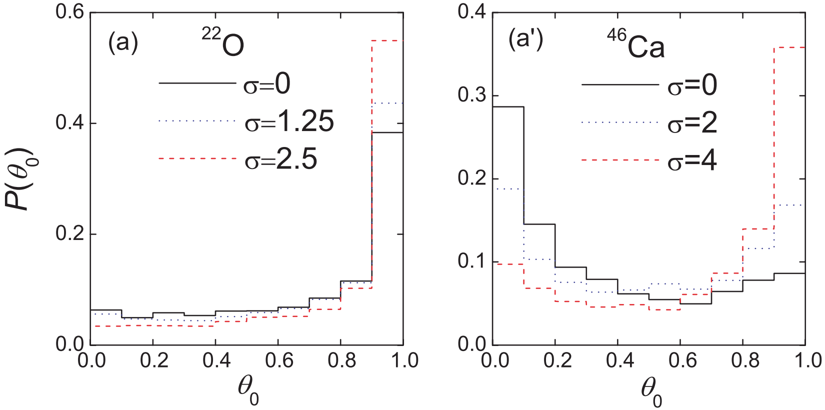
Multiple-j system



Me: large s.p. splitting boosts pairing.

Y. Lei, Z. Y. Xu, Y. M. Zhao, S. Pittel, and **A. Arima**, Phys. Rev. C 83, 024302 (2011).

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What we should do better

- for single-j system
- for larger shell and heavy nuclei.

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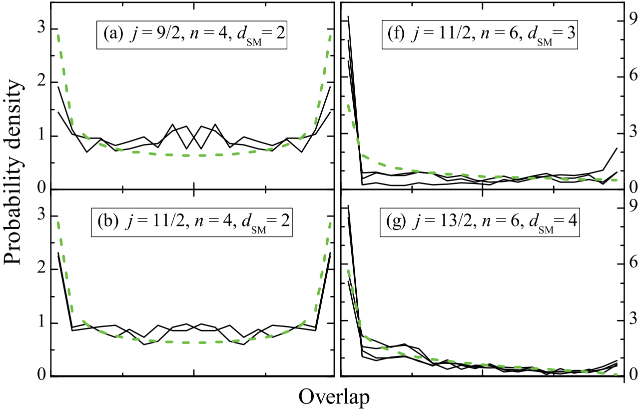
Dr. Fu's work



Fu $et\ al.$: size effect of the $f_{7/2}$ orbit for ^{46}Ca.

G. J. Fu, L. Y. Jia, Y. M. Zhao, and **A. Arima**, Phys. Rev. C 96, 044306 (2017).

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Story of the future

^{22}O : 14 $J=0$ bases, 6 pairing bases:

pairing basis
$[(d_{5/2}d_{5/2})^{J=0}]^3$
$(d_{3/2}d_{3/2})^{J=0}[(d_{5/2}d_{5/2})^{J=0}]^2$
$[(d_{3/2}d_{3/2})^{J=0}]^2(d_{5/2}d_{5/2})^{J=0}$
$[(s_{1/2}s_{1/2})^{J=0}[(d_{5/2}d_{5/2})^{J=0}]^2$
$(s_{1/2}s_{1/2})^{J=0}(d_{3/2}d_{3/2})^{J=0}(d_{5/2}d_{5/2})^{J=0}$
$(s_{1/2}s_{1/2})^{J=0}[(d_{3/2}d_{3/2})^{J=0}]^2$

non-pairing basis
$(d_{3/2}d_{3/2})^{J=2}(d_{5/2}d_{5/2})^{J=2}(d_{5/2}d_{5/2})^{J=0}$
$(d_{3/2}d_{3/2})^{J=0}(d_{3/2}d_{5/2})^{J=2,\ 4}(d_{5/2}d_{5/2})^{J=2,\ 4}$
$(s_{1/2}d_{3/2})^{J=2}(d_{5/2}d_{5/2})^{J=2}(d_{5/2}d_{5/2})^{J=0}$
$(s_{1/2}d_{5/2})^{J=2}(d_{3/2}d_{3/2})^{J=2}(d_{5/2}d_{5/2})^{J=0}$
$(s_{1/2}d_{5/2})^{J=2}(d_{3/2}d_{3/2})^{J=2}(d_{5/2}d_{5/2})^{J=2,\ 4}$
$(s_{1/2}d_{3/2})^{J=2}(d_{3/2}d_{3/2})^{J=2}(d_{5/2}d_{5/2})^{J=0}$
$(s_{1/2}s_{1/2})(d_{3/2}d_{5/2})^{J=2,\ 4}(d_{5/2}d_{5/2})^{J=2,\ 4}$
$(s_{1/2}s_{1/2})(d_{3/2}d_{3/2})^{J=2}(d_{5/2}d_{5/2})^{J=2}$

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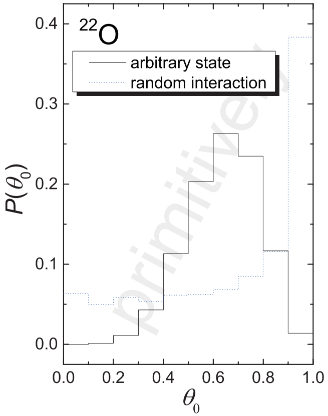
$(s_{1/2}s_{1/2})(d_{3/2}d_{3/2})^{J=2}(d_{5/2}d_{5/2})^{J=2}$



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Short Summary

- "Pairing" exhibits itself everywhere in random-interaction ensemble.
- The overlap calculation enables us to directly and quantitatively probe how importance of the pairing in both random-interaction ensemble and numerical calculation for realistic nuclei.
- It still requires further investigation to understand why and when the pairing emerges.

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Happy Birthday !

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