

Localization properties of quantum correlations in nuclei

R.-D. Lasserri,¹ J.-P. Ebran,² E. Khan,¹ N. Sandulescu,³ and D. Vretenar⁴

¹*Institut de Physique Nucléaire, Université Paris-Sud, IN2P3-CNRS, F-91406 Orsay Cedex, France*

²*CEA, DAM, DIF, F-91297 Arpajon, France*

³*National Institute of Physics and Nuclear Engineering,
P.O. Box MG-6, Magurele, Bucharest, Romania*

⁴*Physics Department, Faculty of Science, University of Zagreb, 10000 Zagreb, Croatia*

(Dated: April 19, 2016)

Correlations play a major part for nuclear structure.

PACS numbers: 21.60.Jz, 21.10.Gv, 27.20.+n, 27.30.+t

I. INTRODUCTION

To describe in an accurate way any fermionic system in interaction one have to take into account correlations. Nuclear system makes no exception and the impact of two-body correlations, namely pairing, have shown all its importance since Bohr Mottelson and Pines [1]. To describe this phenomenon several theoretical techniques have been developed from the Bardeen Cooper and Schrieffer ansatz, [2] to the more advanced Bogoliubov transformations[3]. The principle is to explicitly allow two fermions to form a quasi-bosonic pair. These fermions will be correlated in momentum space. For example for two spin- $\frac{1}{2}$ particles the usual BCS ansatz may be written.

$$\psi_0 = \prod_k (u_k + v_k a_{k,\uparrow}^\dagger a_{-k,\downarrow}^\dagger) |0\rangle \quad (1)$$

This equation translate the fact that a Cooper pair is composed of two fermions of opposite spin and of opposite momenta. This picture do not give direct information on the spatial properties of the pair. Several studies has been conducted on this purpose in infinite matter [4] and in the nuclei [5]. A systematic analysis of the spatial properties of the pair is an important challenge to get a deeper understanding of the correlated substructures on the nucleus as clusters [6] or neutron-proton dimers which may have important experimental consequences [7]. These elements motivate a systematic study

of those spatial properties.

II. SPATIAL PROPERTIES

In order to keep the explicit covariance of our theory one shall define a pair-density in the most general way. An usual prescription will be

$$\hat{\rho}_{pair}(\vec{r}_1, \vec{r}_2) = \langle \vec{r}_1, \vec{r}_2 | \hat{\rho}_{pair} \rangle = \mathcal{N} \sum_{i,j} \bar{\psi}_i^{\tau_i}(\vec{r}_1) \gamma^5 \psi_j^{\tau_j}(\vec{r}_2) \quad (2)$$

Where the ψ^τ is a Dirac spinor, describing a nucleon of isospin τ represented in configuration space. The subscript label the state of

III. COORDINATES CHOICE

Description of Talmi Moshinsky transform

IV. RESULTS

Germanium 64 Neon 20 C12 ? Evolution of the pairing constant

V. CONCLUSIONS

Opening toward Quarteting localization

-
- [1] M. G. Mayer and J. H. D. Jensen, *Elementary Theory of Nuclear Shell Structure* Wiley, New York, 1955.
 - [2] J. Bardeen, L. Cooper, J.R. Schrieffer, "Microscopic Theory of Superconductivity". Physical Review 106 (1): 162164. (1957)
 - [3] N. Bogoliubov *On the theory of superfluidity* J. Phys. (USSR), 11, p. 23 (1947)
 - [4] M. Matsuo *Spatial structure of neutron Cooper pair in low density uniform matter* Phys. Rev. C 73, 044309 (2006)

- [5] N. Pillet, N. Sandulescu, P. Schuck, and J.-F. Berger *Two-particle spatial correlations in superfluid nuclei* Phys. Rev. C 81, 034307 (2010)
- [6] J.P. Ebran, E.Khan, D. Vretenar , T. Niksic *How atomic Nuclei cluster* Nature 487 341 (2012)
- [7] R. Subedi et al, *Probing Cold Dense Nuclear Matter* Science 320 (2008) 1476